FROM CODE TO CURE: HOW INFORMATICS IS TRANSFORMING HEALTH CARE

Authors

Ms. Tamanna Pamnani
Manager (Technical head) at Dr. B. Lal clinical laboratories
Departmentof Molecular Diagnostic
Dr. B. Lal Institute of Biotechnology
Jaipur, Rajasthan,India.
tamannapamnani.18tp@gmail.com

Dr. Aakanksha Kalra
Assistant Professor
Department of Biotechnology
Dr. B. Lal Institute of Biotechnology
Jaipur, Rajasthan, India.
aakankshakalra07@gmail.com

Abstract

The dynamic nature of the healthcare industry demands the development of novel approaches that enhance patient care, optimise operational processes, and increase overall health results. This chapter explores the evolving domain of medical and health informatics, with particular emphasis on the incorporation of information technology (IT) into the healthcare ecosystem. The proper utilisation of information technology (IT) emerges as a critical driver driving positive change as healthcare systems globally undergo transition. These sections encompass several topics within the field of health informatics, such as Electronic Health Records (EHRs), Telemedicine and Remote Monitoring, Clinical Decision Support Systems, Big Data and Analytics, Artificial Intelligence and Machine Learning, Data Security, and Privacy in Health Informatics. The text explores the capacity of these innovations to transform the provision of healthcare, enhancing its focus on patients, streamlining operations, and using data-driven approaches. The chapter utilises real-world case studies and examples to demonstrate the effective incorporation of information technology (IT) into healthcare environments. These instances serve to emphasise the practical advantages, obstacles, and prospective advancements within the area.

In summary, this book chapter highlights the increasing importance of integrating IT technology in the field of medical and health informatics. This integration is crucial in creating a healthcare system that is more interconnected, driven by data, and focused on the needs of patients. This publication is of utmost importance for individuals working in the healthcare field, doing research, formulating policies, and those with a vested interest in the advancement of healthcare delivery.

Keywords: Information & communication technology, public health informatics, Electronic medical records (EMRs), Health Informatics

I. INTRODUCTION TO MEDICAL AND HEALTH INFORMATICS

Every element of our lives has been taken over by the digital era from home appliances to the realm of gadgets. This technological touch does not fall behind in terms of patient care. The patient, the practitioner, and the pursuit of better health outcomes have long been at the centre of healthcare. In the past, healthcare professionals have made decisions based on their clinical experience as well as the information they have learned from medical textbooks and research publications. They now have a new ally in their quest for perfection, though.

Technology is becoming the system's skeleton; it no longer just affects wealthy countries but also rural areas. We have learned about links and connectivity as well as information technology owing to the due credit to the pandemic.

Health information systems are crucial auxiliary tools for managing the provision of healthcare services in both developed and developing nations. For the planning and execution of health interventions as well as for analysing the health requirements of populations and groups, an adequate health information system is essential. When evaluating programmes from the angles of efficacy and coverage, it is equally crucial. Many less developed nations still lack efficient health information systems, despite the fact that the majority of wealthy nations have well-established health information systems to guide the planning and delivery of healthcare services. As a result, insufficient data about the population and groups utilising the services is used for designing and implementing health activities in different regions of the world. As a result, programme planning and implementation frequently rely not only on the opinions voiced by communities and groups but also on educated guesses and predictions, which may lead to inefficiency, inequality, and waste in the delivery of healthcare services [1].

According to WHO (June, 2008) "*The health information system provides the underpinnings for decision-making and has four key functions: data generation, compilation, analysis and synthesis, and communication and use. The health information system collects data from the health sector and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision-making*" [2].

Healthcare can have a bigger impact, and a new era has started in which healthcare institutions and industries can make better decisions by combining data from many different sources. This makes it easier and faster to make the right choice. Computational health informatics is an area of study that is growing both in and out of the medical field. Modern healthcare units that use innovative methods to diagnose and treat patients can encourage people to use public health care system. This gives people faith to use the best public health care services available and helps governments make better health care policies. In the last few years, the amount of medical and healthcare data has grown quickly in the healthcare field.

Today's medical informatics is different in that many informaticians work in the delivery of healthcare, such as in hospitals and "health care Information & communication technology (ICT) industries," in addition to conducting research and providing later-stage teaching. In addition to playing a significant role in improving the effectiveness and quality of healthcare globally, informatics methodology and ICT have also grown to become prominent players in the global ICT market [3].

This chapter is going to focus on all possible aspects of the health informatics system along with their challenges and future opportunities.

II. EVOLUTION OF HEALTH INFORMATION SYSTEMS

The importance of having sufficient and dependable health information systems has been acknowledged as crucial in attaining the objectives of universal health coverage [4]. These systems have been identified as vital in the effective implementation and management of various healthcare initiatives, including maternal and child care, family planning, and immunisation programmes [5]. Data collection in many developing nations continues to rely on the sporadic and predominantly unreliable submission of monthly reports from different divisions and offices within ministries and health departments. The lack of comprehensive health information collection systems, particularly in rural and urban areas, is a prominent issue that local authorities have failed to address. Frequently, there is a tendency to significantly underestimate the occurrence of events such as births, illness, and mortality, resulting in the production of conservative estimates for these occurrences [6]. The analysis and presentation of birth and death data can be challenging due to the presence of incomplete dates in certain circumstances. The importance of obtaining reliable data and statistics has been underscored in order for health managers to effectively strategize and make informed decisions regarding public health interventions.

III. ELECTRONIC HEALTH RECORDS (EHRs)

The term "health record" has become increasingly prominent in recent years due to the recognition that a patient's medical information should encompass not only episodic medical contacts, but also comprehensive health and lifestyle information. Historically, health records were documented in hard copy format, organised into folders that were categorised according to the nature of the information, and limited to a single physical copy. The advent of computer technology during the 1960s and 1970s served as a pivotal catalyst for the subsequent emergence and evolution of the Electronic Health Record (EHR). The use of electronic health records (EHRs) has not only facilitated enhanced legibility and accessibility of patients' medical information across various geographical locations, but it has also brought about a transformation in the structure and content of health records, consequently influencing the delivery of healthcare services.

The escalating utilisation of Electronic Health Records (EHRs) has prompted an examination of the efficacy of Clinical Decision Support (CDS) in enhancing healthcare processes and clinical results. This inquiry encompasses the evaluation techniques employed, the challenges associated with implementation and acceptance, the identification of patients for clinical trials, the emergence of various novel applications, and the inadvertent repercussions that may arise. The inclusion of specific studies is beyond the purview of this work and is therefore not discussed here [7].

Electronic health record (EHR) systems are currently being employed by various autonomous entities, such as primary care physicians, hospitals, insurance companies, and individuals, for the purposes of generating, utilising, modifying, and accessing medical records. Electronic health records (EHRs) are becoming more prevalent in primary-care examination rooms as a means to record and retrieve patients' records. Additionally, they are utilised to access online medical information and decision-making tools, as well as to facilitate the process of prescribing prescriptions. The utilisation of clinician-patient email, virtual consultations, and telemedicine has resulted in a transformation of the dynamics within the patient-clinician contact.

One of the advantages of this programme is the improved accessibility to healthcare services, the process of obtaining and accessing information and the organisation and presentation of information. The concept of decision support refers to the provision of assistance and guidance in making informed and effective decisions. Various tools and calculators have been developed to aid healthcare professionals in making clinical decisions. The prudent selection of a testing strategy is ensuring consistent and dependable subsequent actions. The utilisation of telehealth services the act of assessing diagnostic performance and delivering constructive comments.

The challenges encountered in this study are around the presence of inaccurate, inadequate, and missing information. The issue of "copy-paste" functionality and its associated usability problems. Due to spatial limitations, we are unable to delve into numerous additional factors that diminish the quality of diagnostics. These factors encompass inconsistent and incomplete terminologies for structured data elements, as well as the inconsistency and lack of specificity in the definition and designation of diseases. Electronic health records (EHRs) necessitate ongoing and continuous maintenance. The continuous updating of decision support rules is crucial, as exemplified by the potential consequences of failures that might directly result in errors and injury. One notable issue pertains to the absence of a universally accepted benchmark for assessing the efficacy and usefulness of health information technology (IT) and electronic health records (EHRs). At present, assessments of decision support products aimed at facilitating differential diagnosis are constrained to the comparison of several systems with one another, rather than with a universally accepted benchmark [8].

The forthcoming advancements in clinical reasoning, patient involvement, predictive analytics, the promotion of expertise, and the mitigation of overconfidence through feedback are poised to shape the future of healthcare. Additionally, efforts to address the "i-patient" dilemma are underway, aiming to resolve the challenges associated with patient-centric care.

IV. HEALTH DATA STANDARDS AND INTEROPERABILITY

One of the primary objectives outlined in the Healthy People 2020 initiative is to enhance public health and bolster the national security of the United States by implementing comprehensive methods for global disease detection, response, prevention, and control. The significance of global health lies in its impact on the health status of the people in the United States, which is susceptible to the influence of public health threats and occurrences originating from various regions worldwide. Illustrative instances encompass the outbreak of the Zika and Ebola viruses, which commenced in 2014, the H1N1 influenza pandemic of 2009, and the SARS epidemic of 2003. The occurrence of these epidemics has demonstrated the absence of geographical limitations for highly pathogenic microorganisms. In addition,

the proliferation of developing and re-emerging infectious and communicable illnesses necessitates the allocation of resources and the establishment of informatics infrastructure to expedite the prompt detection, surveillance, control, and mitigation of worldwide epidemics. According to Duchin's persuasive argument, the occurrences of Zika and Ebola have brought to light the vulnerabilities within our public health system. These weaknesses encompass not just inadequate funding for preparedness and response to disease outbreaks and other health hazards, but also the system's level of preparedness and ability to effectively respond [9].
The World Business Council for Sustainable Development (WBCSD) has asserted that the current management of health is widely seen as unsustainable. The current price exceeds our financial means, yet the performance falls short of our anticipated outcomes. In order for the existing public health system to thrive amidst future challenges of limited resources and growing demand, it necessitates the reconfiguration and adoption of novel systems that exhibit both sustainability and real-time reliability. In order to effectively address and mitigate the impact of re-emerging diseases and disasters such as Zika, Ebola, H1N1, and SARS, it is imperative to allocate resources towards enhancing the current public health system and fortifying its information system architecture.

Moreover, Bell et al. highlighted that the response to the Ebola outbreak encountered challenges arising from inadequate health infrastructure, little knowledge of the disease in terms of its geographic and cultural context, and a prevailing sense of mistrust towards government authorities and healthcare professionals. The primary insights garnered from these outbreaks underscore the imperative for the establishment of efficient mechanisms to identify and mitigate the risks posed by infectious diseases [10]. Additionally, it highlights the necessity for enhanced collaborative efforts at an international level to bolster surge capacity. Furthermore, it emphasises the importance of enhancing infection prevention and control measures within healthcare facilities, as well as the implementation of robust information technology systems. Moreover, it underscores the significance of comprehensive training programmes for healthcare professionals and scientists, alongside the advancement of expedited and dependable laboratory testing and genetic analysis techniques. Furthermore, it is imperative to establish comprehensive global response systems and develop action strategies that encompass short-term, medium-term, and long-term plans to effectively tackle risks and mitigate the occurrence of future epidemic outbreaks.

In a similar vein, it is imperative to build and sustain a robust framework comprising fundamental components for a resilient public health emergency response prior to the onset of a crisis. Incorporation of comprehensive surveillance measures and establishment of effective collaboration frameworks are imperative components of contingency plans, facilitating seamless contact with public health authorities and specialists. Furthermore, the utilisation of an event management framework is of utmost importance in the context of health emergency response. Consequently, it is imperative for public health authorities and the medical care system to actively include both governmental and non-governmental players in order to uphold resilient health information systems and disaster management plans, as well as enhance surge capacity. However, the attainment of this objective is contingent upon the successful establishment and accessibility of a functional information system [11].

V. CLINICAL DECISION SUPPORT SYSTEMS (CDSS)

The occurrence of medical errors during many stages of the healthcare process, including prescription, transcribing, dispensing, administering, and monitoring, has been a longstanding concern within hospital settings. This issue necessitates ongoing vigilance and dedication from medical personnel. In order to mitigate these errors, the United States Institute of Medicine proposes the establishment of more secure health systems. Numerous proactive initiatives are currently underway to mitigate medical errors and enhance medical quality through the enhancement of ancillary systems. The ongoing advancement of these systems suggests a positive outlook for achieving the integration of ICT with healthcare. A clinical decision support system (CDSS) has been developed as a means to enhance health management by integrating ICT with medical personnel. Clinical support systems refer to computing systems that have been specifically created to analyse data using scientific principles. These systems aim to aid medical professionals in promptly making decisions pertaining to illness prevention, screening, diagnosis, treatment, and follow-up. It is anticipated that in the future, these systems will possess the capability to do sophisticated functions, such as forecasting the occurrence of diseases, including diabetes mellitus (DM), or identifying high-risk cohorts within the broader population. Currently, Clinical Decision Support Systems (CDSSs) have exhibited the capability to forecast the probability of diabetic problems in individuals diagnosed with diabetes and assist medical practitioners in identifying the optimal timing for conducting tests. Clinical Decision Support Systems (CDSSs) possess the capability to alert healthcare professionals about potential interactions between diabetic drugs, in addition to other beneficial functionalities. In its early stages, Clinical Decision help Systems (CDSSs) primarily focused on providing basic diagnostic help. However, these systems have since evolved to facilitate the identification of high-risk groups suitable for patient disease prevention, with other functionalities [12].

The shift from traditional paper-based medical records to electronic medical records (EMRs) has taken place in the relatively recent past. The advent of electronic medical records (EMRs) has facilitated the accumulation of extensive quantities of quantitative medical information and data. Consequently, EMRs have fostered an atmosphere that is very conducive to the utilisation of computerised decision support systems (CDSSs). In essence, electronic medical records (EMRs) create a conducive setting for the effective operation of clinical decision support systems (CDSS) methodologies. The development of electronic medical records (EMRs) encompassed more than just the digitization and storage of patient treatment and medical data. It also involved the crucial aspect of integrating clinical decision support systems (CDSSs) with EMRs for optimal functionality [13]. CDSSs have been investigated in the United States within the context of a representative Electronic Medical Records (EMR) incentive programme commonly referred to as "meaningful use." The study revealed favourable outcomes in the areas of drug misuse prevention, drug dosage adjustment, drug allergy alerts, prevention of duplicate prescriptions, and drug interaction alerts. The implemented system effectively mitigated medical errors by promptly notifying healthcare personnel of such errors, enabling them to identify and address them using machine-derived knowledge and evidence-based practises. In this particular case, it was the healthcare system itself, rather than the pharmaceutical interventions, that significantly enhanced patient safety. In the medical domain of Korea, numerous Clinical Decision Support Systems (CDSSs) have been implemented. The nationwide drug utilisation review (NDUR) might be seen as an exemplar clinical decision support system (CDSS) [14]. The utilisation of this technology reduces the likelihood of incorrect diagnoses during the initial diagnostic phase, anticipates potential adverse effects of medications during the treatment phase, and identifies and forecasts alterations in a patient's health throughout the subsequent monitoring phase. In the context of Korea, there have been multiple endeavours to implement clinical decision support systems (CDSSs), resulting in the adoption of various CDSSs focused on drug-related interventions. Furthermore, the implementation of hospital information systems has resulted in enhanced medical efficiency through the digitization of medical data, including a patient's medical history, existing ailments, and therapeutic approaches. During the COVID-19 pandemic, a system has been implemented to record the body temperature and respiratory symptoms of employees on a daily basis, with the aim of monitoring the potential risk of infection. The system has the capability to effectively monitor patient symptoms or alterations in circumstances in real-time, hence aiding clinical personnel in promptly responding in a suitable manner. In the context of healthcare, it is worth noting that medical personnel are promptly informed in real-time whether a patient has recently travelled to a nation with a significant prevalence of COVID-19 or has been in a region within Korea that poses a substantial danger [15].

The utilisation of a Clinical Decision Support System (CDSS) can have a significant positive impact on the quality of patient care. However, it is important to acknowledge that the presence of inaccurate or unsuitable information inside the CDSS has the potential to impede a patient's treatment. Artificial intelligence (AI) algorithms, which have emerged as a prominent concern in recent times, are anticipated to be employed in Clinical Decision Support Systems (CDSSs) [16]. Nevertheless, it is imperative to consistently upgrade CDSS algorithms as patient data continues to amass. In order to accomplish this, it is imperative that data-driven or rule-based algorithms, which serve as a fundamental component of Clinical Decision Support Systems (CDSSs), undergo ongoing development, management, and updates. Significant expenditures in time and human resources are needed for this undertaking, hence necessitating the formation of interdisciplinary teams comprising medical personnel well-versed in information and communication technology (ICT), as well as data analysts and ICT specialists with a foundational comprehension of medical care. It is anticipated that the utilisation of interdisciplinary teams will yield significant advantages in enhancing the efficiency and excellence of healthcare delivery, while concurrently mitigating instances of override. CDSS warnings are widely recognised as the most prominent CDSSs. Following the development of the Clinical Decision Support System (CDSS) algorithm, it was integrated into an Electronic Medical Record (EMR) system. In the event that this method is deemed suitable for implementation in the course of patient treatment, a Clinical Decision Support System (CDSS) alert is triggered. These notifications are mostly employed in the context of a patient's therapeutic regimen, particularly in conjunction with the procedure of health insurance claims. Common examples of healthcare systems are those designed to facilitate the scheduling of routine bone mineral density assessments for individuals with osteoporosis, tests to detect complications associated with diabetes mellitus in diabetic patients, and vaccination programmes. The aforementioned procedure exhibits a clear correlation with the financial viability of healthcare institutions, with its role in the methodical administration of patient well-being. The inclusion of medication information prescribed by physicians is an additional benefit of CDSS notifications. Examples of excellent practise include ensuring the administration of an adequate dosage of a given medication to a patient, as well as providing cautionary information regarding excessive dosages, potential drug interactions, any known history of previous drug allergies, and the avoidance of duplicate prescriptions. Furthermore, in the event that a physician's prescription deviates from the CDSS algorithm, it is possible to evaluate the dependability of the algorithm in order to ascertain if the discrepancy is attributable to the CDSS warning system or to the prescribing tendencies of the physician. The primary objective of CDSS alerts is to mitigate medical errors among physicians and enhance the safety of healthcare settings, as well as improve health outcomes and medical procedures.

VI. TELEMEDICINE AND TELEHEALTH

In the contemporary era of technological advancements, medicine and healthcare are undergoing tremendous transformations, much like several other domains. An evident illustration of this phenomenon is telehealth, also known as telemedicine. It pertains to the provision of healthcare services encompassing diagnosis, consultation, treatment, education, care management, and patient self-management. These services are facilitated through real-time, bidirectional electronic audiovisual communication technology, commonly in the form of video conferencing. Telehealth provides patients with a convenient alternative for receiving healthcare services, so enabling them to access care promptly while also resulting in time and cost savings. The crucial aspect lies in achieving a harmonious equilibrium between telehealth and conventional in-person healthcare, while concurrently enlightening consumers regarding the appropriate circumstances for utilising each modality.

One crucial aspect that we underscore to our members is that telehealth ought not to supplant the interpersonal connection that we advocate for our members to establish with their primary care practitioner (PCP). The significance of regular wellness visits, routine screenings and testing, and maintaining a continuous and transparent connection with one's primary care physician (ideally within a patient-centred medical home) is emphasised as an optimal approach to maintaining optimal health. The primary care provider (PCP) or primary care medical home (PCMH) assumes the role of the central coordinator in a patient's healthcare, akin to a "quarterback." It is ideal for the PCP to oversee and manage all aspects of a patient's healthcare requirements, wherever possible. At present, there is a lack of local physicians who have entered into a contractual agreement with BCBSRI to offer telehealth services through doctors online to our members [17]. However, we are utilising the services of board-certified providers who have established a contract with American Well and possess the necessary licensure to practise medicine in the state of Rhode Island. In the coming years, world is ready to accept and develop a comprehensive strategy to initiate the integration of local healthcare professionals with doctors online, with the aim of promoting and strengthening our primary care principles.

Overall, it can be observed that there exists a prevailing sentiment within the medical profession characterised by a simultaneous apprehension and captivation towards the subject matter. There is concern regarding the potential disruption of the physician-patient relationship, juxtaposed with a prevailing intrigue and inquisitiveness surrounding this phenomenon within the context of our technologically advanced era. Could you please provide clarification on the subject matter in question? What is the mechanism behind its functioning? In what ways would it impact my professional endeavours? Are there any technological and workflow obstacles that one must consider, such as the coordination of telehealth appointments with in-person visits, managing billing processes, and ensuring appropriate compensation?

The current state of technology and infrastructure enables physicians to perform the task with relative ease, should they want to do so. The provision of these services to patients can be facilitated by any physician within the local community, provided that they satisfy the stipulations outlined in our telehealth coverage policy. Additionally, any healthcare practitioner is eligible to submit a claim for reimbursement for a telehealth consultation in accordance with our payment policy. Telehealth presents a substantial scope for advancement in the healthcare sector. Ideally, it may be used to enhance comfort and reduce the overall cost of treatment through various well-considered and practical applications. It is imperative to prioritise its utilisation as a means to improve healthcare accessibility rather than solely as a revenue-generating mechanism. Telehealth has the potential to be effectively utilised in order to mitigate or reduce the financial burden associated with emergency department visits. According to claims data from BCBSRI, around 40% of trips to the emergency room are categorised as low-acuity non-emergent (LANE) care visits based on the diagnostic and evaluation and management (E/M) codes. The aforementioned statistic of 40% corresponds to an estimated annual expenditure of around $90 million on avoidable visits to the emergency room, specifically pertaining to ailments such as back pain, signs of influenza, and sinus discomfort. A considerable proportion of these visits could have been effectively managed by telehealth services, so allowing patients to be attended to in their primary care physician's office at a significantly reduced expense and with a shorter duration of time. Furthermore, it is evident that telehealth has clear connections and potential for integrating primary and speciality care, with the overarching objective of minimising inefficiencies, optimising time utilisation, and delivering suitable healthcare at the appropriate moment and in the suitable environment. In an ideal scenario, the primary care physician (PCP) endeavours to effectively diagnose and manage a medical issue. However, prior to making a referral to a specialist, the PCP would employ telehealth as a means to engage in a consultation with the expert, ideally in the presence of the patient. The consultation has the potential to serve two purposes: expediting a subsequent appointment with the specialist or determining the lack of need for such an appointment, contingent upon the specific circumstances.

VII. DATA SECURITY AND PRIVACY IN HEALTH INFORMATICS

Ethics can be characterized as the set of moral rules that dictate an individual's behaviour or guide the actions undertaken within a certain endeavour. According to the Merriam-Webster dictionary, ethics and morality are frequently considered to be synonymous. Medical ethics, which encompasses the principles embodied in the Hippocratic Oath, is commonly understood to be grounded upon four fundamental pillars: There are four key ethical principles that should be upheld in the context of health care procedures. Firstly, autonomy should be respected for both patients and physicians, allowing them to exercise independent thought, intention, and action when making decisions. Secondly, justice necessitates the equitable distribution of burdens and benefits associated with health care procedures, ensuring fairness among all parties involved. Thirdly, beneficence dictates that health care procedures should be provided with the intention of promoting the well-being of the patient. Lastly, non-malfeasance emphasizes that health care procedures should refrain from causing harm to the patient. The field of health informatics demonstrates a clear connection to medical ethics, as it continues to evolve with advancements in biomedical informatics. In the past, EHI primarily focused on the matter of safeguarding data privacy. In the context where a single care provider was responsible for a single patient, the preservation of patient record security and confidentiality mostly relied on the health care practitioner's verbal discretion and the physical safeguards implemented for paper-based medical data. The introduction of electronic health records (EHRs) has given rise to fresh apprehensions over privacy. In the current healthcare landscape, where patients receive care from several providers across various venues, the scope of data privacy concerns has expanded to encompass security and confidentiality issues pertaining to the sharing and interchange of data among the healthcare team members responsible for a particular patient. Furthermore, the application of the Learning Health System (LHS) paradigm, which is a system designed to accumulate knowledge from each patient interaction, might be explored [18]. The incorporation of best practices into the delivery process and the acquisition of new knowledge as an inherent outcome of the delivery experience exemplify health information and data re-use. However, similar to the swift implementation of cloud computing, this technique carries the risk of potential data privacy breaches.

The European Commission has lately raised concerns over the concept of reliable artificial intelligence through the release of Ethics Guidelines. These guidelines propose a series of essential criteria that AI systems must fulfill in order to be considered trustworthy. It is noteworthy that one aspect pertains to the necessity of human agency and oversight, encompassing the concepts of human-in-the-loop, human-on-the-loop, and human-in-command. Additionally, there is a corresponding requirement for transparency, wherein AI systems and their judgments should be elucidated in a manner that is tailored to the relevant stakeholder. The advancement of Explainable AI is necessary in order for healthcare professionals to fulfill their obligation of explaining to patients the reasons behind predictions made by machine learning models, which are often perceived as opaque entities, in accordance with the autonomy principle of medical ethics [19]. An additional concern pertains to the discernment of methods via which a deep learning algorithm incorporates biases related to race, ethnicity, gender, or other factors, so influencing or distorting its outcomes and undermining public trust in the deployment of artificial intelligence systems. Finally, there is a rising apprehension regarding the potential "de-skilling" of medical practitioners that may arise as a consequence of work automation, leading to a decline in their diagnostic precision. The medical field faces several significant challenges related to privacy and data security. These challenges include potential threats to privacy, breaches of confidentiality, inadequate security practices, insufficient patient information, conflicts regarding data sharing and reuse policies, a lack of transparency regarding the effectiveness of healthcare applications, biased algorithms leading to discriminatory outcomes, the need for trustworthy artificial intelligence, and concerns about the re-identification of de-identified data. These issues are of utmost importance as they may deter individuals from seeking medical care or sharing sensitive information with healthcare providers if they lack confidence in the confidentiality of their data. Multiple studies have documented that individuals may choose not to reveal pertinent clinical information to healthcare professionals due to concerns over potential privacy and security threats associated with electronic health records (EHRs), despite the numerous benefits that EHRs offer in terms of enhancing the quality of healthcare delivery. Conversely, the inadequate utilization of digital technology in the provision of patient care, research endeavours, and the establishment of data-driven systems for managing healthcare may potentially give rise to widespread instances of unethical conduct. It is unethical to abstain from reaping benefits derived from AI applications that have the potential to enhance safety, fairness, and wellbeing. In addition, it is worth noting that artificial intelligence (AI) applications possess the capacity to mitigate existing instances of discrimination that arise from human subjectivity [20].

VIII. HEALTH INFORMATICS AND PUBLIC HEALTH

Many major factors have contributed to the expansion of digital health data in the United States (US) and around the world in recent years. The majority of work on the computer data infrastructure in the United States has been done to suit the needs of medical providers for billing health insurance, managing the organisation internally, and reporting to the government. Public health officials have mostly concentrated on developing data systems to track communicable diseases and other events that must be reported. The lack of coordination in data management goals throughout the healthcare spectrum has resulted in the formation of various electronic health data silos. Healthcare practitioners have not prioritised efforts to integrate these data sources in order to improve the health of a certain group of individuals or community. Instead, they regard it as an afterthought. With the exception of a limited number of systems that were very effectively integrated, most clinicians in the United States were less eager and motivated to promote community health applications by linking data across different silos. However, this pattern has shifted in recent years. In select, limited countries, the use of EHR-based surveillance programmes is an early attempt to merge clinical and public data to benefit the health of the community as a whole. In the United States, there has been a shift in this trend, which has been enhanced and made easier by changes in government, incentive alignment, and increased use of protocols and infrastructure for data exchange.

The policies referred to as "value-based" implemented by insurance companies, both commercial and governmental, have initiated a shift in clinical organizations' priorities. Rather of solely focusing on individual patient visits, these organizations are now concentrating on managing bigger populations and enhancing their overall health outcomes, all while ensuring cost efficiency. In recent times, there have been state and federal policies implemented that have brought about an escalation in financial risk-sharing and the establishment of fixed budgets for provider organizations. Consequently, this has compelled clinicians to utilize their digital resources in order to tackle social determinants of health (SDH) [21]. These determinants encompass gaps in care and other non-clinical factors that have the potential to result in expensive tertiary interventions, for which clinicians do not receive any reimbursement. The current prevailing trends have effectively brought medical and public health objectives into unprecedented alignment. Several health information technology (IT) solutions, including health information exchanges (HIEs) and population- or community-level analytics have facilitated the collaboration between health systems and public health departments. This collaboration aims to enhance the management of shared "community" factors and integrate them across various digital platforms. Population health refers to a collection of structured endeavours aimed at evaluating and enhancing the physical and mental health, as well as the overall quality of life, within a specific and delineated group of individuals.

It's important to note that integrating social services and social welfare informatics with health data may be standard in some European countries, but it's a new idea in many places in the United States. Consequently, this article places particular emphasis on the topic of digital solutions aimed at addressing "social determinants" within the context of population health. This focus aligns with the unifying framework presented in Public Health Informatics, which detailed the blending of information and computer sciences into the public health practice, research, and learning. Dixon et al. gave an insight view at public health informatics and applications [22]. Along with the area of precision medicine, there is an emphasis on getting the right treatments to the right people at the right time. The goal is to use advances in technology, especially health information technology, to make it easier to measure the health of a community and put preventive treatments and policies into place. Publications often use monitoring of epidemics and health problems in communities as examples of important cases. Using new tools and analysing large data sets could help find epidemics faster and with more accuracy. This may be achieved through the utilization of laboratory, satellite, and phone data, as well as the monitoring of population mobility patterns. By combining these diverse sources of information, more accurate estimations can be obtained, hence facilitating the prompt detection of epidemics. The utilization of epidemiological models to assess the risk of epidemics within clearly delineated regions can facilitate the strategic allocation of activities aimed at preventing the occurrence and spread of such epidemics. Furthermore, a considerable body of literature exists that showcases several methodologies for optimizing and analyzing online data pertaining to diverse infectious agents, similar to the approach employed by Google Flu. The integration of new digital techniques into the field of classical epidemiology of infectious diseases holds promise for its potential utility in public agencies and the surveillance of several other diseases. Public health informatics encompasses a broad range of study domains, one of which pertains to communication. The utilization of recently developed tools, particularly those accessible over the internet, is expected to yield advantages for the public health informatics community [23]. In order to fulfil this requirement, the field of public health must allocate resources towards enhancing workforce development and capability by means of education and training in the field of informatics [24].

IX. ARTIFICIAL INTELLIGENCE (AI) IN HEALTHCARE

The field of healthcare and biomedical research is being steadily transformed by the advent of artificial intelligence. Within the Aravind Eye Care System in India, a collaborative effort between ophthalmologists and computer scientists is underway to assess and implement an automated image classification system. The primary objective of this system is to efficiently scan a vast number of retinal pictures of diabetes patients. Diabetic retinopathy (DR) has a global prevalence of over 90 million individuals and is a prominent contributor to adult blindness. Fundus photography has been demonstrated as a highly effective technique for monitoring the severity of diabetic retinopathy (DR) and identifying individuals who would derive significant advantages from prompt intervention. Nevertheless, it is worth noting that in numerous regions across the globe, there exists a scarcity of ophthalmologists who possess the capacity to interpret fundus photos and provide necessary follow-up care for every individual afflicted with diabetes [19]. A group of researchers from Google Inc. and affiliated institutions demonstrated that an artificial intelligence (AI) system, after being trained on a large dataset of images, can attain a level of sensitivity and specificity in diagnosing referable DR5 that is comparable to that of physicians. Additionally, the AI system was able to identify previously unknown connections between patterns observed in fundus photographs and risk factors related to cardiovascular health. The integration of artificial intelligence (AI) technology into clinical practice is currently being implemented by a prominent technology company in a network of eye hospitals in India. FDA has also approved technology, invented by the University of Iowa, to diagnose moderate-to-severe diabetic retinopathy (DR) [25]. Artificial intelligence (AI) has had a resurgence in both scientific and public awareness due to the rapid rate at which technology businesses and scientists are announcing new breakthroughs and advancements in this field. When the science-fiction elements and ambitions are removed, artificial intelligence (AI) can be seen as a field within computer science that seeks to comprehend and construct intelligent beings, typically in the form of software programs. The field of artificial intelligence (AI) has a rich and extensive historical background, originating from a seminal conference held at Dartmouth College in 1956, during which the phrase "artificial intelligence" was coined for the first time. The recent comeback of AI has been attributed, in part, to the successful advancement of image classifiers since 2012. Despite significant advancements in recent years, the field of artificial intelligence (AI) has encountered challenges in establishing a clear and definitive definition of what qualifies as "real AI." It is well acknowledged within the field of AI research that achieving a particular performance objective renders that level of performance ineligible for being considered as true AI. Consequently, this phenomenon poses challenges in accurately monitoring advancements in the field. Automated route planners were heralded as exemplars of sophisticated artificial intelligence throughout the 1970s; nevertheless, their prevalence in contemporary society has rendered them so commonplace that the characterization of these systems as AI would elicit surprise from the majority of individuals. As a result, the achievements of artificial intelligence (AI) throughout the period spanning from the 1970s to the 1990s, which were once celebrated as significant advancements in the field of medicine, namely in the automated analysis of electrocardiograms (ECGs) [26], are presently acknowledged as valuable contributions but are not widely recognized as genuine instances of AI. In recent times, there has been a notable expansion in the utilization of medical-image diagnostic systems, which has led to the extension of artificial intelligence (AI) into domains that were traditionally occupied by human experts. The ongoing expansion of this frontier extends to other domains within the field of medicine, including clinical practice, translational medical research, and basic biomedical research. Kun-Hsing Yu *et al*. article centres on the various AI applications that have the potential to enhance or transform clinical practice. Additionally, it outlines the areas where AI has been successfully applied, highlights the potential societal implications that may arise from the development and implementation of biomedical AI systems [27], and proposes potential avenues for future research [19].

X. CHALLENGES AND FUTURE TRENDS IN MEDICAL AND HEALTH INFORMATICS

In the realm of comprehensive analysis, F. Collins proposes the development of innovative methodologies to detect, quantify, and evaluate a diverse array of biomedical data including genetic, genomic, cellular, clinical, behavioural, physiological, and environmental factors [28]. The utilisation of diverse data modalities enables a multifaceted understanding of health issues, as each modality provides unique perspectives. By employing integrative mining techniques on these heterogeneous data sources, a full and holistic understanding of health can be achieved. In recent years, there has been a notable surge in scholarly investigations and endeavours pertaining to artificial intelligence (AI) in the field of healthcare [19]. These endeavours encompass the integration of diverse facets of clinical data, the establishment of connections between biorepositories and clinical data, and the forging of links between pharmaceutical research and development and clinical data. The crucial aspect lies in the integration of knowledge and data, as it serves as the fundamental element in the development of effective artificial intelligence algorithms for healthcare. In comparison to other domains in computer science, including as vision and voice analysis, which typically have access to extensive datasets, the availability and variability of patient data is generally constrained. Moreover, it is important to note that health issues encountered in real-world scenarios tend to exhibit a high degree of complexity. In order to mitigate this issue, it is imperative to incorporate the knowledge and insights of physicians and biologists into the model's learning process, hence preventing the model from excessively fitting the data.

Model Safety We frequently emphasise about the necessity of maintaining the security and privacy of health data, particularly data pertaining to specific patients. As the number of AI models in health grows, we must be aware of the possible security risks posed by those models. One example is an adversarial attack, which is the process of creating data that can confuse machine learning models and lead to poor or even wrong choices. Studies have shown that pollution on transportation signs can readily confuse autonomous driving systems [29]. Sun et al. demonstrated that minor changes in lab values in a patient's EHR can entirely affect a well-trained predictor's mortality prediction [30].

Federated learning is a distributed machine learning approach that enables training of models over multiple decentralised devices or servers while preserving data privacy. Health data is extensively disseminated within and among organisations relevant to health, with each institution potentially being affiliated with a distinct group of stakeholders. In numerous instances, these instructions exhibit a level of sensitivity that precludes their aggregation. From a perspective focused on training models, it is advantageous to possess a greater quantity of diverse data in order to enhance the effectiveness of model training. Federated learning has the potential to provide assistance in addressing this particular difficulty.

According to Konencny et al., federated learning is a machine learning framework that tries to construct a centralised model of high-quality using training data distributed across many clients [31]. These clients' network connections are usually unreliable and have somewhat slow speeds. The development of federated health artificial intelligence (AI) systems is critical and presents considerable obstacles. The model changes will be combined into a short update, which will then be delivered to the cloud via secure connection. Following then, the concentrated updates supplied by diverse users will be combined to improve the model. Throughout the process, all data will be retained solely on local devices, with no individual updates stored in the cloud. As a result, the model will be updated on a regular and secure basis [32].

To summarise, health and information technology partnership is one of the best associations, but only if we are capable of accepting advanced technology while being aware of potential hazards. It is critical for healthcare practitioners to be aware of this potential risk, for artificial intelligence researchers to develop effective defence mechanisms in response to medical adversarial attacks, and for policymakers to consider the potential security risk associated with models when developing new regulatory frameworks.

REFERENCES

[1] Azubuike, Marcel C., and J. E. Ehiri. "Health information systems in developing countries: benefits, problems, and prospects." *The journal of the Royal Society for the Promotion of Health* 119, no. 3 (1999): 180-184.

[2] WHO. "Toolkit on monitoring health systems strengthening: Health information systems." (2008).

[3] Haux, Reinhold. "Medical informatics: past, present, future." *International journal of medical informatics* 79, no. 9 (2010): 599-610.
[4] World Health Organization. "Primary health care, Alma Ata Health for All." *Series. Génova: WHO* (1978).
[5] Brown, Joanne. "The computer in the general practice consultation: a literature review." *Health Informatics Journal* 4, no. 2 (1998): 106-108.
[6] Taylor, William R., Anouch Chahnazarian, Joanne Weinman, Monica Wernette, Jean Roy, Anne R. Pebley, Okwo Bele, and Mambu Ma-Disu. "Mortality and use of health services surveys in rural Zaire." *International Journal of Epidemiology* 22, no. Supplement_1 (1993): S15-S19.
[7] Evans, R. Scott. "Electronic health records: then, now, and in the future." *Yearbook of medical informatics* 25, no. S 01 (2016): S48-S61.
[8] Graber, Mark L., Colene Byrne, and Doug Johnston. "The impact of electronic health records on diagnosis." *Diagnosis* 4, no. 4 (2017): 211-223.
[9] Williams, F., A. Oke, and I. Zachary. "Public health delivery in the information age: the role of informatics and technology." *Perspectives in public health* 139, no. 5 (2019): 236-254.
[10] Bell, Beth P. "Overview, control strategies, and lessons learned in the CDC response to the 2014–2016 Ebola epidemic." *MMWR supplements* 65 (2016).
[11] Kruse, Clemens Scott, Anna Stein, Heather Thomas, and Harmander Kaur. "The use of electronic health records to support population health: a systematic review of the literature." *Journal of medical systems* 42 (2018): 1-16.
[12] Kim, Sira, Eung-Hee Kim, and Hun-Sung Kim. "Physician knowledge base: clinical decision support systems." *Yonsei Medical Journal* 63, no. 1 (2022): 8.
[13] Wasylewicz, A. T. M., and A. M. J. W. Scheepers-Hoeks. "Clinical decision support systems." *Fundamentals of clinical data science* (2019): 153-169.
[14] Kim, Junghee, Young Moon Chae, Sukil Kim, Seung Hee Ho, Hyong Hoi Kim, and Chun Bok Park. "A study on user satisfaction regarding the clinical decision support system (CDSS) for medication." *Healthcare informatics research* 18, no. 1 (2012): 35-43.
[15] Bae, Ye Seul, Kyung Hwan Kim, Sae Won Choi, Taehoon Ko, Chang Wook Jeong, BeLong Cho, Min Sun Kim, and EunKyo Kang. "Information technology–based management of clinically healthy COVID-19 patients: lessons from a living and treatment support center operated by Seoul National University Hospital." *Journal of medical Internet research* 22, no. 6 (2020): e19938.
[16] Kim, Hun-Sung. "Decision-making in artificial intelligence: is it always correct?." *Journal of Korean Medical Science* 35, no. 1 (2020).
[17] Manocchia, Augustine. "Telehealth: Enhancing care through technology." *Rhode Island Medical Journal* 103, no. 1 (2020): 18-20.
[18] Friedman, C. P., J. C. Rubin, and K. J. Sullivan. "Toward an information infrastructure for global health improvement." *Yearbook of medical informatics* 26, no. 01 (2017): 16-23.
[19] Yu, Kun-Hsing, Andrew L. Beam, and Isaac S. Kohane. "Artificial intelligence in healthcare." *Nature biomedical engineering* 2, no. 10 (2018): 719-731.
[20] Sheikh, Aziz, Michael Anderson, Sarah Albala, Barbara Casadei, Bryony Dean Franklin, Mike Richards, David Taylor, Holly Tibble, and Elias Mossialos. "Health information technology and digital innovation for national learning health and care systems." *The Lancet Digital Health* 3, no. 6 (2021): e383-e396.
[21] Adler, Nancy E., M. Maria Glymour, and Jonathan Fielding. "Addressing social determinants of health and health inequalities." *Jama* 316, no. 16 (2016): 1641-1642.
[22] Dixon, Brian E., H. Kharrazi, and H. P. Lehmann. "Public health and epidemiology informatics: recent research and trends in the United States." *Yearbook of medical informatics* 24, no. 01 (2015): 199-206.
[23] Flahault, A., A. Bar-Hen, and N. Paragios. "Public health and epidemiology informatics." *Yearbook of medical informatics* 25, no. 01 (2016): 240-246.
[24] Williams, F., A. Oke, and I. Zachary. "Public health delivery in the information age: the role of informatics and technology." *Perspectives in public health* 139, no. 5 (2019): 236-254.
[25] Abràmoff, Michael D., Philip T. Lavin, Michele Birch, Nilay Shah, and James C. Folk. "Pivotal trial of an autonomous AI-based diagnostic system for detection of diabetic retinopathy in primary care offices." *NPJ digital medicine* 1, no. 1 (2018): 39.
[26] Kundu, Mahantapas, Mita Nasipuri, and Dipak Kumar Basu. "Knowledge-based ECG interpretation: a critical review." *Pattern Recognition* 33, no. 3 (2000): 351-373.
[27] Jiang, Fei, Yong Jiang, Hui Zhi, Yi Dong, Hao Li, Sufeng Ma, Yilong Wang, Qiang Dong, Haipeng Shen, and Yongjun Wang. "Artificial intelligence in healthcare: past, present and future." *Stroke and vascular neurology* 2, no. 4 (2017).

[28] Collins, F. S., and H. A. Varmus. "New initiative on precision medicine N Engl J Med, 372." (2015): 793-795.
[29] Sitawarin, Chawin, Arjun Nitin Bhagoji, Arsalan Mosenia, Mung Chiang, and Prateek Mittal. "Darts: Deceiving autonomous cars with toxic signs." *arXiv preprint arXiv:1802.06430* (2018).
[30] Sun, Mengying, Fengyi Tang, Jinfeng Yi, Fei Wang, and Jiayu Zhou. "Identify susceptible locations in medical records via adversarial attacks on deep predictive models." In *Proceedings of the 24th ACM SIGKDD international conference on knowledge discovery & data mining*, pp. 793-801. 2018.
[31] Konečný, Jakub, H. Brendan McMahan, Felix X. Yu, Peter Richtárik, Ananda Theertha Suresh, and Dave Bacon. "Federated learning: Strategies for improving communication efficiency." *arXiv preprint arXiv:1610.05492* (2016).
[32] Wang, Fei, and Anita Preininger. "AI in health: state of the art, challenges, and future directions." *Yearbook of medical informatics* 28, no. 01 (2019): 016-026.