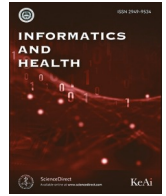


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# Health informatics to enhance the healthcare industry's culture: An extensive analysis of its features, contributions, applications and limitations

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## ABSTRACT

**Background:** Health informatics is a fast-growing area in the healthcare sector. It concerns the technologies, tools, equipment, and procedures required to gather, store, retrieve, and use health data and medical data. Healthcare informatics provides patients, nurses, hospital administrators, physicians, insurance providers, and other stakeholders with electronic access to medical records through health information technologies (HIT). Health informatics combines nursing science with data science and analytical disciplines to gather, handle, interpret, and convey data, bringing together specialists and making health information accessible and meaningful.

**Methods:** This research is an outcome of an extensive scopic review, which has been conducted by identifying research and development through search keywords such as "Health informatics," "Technologies," and "Healthcare" from databases of Scopus, PubMed, Google Scholar, ResearchGate, and other research platforms. Further, the most relevant papers are identified and studied.

**Findings:** This paper explores health informatics, its technologies, and their need in the present healthcare domain. It also identifies vital aspects, characteristics, and versatile contributions of health informatics to the healthcare sector. Further, the paper identifies and discusses significant health informatics applications in the healthcare field. Patients' health information can be effectively analysed individually or in groups using health informatics technologies to meet diverse requirements.

**Interpretation:** Effective use of health informatics improves practice management as information is quickly shared among healthcare professionals, patients and other stakeholders. Healthcare informatics specialists' knowledge of utilising data to assist choice-making and creating best practices. It enables healthcare organisations to identify specific data offering the appropriate information for the given therapy, procedure, or training. Informatics in healthcare also addresses issues at the macro level of the organisation and also at the personal level of patient care via innovative technologies and best practices.

## 1. Introduction

Health informatics is a broad and rapidly developing field that deals with many facets of healthcare. Health informatics, which combines communications, information technology (IT), and health care to enhance patient care, is at the forefront of the medical technological revolution<sup>1-3</sup>. Numerous sectors have undergone fast technological change, and healthcare is no exception. Technology has dominated the healthcare sector to provide patients with better and more effective outcomes, from surgical robotic arms to nanorobots that carry pharmaceuticals through the bloodstream. Automating administrative activities is one use of AI in healthcare<sup>4,5</sup>. It guarantees that critical work is

prioritised by healthcare personnel, allowing physicians, assistants, and nurses to spend less time on routine tasks. Voice-to-text transcriptions may help the administrative side of healthcare. They aid in automating non-patient care duties such as requesting tests, recommending medications, and writing chart notes<sup>6-8</sup>.

Every person has a digital profile that includes information on their background, medical history, allergies, lab test results, and so on. Records are accessible to providers from both the public and private sectors and transmitted via secure information networks. Because each record is composed of a single editable file, physicians may make changes over time without completing additional paperwork or worrying about data replication. Acquiring large amounts of data for medical reasons has

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been costly and time-consuming for years<sup>9–13</sup>. With today's ever-evolving technology, it is now easier not only to collect this data but also to create comprehensive healthcare reports and translate them into relevant vital insights that can be used to deliver better treatment. Electronic Health Records (EHRs) can also provide notifications and reminders when a patient requires a new round of lab work, or they can monitor medicines to ensure that patients are following doctors' orders<sup>14–16</sup>. A "health information system" is any system that uses computer hardware and software to capture, store, manage, and transmit data relevant to people's health or the activities of organisations supporting the healthcare business.

Health professionals could track COVID-19's spread in real time, its alteration under different conditions, and its influence on worldwide economies using cutting-edge data management systems. Massive data sets from many sources, including medical records and individual human activities, are examined to do this. Using big data in healthcare requires several strategies and tools to collect, cleanse, process, and analyse the enormous data available<sup>17–20</sup>. Due to the quantity of information and abilities necessary, it is a challenge for aviators. While data is critical for ensuring patients receive the best possible care, the health industry may also benefit from her operational areas. Big data may also be utilised to optimise the facility, an essential part of providing high-quality care<sup>21–25</sup>. Informatics may be used to avert scenarios by streamlining how medical data is stored and retrieved in electronic healthcare record systems. Using this cutting-edge data storage technology, any healthcare practitioner accessing the electronic database may analyse their patient's medical history in real time<sup>26–28</sup>.

People are used to verbal and tactile modes of communication. In healthcare informatics, people may contact healthcare practitioners through various apps, including the phone, fax, pager, instant messenger, email, etc. Managers must use these health informatics solutions to facilitate their jobs and enhance practice management<sup>29,30</sup>. Time management is practised in the healthcare industry, but health informatics helps organise and streamline processes to ensure speedy completion. Health informatics may help healthcare practitioners manage their time and workload. When health research and technology are directed appropriately, patient health outcomes improve. One of the significant methods for expanding the healthcare industry is to investigate new informatics technologies to improve communication between patients and medical workers<sup>31–33</sup>.

Recognising a patient's medical data is critical for providing high-quality care tailored to each patient's needs. Critical information recorded by earlier doctors, surgeons, and specialists will likely not be available during diagnosis, resulting in potentially incompatible therapy. For instance, if a patient has an allergy to a specific medication, the nurse or doctor's inability to obtain that information before giving that medication could result in an allergic response<sup>34–37</sup>.

The primary research questions of this article are as follows:

**Research Question 1:** - to brief health informatics and its need in the healthcare domain;

**Research Question 2:** - to identify different associated vital aspects and characteristics of health informatics for the healthcare sector;

**Research Question 3:**-to brief the contributions of health informatics in healthcare administration;

**Research Question 4:**-to analyse and discuss significant health informatics applications in healthcare.

This paper is divided into eight major sections and sub-sections. [Section 1](#) provides an introduction, and [Section 2](#) discusses the key aspects and characteristics of health informatics for the healthcare sector. The versatile contributions of health informatics to healthcare administration are discussed in [Section 3](#). Significant applications of health informatics for healthcare are discussed in [Section 4](#). [Section 5](#) provides considerable discussion regarding the study. [Sections 6 and 7](#) discuss the limitations and future scope of health informatics in healthcare; finally, the conclusion is provided in [Section 8](#).

## 1.1. Health Informatics

Health informatics is a speciality field that deals with patient data administration via clinical databases and health information clinical decision support systems. This specialist field includes several specialised subfields, including nursing informatics, clinical informatics, consumer health informatics, public health informatics, etc. The phrase "health informatics" in healthcare refers to IT that may assist the organisation and analysis of health data to enhance healthcare outcomes<sup>38,39</sup>. The primary health informatics technologies are Artificial Intelligence (AI), Internet of Medical Things (IoMT), 3D bioprinting, Telemedicine, Cloud computing, Big data, Nanomedicine, mHealth, IT Systems, Robotics, Augmented (AR)/Virtual Reality (VR), Wearable Technology etc. Healthcare informatics solutions are concerned with the types of resources, tools, and techniques that may be used in medical practice. Several instruments exist, such as computers, communication networks, and medical tech. It gives the patient, nurses, hospital administrators, insurance companies, and health information technologists electronic access to the patient's medical records<sup>40,41</sup>.

## 1.2. Evolution of health informatics and its impact on healthcare

Health informatics encompasses information technology, computer science, and healthcare. Its origins may be seen in the middle of the 20th century when innovators realised how effective computing tools might be for organising medical data. Health informatics first emerged with the emergence of early computing technology in the mid-1900 s. Simple electronic systems first appeared in the 1950 s and 60 s, primarily intended to automate administrative activities like billing and appointment scheduling. Most clinical data eventually began to be stored and retrieved using computer systems and networks, creating the first hospital information systems. It was due to developments in computer science and IT. These information systems are being used in hospitals for various tasks<sup>12,15</sup>.

Healthcare expenditures may be decreased by health informatics by streamlining processes and minimising human mistakes. Predictive analytics may be used to control and foresee health events, lowering emergency hospital admissions. Health informatics is essential for monitoring and managing population health trends, forecasting epidemics, identifying patterns in chronic diseases, and creating preventative care plans<sup>3,19</sup>. Health informatics combines management techniques, IT, and healthcare to maximise data gathering, storage, retrieval, and application in biomedicine and health. It includes all the tools, resources, and techniques needed to enhance data gathering, storing, retrieving, and use in health and medicine. Health informatics makes it simple for different healthcare providers to share patient data, guaranteeing that patients receive consistent care regardless of provider changes<sup>8,21</sup>.

Integrating data mining techniques and intelligent data analytics for clinical and administrative decision-making is the latest emphasis of health informatics. Recent developments in computer science and technology have fueled this tendency by enabling the analysis of large amounts of data using cutting-edge machine learning (ML) techniques, leading to precise estimations and forecasts that may be very helpful when making decisions<sup>5,14</sup>. Predictive algorithms will eventually be included in EHRs in the upcoming years, offering patients advice at the time of care. Patients may access their health information, make appointments, and connect with their healthcare providers using health informatics technologies. As a result, patients are given more authority to manage their health and well-being. This eliminates paper records, which need much storage space and are vulnerable to physical harm<sup>17,18,32</sup>.

## 1.3. Major health informatics technologies and devices

One of the most significant businesses in healthcare and

advancements in this field can potentially treat patients, even uncommon disorders. Technologies are essential because they provide a greater understanding of the human body. Patients and medical professionals can live sustainably and treat even previously incurable illnesses using technology in medical applications<sup>4,42,43</sup>. Table 1 analyses the role of various technologies that enhance the effect of Health informatics.

#### 1.4. Need for health informatics in healthcare

The field of health informatics is expanding much too quickly. It mainly focuses on administering EHRs and their use in clinical settings<sup>42,43,154</sup>. Patients often need care from many healthcare professionals, and Healthcare institutions need access to shared health records; this can be possible with health information systems like health information exchanges (HIEs). Patients with electronic access to their medical records are better informed about the medicines they have already taken and will need to take going forward. Consequently, patients can communicate crucial information with their physicians<sup>155–157</sup>. If patients access their health recommendations and history, they may have more control over their treatment and take their illnesses more seriously. Patients may readily interact with physicians and other healthcare professionals<sup>158–160</sup>. Family members gain from patient access to health records because it gives them access to the patient's health information that they would have otherwise missed. Additionally, patients are more likely to take an active role in their care when they can access their recommendations and medical history<sup>161,162</sup>.

#### 1.5. Goals of research

Informatics integrates information technology with healthcare to improve patient-centred and efficient healthcare. The main goal of health informatics is to use data management and technologies to enhance healthcare support. Improving patient care, streamlining healthcare procedures, and enhancing overall health outcomes entails efficiently organising, analysing, and managing health information. It involves using data management and technology to improve healthcare service delivery and efficiency. The healthcare utilises EHRs to organise, store, and manage patient health data, which enhances patient experience<sup>15,20,22</sup>. The importance of healthcare systems and those working in them has increased in today's big data environment. By employing these technologies, healthcare practitioners may obtain patient data more efficiently, leading to speedier decisions and results for physicians and nurses.

This describes the use and upkeep of IT systems in the healthcare sector. It focuses on using technology, such as health information exchange systems, EHRs, and other technologies that make it easier to store and transmit healthcare data electronically and manage and communicate health information. Health informatics facilitates coordination by integrating medical staff and patient care in the recording, sharing, and distributing records. It ensures that discharge instructions, rehabilitation, and nutrition are connected or interrelated to prevent issues. It allows patients to monitor their health, giving physicians instant access to patient information. During a single visit, patients receive therapy concurrently from several specialists<sup>33,37</sup>.

Community health protection and improvement are the main objectives of public health. Technology may give public health workers sophisticated tools to get precise, comprehensive population data in real-time. They may use this data to develop more functional, practical health strategies that meet various situations, from managing individual care plans to organising support networks that can handle pandemics. Technology includes anything from instruments for data collection to life-saving equipment, so there are many different ways that technology and public health may work together<sup>16,28</sup>. Technology has played a critical role in supporting healthcare innovation and research. Large hospitals use technologies like cloud computing, mobile, and big data to

**Table 1**

- Major technologies and devices of health informatics.

S. No	Technologies and devices	Description	References
1.	Artificial Intelligence	<ul style="list-style-type: none"> <li>AI has several uses in the healthcare industry, including analysing patient data and other sources, creating novel drugs, and enhancing the efficacy of diagnostic tests. AI in the form of ML significantly influences the healthcare industry.</li> <li>Recently, this technique has helped treat the impacts of coronavirus by analysing CT images. AI's new capabilities have made advancements in medical settings possible.</li> <li>Health informatics uses AI and ML to help doctors diagnose patients more accurately and predict which ones may be at high risk. AI also helps to personalise therapy by providing clinicians with more insights into symptom patterns and effective treatment plans.</li> <li>The optimal conditions for AI and ML are found in environments with enormous volumes of unprocessed data, such as those in and out of medical facilities. Doctors may see more patients daily and use their time better with each patient using algorithms and virtual assistants.</li> </ul>	44–50
2.	Information Technology (IT) Systems	<ul style="list-style-type: none"> <li>It provides timely and seamless information portability and optimises the health of individuals and populations globally; interoperability is the ability of different information systems, devices, and applications to access, exchange, integrate, and cooperatively use data in a coordinated manner within and across organisational, regional, and national boundaries</li> <li>Patients would have to find all of their medical records and provide them to new physicians that their medical network shared all of the information.</li> <li>Healthcare practitioners now have access to a patient's medical history and information using health IT systems, even if they are spread across many dissimilar computer systems in various places. Ensuring that medical carers at any medical facility have a comprehensive understanding of a patient's medical history is crucial for maintaining continuity of treatment.</li> </ul>	51–57
3.	mHealth	<ul style="list-style-type: none"> <li>Mobile technology in healthcare, or "mHealth," simplifies medical care and provides a far more convenient patient experience.</li> <li>Patients may now book appointments, interact with healthcare practitioners, monitor their health more effectively, and obtain health information through a growing number of smartphone applications.</li> <li>Technologies that enable remote monitoring of certain medical conditions and equipment also</li> </ul>	58–63

(continued on next page)

Table 1 (continued)

S. No	Technologies and devices	Description	References
4.	Internet of Medical Things (IoMT)	<p>assist clinicians in enhancing patient compliance.</p> <ul style="list-style-type: none"> <li>• Several mobile technology businesses are developing apps that will revolutionise how patients and physicians communicate in the contemporary world.</li> <li>• The collection of internet-connected software and devices is known as the Internet of Medical Things. Medical facilities are crammed with gadgets and overflowing with data, but the IoMT enables communication across all those disparate components, and the effects are already apparent.</li> <li>• By considering nurse proximity, detailed demographics, and more than a dozen other factors to analyse better and service the patients' particular requirements, it does so with greater efficiency and transparency than staff members would.</li> <li>• This network is created by physical items linked to the Internet. Smart medical devices can network with other smart devices nearby to enhance patient outcomes as technology and software advance.</li> </ul>	64-69
5.	Blockchain	<ul style="list-style-type: none"> <li>• Blockchain technology is enhancing data security in several sectors, including medicine. Blockchain is a shared, unchangeable ledger that makes it easier to track assets and record transactions across a network of businesses.</li> <li>• Blockchain is used to improve medical record management and the insurance claim process, accelerate clinical and biomedical research, and advance biomedical and healthcare data ledger.</li> <li>• Patients will be able to manage more aspects of the security of their medical information, including who has access to it, when, and how much. The notion that medical data exchange between institutions and scientists may significantly accelerate the discovery of efficient therapies exacerbates the issue. Blockchain technology provides answers to various problems.</li> <li>• This technology maintains a distributed ledger of enormous volumes of data. It eliminates the intermediary, saves money for both patients and providers and securely maintains data.</li> </ul>	70-76
6.	Cloud & Data Analytics	<ul style="list-style-type: none"> <li>• The cloud and data analytics are emerging as reliable methods for storing and exchanging extensive data because of the abundance of data that health centres receive from wearables, EHRs, and other sources.</li> <li>• Health care can now function and develop more quickly and effectively than ever using data analytics initiatives and cloud computing services. When combined with AI and other technologies, data integration and</li> </ul>	77-83

Table 1 (continued)

S. No	Technologies and devices	Description	References
7.	Robotics	<p>predictive analysis enable extracting pertinent information about patients' situations.</p> <ul style="list-style-type: none"> <li>• The number of data sources healthcare organisations utilise and the volume of healthcare data gathered will grow exponentially. Healthcare providers will search for cutting-edge systems like data fabrics to integrate and handle massive amounts of dispersed and structured data.</li> <li>• The rapid advancement of technology has resulted in an incredible accumulation of healthcare data in recent years. Scientists can find new correlations between population health and factors like economy, ecology, and demography by analysing vast amounts of anonymised data. These data arrays can also identify medical patterns and trends in healthcare IT.</li> <li>• Robotics is becoming more prevalent in facility maintenance and care management due to AI and ML's improved capabilities.</li> <li>• Robust AI-capable robotics provide delivery and transportation assistance and surgical helpers. Robotic surgery heals more quickly, is less invasive, more accurate, and less prone to infection.</li> <li>• Now, brain lesions may be explored by image-guided robots without causing harm to the surrounding tissue. They can accurately mould a bone to suit a prosthesis more precisely than a person could.</li> <li>• As AR and VR technologies advance, technology may expand beyond essential virtual examinations to a wide range of remotely conducted medical treatments, including whole surgical operations assisted by robotics.</li> </ul>	84-89
8.	Telemedicine	<ul style="list-style-type: none"> <li>• Telemedicine involves virtual patient-physician contact. Patients no longer need to travel to a doctor's office or clinic since telemedicine allows doctors to view and treat patients via video conference.</li> <li>• A significant advancement in telemedicine occurred during the COVID-19 pandemic. The development of wearable technology, mobile internet penetration, and video conferencing capabilities has made telehealth one of the significant medical technology trends.</li> <li>• A mobile gadget with a two-way camera allows carers to interact one-on-one with patients when they are apart. Most of these patients live in remote locations or require assistance finding a way to go to a medical institution.</li> <li>• Wearable technology and other health monitors may measure blood pressure, oxygenation, and heart rate. Supplements with web and app capabilities can limit patient requests appropriately,</li> </ul>	90-95

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Table 1 (continued)

S. No	Technologies and devices	Description	References
9.	Nanomedicine	<p>saving patients and doctors valuable time and effort. Routine telehealth consultations have the potential to save lives and reduce the risk of contracting other diseases.</p> <ul style="list-style-type: none"> <li>• Nanomedicine uses nanoparticles, nanoobjects, such as nanorobots, or any other nanoscale substance in the medical field.</li> <li>• Nanomedicine is one of the future most promising areas of medicine.</li> <li>• It is beneficial for treating cancer and injecting specific drugs with nanotechnology functions at the atomic, molecular, or supramolecular scales.</li> <li>• Nanomedicine has applications in imaging, sensing, diagnostics, and distribution through medical devices, and its potential is enormous for something so small.</li> </ul>	96-101
10.	Automated medical coding	<ul style="list-style-type: none"> <li>• Healthcare services, treatments, and diagnoses entered into electronic EHRs are given standardised codes via automated medical coding.</li> <li>• It ensures correctness and consistency while saving time and lowering mistakes related to manual coding. The programme extracts important data from lab results, clinical notes, and other sources using ML and natural language processing techniques.</li> <li>• Over the past few years, several new technologies have been developed, and patients now have more tools to enhance their mental health between consultations. Even if most assessments and first treatments may still require the assistance of a physician, the aforementioned digital therapies are especially well-suited to offering continuous, high-quality mental health treatment.</li> </ul>	102-105
11.	Electronic Health Records	<ul style="list-style-type: none"> <li>• Electronic Health Records, which are digital records of a patient's medical history, guarantee that clinicians are diagnosing and treating patients based on a comprehensive picture of their past and present health, improving continuity of care for patients and improving results.</li> <li>• EHRs have also decreased healthcare inequities, enhanced provider-to-provider care coordination, and expedited telehealth and e-prescribing procedures.</li> <li>• EHRs are helping doctors organise patient care, guarantee accuracy in a digitally linked world, and give patients greater autonomy to advocate for themselves. They have immediate access to whatever health history information they require.</li> <li>• Patients may view their test results and medical information and connect with their primary care physician using patient portals offered by many clinics and hospitals.</li> </ul>	106-111

Table 1 (continued)

S. No	Technologies and devices	Description	References
12.	5 G-enabled devices	<ul style="list-style-type: none"> <li>• AI, IoT, and Big Data need a dependable and lightning-fast internet connection to realise their full potential in the healthcare industry.</li> <li>• Telemedicine allows people to access treatment; a dependable real-time link will immediately benefit it. An advanced healthcare system might be possible with more authentic data streams and linked gadgets.</li> <li>• 5 G-connected sensors and medical equipment can gather and transfer data instantaneously with next-to-zero latency.</li> <li>• This will lead to better patient outcomes through improved patient monitoring. Researchers are already analysing the advantages of combining robots, 5 G, and healthcare. 5 G-enabled gadgets will quickly usher in a new healthcare. Patients will not have to wait long to see a difference.</li> </ul>	112-117
13.	Virtual reality and augmented reality	<ul style="list-style-type: none"> <li>• These technologies have several applications in the medical field. These technologies enable multiple connections between the digital and physical worlds.</li> <li>• VR has applications in physical treatment, such as treating phobias and emotional trauma. Physicians may see into patients' bodies by superimposing 3D scan data on AR glasses. Healthcare workers benefit from VR and AR in numerous ways, from aiding operations to mentoring upcoming professionals.</li> <li>• With the help of VR and AR technology, surgeons can operate more precisely while using both hands. While doing surgery, other medical professionals can wear the VR lens and offer insightful advice.</li> <li>• Medical education has found a natural home for simulated and hybrid environments, which provide simulation training that complements and enriches traditional classroom settings. VR has applications in physical therapy for the treatment of complicated limb injuries.</li> </ul>	118-123
14.	Wearables devices	<ul style="list-style-type: none"> <li>• Wearables are electronic devices that can be integrated into clothes, worn as an accessory, implanted in the body, or tattooed on the skin.</li> <li>• Smartwatches give information on blood vitals, blood oxygen saturation, and heart rate, making it possible to check a patient's status remotely. Additionally, wearables like pedometers and other sensors can gauge a patient's physical health.</li> <li>• Smart hearing aids and biopatch technology are two more wearables that enhance medical diagnosis of a patient's condition in addition to smartwatches. Beyond electronic patient records, wearables provide an additional means of data collection, prevention, and better health outcomes for users.</li> </ul>	124-129

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Table 1 (continued)

S. No	Technologies and devices	Description	References
15.	3D bioprinting	<ul style="list-style-type: none"> <li>Wearables' capacity to notify users and their physicians of unexpected medical problems is a valuable feature. Wearables gather data in real time, which a system combines and examines to inform physicians of a problem with their patients. This enables medical professionals to take the initiative and get in touch with individuals who might not even be aware that they require emergency care.</li> <li>3D bioprinting is a cutting-edge technology used in organ transplantation. It involves building a three-dimensional structure using biological material.</li> <li>This technology aims to print organs that can be safely transplanted into people. This might address the lack of donor organs and the problem of organ rejection.</li> <li>One of the exciting features of bioprinting is the potential to fabricate these organs using a patient's cells. With this technology, rejection after a transplant might be considerably decreased.</li> <li>Although this cutting-edge medical development is still in its early stages, it has the potential to produce medications, prosthetic limbs, and even human tissue and organs.</li> </ul>	130-135
16.	Digital twin	<ul style="list-style-type: none"> <li>By linking things in computer-generated virtual settings with real-world surroundings, mixed reality allows the interaction of both sorts of objects simultaneously, known as digital twins.</li> <li>Digital twin technology eliminates the need to build a physical prototype or sample for laboratory testing. Alternatively, medical engineers can create a virtual model of an object that is physically and geometrically exact and then test it in a virtual environment.</li> <li>This strategy can also be helpful for medical practitioners when using remotely managed healthcare equipment to do distant procedures such as remote surgery. The digital twin approach can reduce the time and expense of creating sophisticated medical devices, anticipate and address their shortcomings, and enhance the time-to-market measure.</li> </ul>	136-142
17.	Precision medicine	<ul style="list-style-type: none"> <li>Personalised medicine, precision medicine, is a cutting-edge approach to illness prevention and treatment that considers each person's genetic composition, lifestyle, and environment.</li> <li>With this method, medical professionals and researchers may more precisely forecast which preventative and treatment measures will be effective for a specific illness within a given population.</li> <li>It stands in contrast to a one-size-fits-all strategy, in which methods</li> </ul>	143-148

Table 1 (continued)

S. No	Technologies and devices	Description	References
18.	ChatGPT	<p>for preventing and treating disease are created for the typical person without considering the wide range of genetic and environmental differences between people.</p> <ul style="list-style-type: none"> <li>People can benefit from precision medicine by receiving individualised care that may improve their health. It can identify people who may be more susceptible to particular diseases because of their genetic makeup, opening the door to early treatments or preventive measures.</li> <li>ChatGPT is a highly useful chatbot that can help to book appointments, provide information about common medical problems, and respond to non-medical general patient concerns. Getting access to healthcare is a significant problem in many countries.</li> <li>ChatGPT not only makes medical professionals' days easier, but it also benefits patients and administrative workers.</li> <li>The most significant impediments to accessing healthcare are the need for knowledge and language problems. By offering language translation services and facilitating language-impaired people's access to medical information, here ChatGPT can assist in removing various obstacles.</li> <li>ChatGPT can provide medical advice and information to patients in underserved or distant locations with little access to healthcare resources.</li> <li>By responding to commonly requested inquiries, classifying patients, and setting up appointments, ChatGPT can also help patients have shorter wait times. Patients would have better access to care, and healthcare workers would be less stressed.</li> </ul>	149-153

increase communication between researchers, healthcare practitioners, and patients to improve the results of clinical trials and research<sup>33,41</sup>.

In the modern world, technology influences every facet of healthcare and the infrastructure supporting it while tackling underlying issues with how healthcare is understood, provided, and accessible. A new era of medicine and patient care is ushered in by the revolutionary changes brought about by advancements in healthcare technology<sup>154,156</sup>. The consumerisation of healthcare, where information systems and technology are used to enhance hospital efficiency and patient outcomes, is the result of technology and the digitisation of healthcare. Hospitals can organise their resources, inventory, register patients and information, manage finances and accounting, manage assets, manage the entire healthcare network, and perform auxiliary duties effectively when they use technology. This increases resource efficiency, helps eliminate pointless procedures, and eventually boosts hospital productivity<sup>35,160</sup>.

**2. Different associated key aspects and characteristics of health informatics for the healthcare sector**

Various vital aspects associated with health informatics are illustrated in Fig. 1. The reflection of these aspects has been explored in two

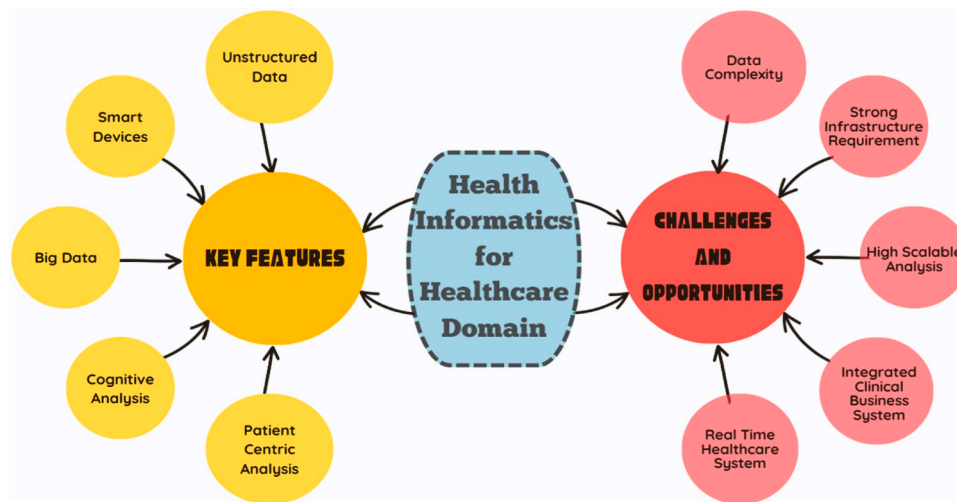


Fig. 1. Key Features, Challenges & Opportunities with Health Informatics in healthcare domain.

segments, i.e. the first is related to the various key features, and the second is about the challenges and opportunities for the healthcare sector. These smart pillars and critical aspects of health informatics are explored in terms of structured data, the use of smart devices, big data, cognitive analysis, etc. In contrast, the related facts with challenges and opportunities are described as the complexity of data, highly scalable analysis, infrastructure requirements, real-time healthcare system, etc<sup>163–165</sup>.

In its broadest sense, informatics is a subfield of computer science that examines how people utilise technology. It explores how data and technology affect people and emerging applications for digital technology and information-driven technology<sup>166–169</sup>. Businesses, hospitals, and other care providers are among the entities that work together to offer care to people. All of the facilities in this network must be able to interact with one another. They must be able to communicate data safely, quickly, and securely. Staff, nurses, and physicians must pool their knowledge, abilities, and experience to provide appropriate care to each patient and enhance their techniques and processes. Health informatics professionals investigate the efficacy and efficiency of all care facilities<sup>170–174</sup>.

The use of technology like ML by health informaticians to do predictive analytics about the risk of certain illnesses striking both individual individuals and larger patient groups, as well as about the prognosis for treatment, is growing. EHRs are gathered into clinical big data, which is then utilised to innovate<sup>175–178</sup>. Thus, practice-based medicine and the evidence-based approach presently used in medicine should be combined to improve patient outcomes. Informatics' initial focus was on standardising electronic communication protocols to make it easier for departments to communicate data. Today, patients may consult with doctors from anywhere using data-driven telemedicine systems, virtual healthcare platforms, and linked vital sign monitoring technology<sup>179–182</sup>.

Informatics is described by the Healthcare Information and Administration Systems Society as "the integration of health care sciences, computer science, information science, and cognitive science to assist in the management of health care information." Research on the social effects of computerisation and how IT influences how society views these systems is a part of social informatics<sup>183–186</sup>. Students who study social informatics could ultimately effect more significant change than those in other disciplines since it is based on much more research and theory than other fields<sup>187,188</sup>. Computer systems and the programs that run on them must be maintained to support health information technology (HIT). Health informatics focuses on utilising these programmes to improve patient outcomes and comprehend trends and perspectives in the healthcare industry<sup>189–193</sup>.

Informatics is employed by government and nonprofit health managers to make data-driven choices concerning public health policies and programmes, such as clinical data registries and chronic disease prevention. Thus, biomedical informatics interprets numerous biological systems to link clinical research with real-world healthcare applications and focuses on exchanging and using biomedical data. It divides the discipline from adjacent fields like biomedicine and mentions the study of data<sup>194–197</sup>. Problems with biomedical informatics are challenging when dealing with hard-to-capture ideas. Instead of focusing simply on computer applications in biomedicine, this informatics research, education, and service approach emphasises biological information as data plus meaning. By combining health informatics with other cutting-edge technology, the healthcare system can adequately handle this data and provide its patients with specialised treatment<sup>198–202</sup>.

Bioinformatics uses computing and analytics to collect and analyse biological data. Biological data and amino acid sequences are the main emphasis of this branch of biology and computer science, which focuses on collecting, storing, analysing, and exchanging biological data. Computer programs are used in bioinformatics to study the roles of genes and proteins, infer evolutionary links, and predict protein structure, among many other things. The generation, storage, sharing, and consumption of healthcare data are all being altered by cloud computing<sup>203–205</sup>. Today, healthcare providers use this technology effectively to increase productivity, streamline processes, save costs, and deliver individualised treatment to enhance results. The healthcare sector benefits from cloud computing in two ways: First, it lowers operating costs for hospitals, physicians, and other medical professionals by improving network and storage capacities while providing scalability<sup>206–209</sup>. On the other hand, providing patients with high-quality, individualised treatment makes it possible.

In the age of big data, the relevance of healthcare systems and the people who work in them has grown. When using these platforms, healthcare personnel have easier access to patient information, allowing physicians and nurses to make choices and accomplish results more swiftly. By communicating, these health professionals function as a link between the realms of IT and policy<sup>210–213</sup>. They are a great asset in healthcare organisations because of their grasp of people, medicine, and HIT. This focuses on data science and preventative wellness to shield whole populations from illnesses, accidents, and other medical issues. The experts use IT to support public health research, monitor health trends, and make data-driven choices to address public health issues<sup>214–217</sup>.

### 3. Versatile contributions of health informatics in healthcare administration

Fig. 2 highlights the several quality contributions of health informatics towards strengthening the healthcare sector. These several contributions have been revealed to provide an extraordinarily supportive and progressive environment to ensure the healthy growth of health informatics conceptualisation<sup>218–220</sup>. It includes various significant contributions, namely healthcare mobility issues, assurance, policy-making aspects to ensure highly efficient policy and resources, smart care of patients through improved diagnosis and data integration, etc. Effective communication and coordination provide the highest calibre of services to the healthcare industry<sup>221–224</sup>.

The healthcare industry depends on information. Information must be accurate, relevant, and come from a reputable source. Healthcare professionals may connect worldwide while seated in their offices through computerised information and surveillance systems. However, new developments and opportunities to go above and beyond what is necessary are discovered daily. Healthcare-related technology has never been more sophisticated<sup>225–227</sup>. Hospitals deal with obsolete hardware, outdated operating systems, and networks in addition to popular electronic health record systems, medical practice management software, or patient data management systems. Significant security issues exist when managing and combining outdated technologies with contemporary systems<sup>228–233</sup>.

Nowadays, many healthcare providers use EHRs to digitise patient data. The patient's immunisations, treatment regimen, pharmaceutical regimen, test findings, and medical imaging may be updated in real-time in these digital health records. This encourages more professional cooperation and makes information more easily accessible to patients. Biomedical and health research are the main areas of concentration for research informatics<sup>234–236</sup>. Experts put computer science innovations to use to speed up medical research and subsequently enhance patient outcomes. They utilise their results to suggest adjustments to their organisation's processes and practices to improve patient care<sup>237,238</sup>. For instance, a clinical informatics analyst would try to lower the proportion of surgical patients who must be readmitted to the hospital. Because there are so many aspects of healthcare informatics, practitioners may be working on enhancing current technologies, developing new ones,

doing research, or analysing data, to mention a few.

The specialisation of biomedical informatics, called bioinformatics, focuses on medical treatment at the cellular, molecular, and genetic levels. It employs innovations in data science, AI, and related fields to look for new treatments for illnesses<sup>239–242</sup>. The EHR has made it possible for doctors to transmit essential patient data. Doctors can provide better, quicker care and spend more time with their patients because of the immediate access to and interchange of medical information. Critical health information may also be shared between the doctor and the chemist in the chain of care. Because everyone on a coordinated care team has access to the same information, they can work more efficiently, arrive at better diagnoses, and make fewer errors<sup>243–246</sup>.

A health information system (HIS) is designed to manage healthcare data. This includes systems that gather, store, maintain, and transmit a patient's electronic medical record, as well as technologies that assist the creation of healthcare policy. Medical treatment is often expensive and sometimes resource-intensive, one of the most prevalent concerns of consumers and doctors<sup>247–249</sup>. Much money is lost on recurrent procedures when a patient sees many physicians who must be made aware of past prescriptions and treatments. Patients often need to be made aware of the tests they are undergoing or the purpose behind them. They trust their doctor to make the right choices. Health information systems may comprise systems that manage data related to the operations of providers and healthcare organisations. These might improve research, patient outcomes, policy, and decision-making<sup>250–253</sup>.

The healthcare industry is constantly producing data. Health information systems gather, integrate, and analyse health data to manage population health and reduce healthcare expenditures. The analysis of healthcare data could improve patient care. An electronic medical record replaces the paper version of a patient's medical history. The EHR contains more health information, test results, and treatments. It is also designed to communicate data with other EHRs so other healthcare practitioners can view a patient's medical information<sup>254–257</sup>. Health information systems may gather patient data, evaluate it, and identify demographic trends. Clinical decision support systems may leverage big data to help diagnose and treat individual patients. The exchange of healthcare data via digital networks enhances efficiency and reduces costs. When regional marketplaces use health information exchanges to

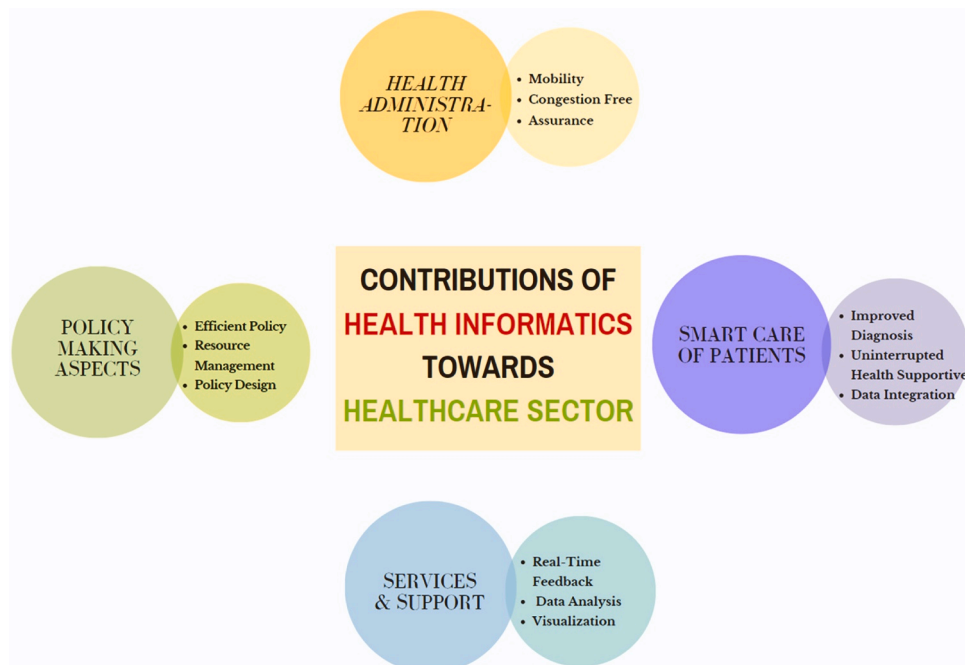


Fig. 2. Capabilities of Health Informatics in Smart Care and Policy Making for the Healthcare Domain.

share data, healthcare providers experience decreased prices. On a smaller scale, hospitals employ EHRs to save money<sup>258–261</sup>.

Researchers, clinicians, hospital administrators, and insurance executives are responsible for data analytics in various healthcare contexts. Healthcare professionals can work directly with new analytics tools that feature graphical interfaces for people without analytics experience and collaborate with specialists knowledgeable in the application of complicated data analytics methodologies<sup>262–266</sup>. Internal working techniques and organisational structure of healthcare providers substantially impact the quality of therapy patients get and the likelihood of effective patient outcomes<sup>267,268</sup>. To effectively evaluate the influence of process and organisational changes on outcomes and operational efficiency, healthcare providers must be able to obtain and interpret data relevant to these processes and structures in complex healthcare environments. For many years, informatists have significantly influenced clinical decision support, where analytics have significantly changed treatment pathways to yield improved patient outcomes<sup>269–274</sup>.

#### 4. Health informatics applications in healthcare

Health informatics is a large group of multidisciplinary sciences investigating the design, development, and use of computers and advanced technologies to improve healthcare. It combines medical and computing fields, particularly computer engineering, software engineering, information engineering, bioinformatics, data science, information technology, bio-inspired computing, theoretical computer science, information systems, autonomic computing, and behavioural informatics<sup>275–282</sup>. The purpose of the scientific and technical field is to analyse patient data that might come from various sources and modalities, such as EHRs, diagnostic test results, and medical scans. Computational approaches may tackle various health-related problems<sup>283–286</sup>. The most common use of classical ML in healthcare is to estimate which treatment regimens are likely to be effective on a patient based on a range of patient attributes and the treatment environment. The use of automated techniques, tools, or systems to acquire, process, and store data gathered from a source, such as optical scanners, bar code readers, or magnetic stripe readers, is known as data automation<sup>287–295</sup>. Table 2 provides significant applications of Health Informatics in Healthcare.

Health informatics encompasses various tactics for improving healthcare and lowering the cost of high-quality healthcare. In the healthcare industry, patient health informatics were formerly organised, stored, and analysed by hand using paper-based approaches. It is where information technology comes into play, rapidly developing and infiltrating the healthcare business. Healthcare providers and organisations may now store patient data securely on cloud-based systems. Health informatics combines information technology and health<sup>296–300</sup>. This includes digital capturing, storing, retrieving, and displaying data so that healthcare professionals and patients may make informed decisions. It is an example of modern healthcare that integrates healthcare, communications, and healthcare information technology to improve patient care quality and security<sup>301–304</sup>. Healthcare operations include a variety of administrative responsibilities, such as arranging appointments and invoicing for services, which are made more accessible by health informatics' use of automation and data security<sup>305–307</sup>. Health practitioners may turn data into valuable insights using technology that links, integrates, aggregates, and harmonises massive amounts of data from several sources that can be shared and accessed across conventionally distinct systems<sup>308–312</sup>.

Health informatics studies how medical professionals and patients may access and use patient data and other information through an electronic system that stores it. Patients can access pertinent health information for clinicians inside the healthcare informatics technology system<sup>313–316</sup>. The patients or other clinicians may get treatment information from healthcare practitioners who are authorised to do so. Important information supplied by either side is made accessible by the

**Table 2**

- Significant applications of health informatics in healthcare.

S. No	Applications	Description	References
1.	Managing health data	<ul style="list-style-type: none"> <li>Health informatics obtains, evaluates, and manages health data and applies medical ideas to HIT systems to aid physicians in providing better care. This is facilitated by increasing computing power, data processing speed, and higher data security standards.</li> <li>Health informatics will evolve as standards, technology, and patient information rights are accepted. Patients may now visit with a specialist at their primary care physician's office rather than having to travel hundreds of miles in the past.</li> <li>All physicians participating in the patient's treatment may rely on informatics specialists to share all pertinent data with all the relevant parties. People may also benefit from quicker access to the necessary care. Shorter wait times are connected with higher investments in health-focused IT, and interestingly, non-white patients see a more significant decrease in wait times than white patients.</li> <li>Due to widespread data collection and analysis, medicines for specific individuals are evolving, expanding the scope of research for difficult-to-treat disorders.</li> </ul>	3,25,30,82
2.	Direct patient care	<ul style="list-style-type: none"> <li>Clinical informatics is employed in direct patient care by giving doctors, nurses, physical therapists, home health aides, and other carers access to data that may be utilised to create a care plan.</li> <li>Clinical informaticists provide data analysis or assist physicians in retrieving medical pictures or data. Several non-clinical positions in medicine and medical research have measurable effects on patients. Whether they deal with clinical data or not, informatics experts play a significant behind-the-scenes role in improving patient outcomes. While some informatics specialists operate in clinical settings with patient or administrative data, others are employed by health IT vendors, consultancies, health insurance providers, and pharmaceutical corporations.</li> <li>Biological data from patient groups or individuals are collected and analysed through biomedical informatics or clinical informatics. Aside from that, online forms may be used to gather information regarding the customer's information, requirements, inquiries, and complaints rather than recording customer comments</li> </ul>	57,104,157,171,208

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Table 2 (continued)

S. No	Applications	Description	References
3.	Telehealth	<p>and complaints over the phone or sifting through emails. Online forms may help in data collection in place of independent research.</p> <ul style="list-style-type: none"> <li>• Telehealth offers medical services and knowledge through electronic communication and information technology. Remote admissions, long-distance patient and doctor connection, care, advice, and reminders are possible. The word "telemedicine" is sometimes used synonymously or in a limited sense to refer to remote healthcare services such as diagnosis and monitoring. Remote monitoring, often known as self-monitoring or testing, allows medical practitioners to observe patients remotely using various technology devices.</li> <li>• This strategy has significant applications in managing chronic diseases or specific conditions such as heart disease, diabetes mellitus, or asthma. Healthcare automation using cloud-based informatics streamlines medical procedures, such as scheduling and invoicing. Due to better diagnosis and simple access to patient data, healthcare efficiency also rises. Patients may follow their symptoms and prescriptions by logging into their electronic medical records. Nursing informatics raises patient engagement by encouraging patients to participate actively in treatment plans.</li> <li>• Health informatics enables practitioners to access the appropriate data for clinical decision-making. It provides clinical decision support to build knowledge and informational assistance. This allows healthcare professionals to consider safety, treatment alternatives, and education before judging patient care.</li> </ul>	188,240,263
4.	Understand and comprehend healthcare data.	<ul style="list-style-type: none"> <li>• AI and ML algorithms are used to assess, understand, and grasp complicated medical and healthcare data in human-like ways. AI mainly refers to the ability of computer systems to approximate conclusions based only on input data. AI applications include treatment protocol development, pharmaceutical development, personalised medicine, patient monitoring, and patient care.</li> <li>• Healthcare organisations use health informatics systems to prioritise clinical efforts to reduce medical mistakes. Clinical informatics may assist in managing diagnostic data</li> </ul>	216,222,241, 262

Table 2 (continued)

S. No	Applications	Description	References
		<p>and recommending the best prescription medications.</p> <ul style="list-style-type: none"> <li>• Digital systems are used in healthcare informatics to record and analyse diagnoses, and these systems may prevent inaccurately obtained data or incorrect diagnoses resulting from misread lab results. Using bar-coded and automated pharmaceutical distribution systems also lowers medication mistakes.</li> <li>• Healthcare workers worldwide strive to enhance patient health outcomes while decreasing costs. Users may now quickly access a patient's cardiovascular system. The enterprise's disparate healthcare systems are linked via health informatics to enable rapid data interchange and decision-making.</li> <li>• Due to the health informatics sector, web-enabled cardiovascular imaging and information management solutions are becoming more readily available.</li> </ul>	
5.	Health management	<ul style="list-style-type: none"> <li>• Experts in health data analytics who can monitor and analyse health informatics data are becoming increasingly valuable for healthcare systems' population health management projects, which are used to monitor and improve the health of people with chronic conditions such as diabetes, hypertension, and obesity.</li> <li>• This type of health informatics software aims to improve the management of healthcare institutions and organisations. Apps for hospital management ensure that businesses function correctly and that various interconnected components are handled. The move from paper-based to electronic health informatics systems has effectively linked several health networks.</li> <li>• Future advancements in health informatics will simplify data analysis through dashboard customisation and visualisation. This will consider how long it takes for patients to receive procedures and therapies. Healthcare analytics will make the area of health informatics easier when it comes to processing large amounts of data and employing computer models.</li> <li>• Nursing informatics will soon include robust data analytics that can swiftly examine enormous volumes of data. It collects patient information from several places, including hospitals and social services. Public health informatics</li> </ul>	6,42,51,165

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Table 2 (continued)

S. No	Applications	Description	References
6.	Address issues of medical images.	<p>reduces the causes of illness and mortality and fosters a healthy community through outreach, education, and policies that reduce health concerns.</p> <ul style="list-style-type: none"> <li>• Medical image computing and imaging informatics create computational and mathematical techniques to address issues relating to the use of medical images in clinical treatment and biological research. These domains aim to derive knowledge or information that is therapeutically relevant from computer analyses of medical pictures. Where healthcare practitioners emphasise incorporating it into their care delivery, patient-centred care is becoming increasingly important. It all comes down to putting the patient at the centre of healthcare and giving them a say in treating them.</li> <li>• Health informatics may assist doctors in delivering patient-centric care by providing important health information and encouraging people to participate in their care. Medical professionals may use health informatics tools to discuss difficult issues and provide integrated care.</li> <li>• Patients may also view their reports and health information to understand their therapy. Through patient portals, doctors and patients may consult and make choices about treatment together. Health informatics ensures that data is controlled, standardised, and updated as necessary.</li> <li>• Private practices and hospitals may more effectively market their services to the public using health informatics. For instance, hospitals may raise awareness of a new development in healthcare. Several practices employ social media sites to communicate with health informatics. They use films, photos, and educational information to advertise patient services and improve patient results.</li> </ul>	242,244,264
7.	Patient education programmes	<ul style="list-style-type: none"> <li>• Patients may take better care of themselves outside of medical settings using data-driven wearables and patient education programmes, which can improve patient-provider relationships and results. Several reasonably priced consumer-grade gadgets enable people to participate more actively in health care.</li> <li>• Consumer informatics apps have been developed to assist patients in self-care, and research has demonstrated that</li> </ul>	14,121,183,212

Table 2 (continued)

S. No	Applications	Description	References
		<p>these and other software programs may enhance clinical results. Health informatics experts gather, communicate, and use data and clinical knowledge to aid healthcare practitioners.</p> <ul style="list-style-type: none"> <li>• They collect, store, and retrieve records required for patient diagnosis and treatment, and they guarantee that professionals may use cutting-edge technology to deliver improved patient care. Health informatics combines several academic fields and uses technology and data to enhance patient outcomes. Because of informatics, hospitals, clinics, doctor's offices, and other healthcare organisations may now provide patient-centred treatment.</li> <li>• Health informatics contributes considerably to the fight for healthcare reform by collecting, preserving, retrieving, and exploiting medical data. Experts in health informatics focus on the methods, techniques, and resources required to optimise the collection, archiving, retrieval, interpretation, and use of information in health and biomedicine.</li> <li>• Health informatics technology increasingly improves patient health and healthcare workers' jobs. While several technologies have been proposed or are in use, the healthcare sector still requires more health informatics people to implement advancements properly.</li> </ul>	
8.	Enhance public health outcomes.	<ul style="list-style-type: none"> <li>• Population health informatics utilises computer science, information science, and population health data to guide public health activities and enhance public health outcomes. Analysing data in a multidisciplinary setting is more likely to result in long-lasting improvements in healthcare that are advantageous to organisations, physicians, and patients.</li> <li>• Healthcare is being transformed by innovations created via cooperation between the healthcare team's clinical, operational, technological, and financial members. These innovations result in better patient experiences, better results, and more affordable treatment. This area of healthcare focuses on building communication protocols, enabling physicians and other healthcare workers to have rapid, simple, and effective access to medical records. It</li> </ul>	108,242,285

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Table 2 (continued)

S. No	Applications	Description	References
9.	Best treatment options	<p>also creates places to keep private health information.</p> <ul style="list-style-type: none"> <li>Health informatics is a developing discipline that intends to revolutionise the healthcare sector by speeding up data processing and disseminating insightful information across the healthcare system. It refers to collecting, storing, and retrieving medical data to promote the best cooperation between patients and healthcare professionals.</li> <li>Assessing the information gathered by EHRs will give the best treatment options and help create a healthy population. The overall goal of determining the best course of treatment for each patient is only tangential to whether or not this data is coupled with financial data to examine cost-effectiveness. Because of longer lifespans, treatment models have evolved, and many of these changes are primarily the consequence of data.</li> <li>Doctors strive to understand as much as they can about patients as early in their lives as possible since treating any disease at an early stage is significantly more straightforward and less expensive. This enables them to detect early warning signs of serious illness.</li> <li>Medical specialists may evaluate enormous amounts of data on patient treatment regimens and recovery rates to uncover patterns and therapies with the highest success rates in the real world. As a result, many businesses have begun using analytics to identify changes in network traffic or any other activity that might suggest a cyber-attack and aid in preventing security risks.</li> <li>Big data has inherent security concerns; many feel it would make businesses even more vulnerable. Healthcare Internet business intelligence attempts to help physicians make data-driven decisions more rapidly and improve patient care. This is especially beneficial for patients with complicated medical histories and several ailments.</li> </ul>	17,22,129
10.	Stores patient's medical history digitally	<ul style="list-style-type: none"> <li>Health informatics digitally saves a patient's medical history from retrieving it instantly from any smart device. Medical informatics uses information and communication technology in healthcare through software. Through data-driven genetic information analysis and patient-reactionary predictions, big data analytics in healthcare</li> </ul>	106,111,300

Table 2 (continued)

S. No	Applications	Description	References
11.	Maintaining the privacy and confidentiality of the patient	<p>may also be critical in developing groundbreaking new drugs and cutting-edge therapies. Analytics in healthcare may be used to improve procedures, innovate, offer security, and save lives.</p> <ul style="list-style-type: none"> <li>Healthcare analytics ensures that the medical sector has a bright and adventurous future. The use of big data in healthcare has the potential to aid in the creation of new therapies and medications. Healthcare practitioners may discover potential advantages and downsides in trials or treatments using a mixture of historical, real-time, and expected measures and a coordinated mix of data visualisation tools.</li> <li>Professionals may use suitable software to gather and evaluate real-time data about their organisation's operations, finances, and people management performance. Predictive analytics solutions, for example, may give relevant data on admission rates. These data may be utilised to build demand-driven staffing plans and medical supply inventories. Care facilities can stay on top of innovations and ensure patients have the best experience possible.</li> <li>Maintaining the privacy and security of patient health information is a critical component of healthcare. Patients and providers may rest easy knowing that data security safeguards will prevent breaches or information loss. Additionally, actively participating in their treatment and providing more important information fosters patients' faith in medical professionals.</li> <li>Medical professionals must precisely document their work for reasonable compensation for Medicare-covered medical services. Following confirmation that they treated patients, they must utilise the appropriate electronic forms to keep and record the patient's medical history. Applying informatics in this process speeds up information transmission between the government and healthcare providers. Furthermore, it improves the uniformity of patient data, allowing future healthcare practitioners to streamline their operations.</li> <li>Informatics facilitates faster file submission, which results in tighter reimbursements to healthcare providers and more closed notification to patients of covered therapy. Shorter</li> </ul>	3,87,192

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Table 2 (continued)

S. No	Applications	Description	References
12.	Enhance organisational performance	<p>hospital stays, increased facility capacity, and resource availability benefit patients and health systems. This ensures that the patients who need them the most will always have access to beds, carers, and drugs. Additionally, by predicting which patients are most likely to be readmitted, informatics systems enable doctors to allocate resources for these patients better.</p> <ul style="list-style-type: none"> <li>Health informatics provides organised healthcare data, which may enhance organisational performance. Personnel may be better equipped to comprehend and respond to patients' demands and exercise leadership to improve the standard of care and the security of patient information.</li> <li>AI technology in the form of collaborative robots has brought about a revolution in the surgical business. The revolution may be seen in depth and cutting rate when making little incisions. In general, the surgeon's competence can influence the result of a surgery, especially if it involves a unique or sophisticated treatment. Even surgeons can operate more effectively when AI eliminates case-to-case differences. Because AI robots are accurate, they limit the likelihood of tremors or other unintended movements during surgery. For example, AI-controlled robots can do core activities such as precision cutting and stitching while functioning with more accuracy and miniaturisation.</li> <li>Data science employs various techniques to identify variations in picture and resolution states and examine orthogonality. Data scientists are developing increasingly sophisticated methods to raise the standard of image analysis to extract medical data from images effectively.</li> </ul>	55,201,227
13.	Protect private data	<ul style="list-style-type: none"> <li>In the future, enhanced cybersecurity linked to EHR will be the cornerstone of nursing informatics. Hackers are threatening secure and critical patient data in the healthcare business.</li> <li>Evolving health informatics will require new cybersecurity technologies to manage greater datasets. A future trend in health informatics will be the development of secure data interchange systems to preserve private data. Computer systems will be improved and encrypted to ensure data protection. The</li> </ul>	146,163,170

Table 2 (continued)

S. No	Applications	Description	References
14.	Reduce mistakes	<p>exchange of electronic data interchange would be facilitated via safe gateways.</p> <ul style="list-style-type: none"> <li>Data science helps discover faults in scanned images, assisting clinicians in formulating an effective treatment plan. These include X-rays, sonograms, MRIs, CT scans, and other medical imaging procedures. Physicians can treat patients more effectively by adequately analysing the pictures from these tests.</li> <li>Numerous bodily problems sometimes appear due to the expanding global population. Poor nutrition, psychological disorders, pollutants, physical ailments, etc might bring this on. Finding quick treatments or vaccinations for illnesses has become a problem for medical research institutions. Health informatics covers all the tools, processes, and equipment used to handle health and medical data. Various healthcare specialists have access to patients' medical records via it.</li> <li>Public health informatics must enhance care coordination and ensure that health and medical data are effectively exchanged amongst covered organisations.</li> <li>Healthcare providers can provide high-quality treatment, reduce mistakes, and improve patient health outcomes when they are familiar with their patients and have access to their electronic medical information.</li> <li>Computer applications and information technology are primarily used as learning tools, as well as in medical research and public health promotion. As a result, a coalition of health data from various fields, including microbiology, pathology, and toxicology. It also actively participates in reorganising information systems that may no longer be useful or practical so that the data collected can be used for a new surveillance task.</li> <li>Modern IT systems support hospitals' departments, staff members, and patients. They enhance the ability to send patient data in real-time, benefitting clinicians by accelerating diagnostic and therapeutic procedures. Medical professionals may also use systems for equipment localisation, which precisely display what they require.</li> <li>The use of new technology may aid patients in finding their route. Health organisation operations are increasingly dependent on data and how it</li> </ul>	70,115,157,271

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Table 2 (continued)

S. No	Applications	Description	References
15.	Automating operations	<p>affects them. All of them are gathering enormous volumes of data, and the businesses that can best assemble and analyse this data will have an advantage over the competition. They will operate more effectively, improving cost reductions and patient outcomes.</p> <ul style="list-style-type: none"> <li>Healthcare organisations and insurance firms may save time and money by automating operations previously done manually. Health informatics has also improved diagnosis and decreased mistakes, increasing healthcare effectiveness. EHRs are used to organise, store, and manage health data. Health informatics is a behind-the-scenes function that may enhance the patient experience.</li> <li>Health informatics may also help healthcare practitioners make timely choices by managing large amounts of data and making patient data more accessible. Using health informatics, healthcare professionals may collaborate with IT professionals and lawmakers. Their grasp of patients, medicine, and HIT has grown tremendously, making them a valued asset in healthcare organisations.</li> <li>Public health professionals are emphasising prediction and prevention over reaction and treatment. Predictive analytics is utilised in the early stages of a disease to identify those most likely to acquire a chronic illness. Analysing lab test claims data, patient-generated data, and various social aspects reduces the risk of long-term illness, lowering total healthcare expenditures and improving patient outcomes.</li> </ul>	190,221,265
16.	Enhanced workflow	<ul style="list-style-type: none"> <li>Several clinical procedures use health informatics in their daily operations. Inpatient or outpatient healthcare professionals and patients use online portals, EHRs, and data-gathering tools, including vital sign monitors and glucometers, personal data devices, and more.</li> <li>When analysing these health informatics applications and how they affect practice management, it is critical to comprehend the technology, enhanced workflow, and data management. Health informatics improves collection, storage, and access while bridging the gap between technology and procedures. Health sciences have made significant advances</li> </ul>	5,95,97

Table 2 (continued)

S. No	Applications	Description	References
17.	Patient-centred approach	<p>throughout history and moved closer to a technology era.</p> <ul style="list-style-type: none"> <li>Data Science, AI, ML, deep learning, and Natural language processing (NLP) are just a few of the technologies now accessible. These technologies can potentially revolutionise the healthcare industry by offering precise forecasts, in-depth analyses of issues, and medication dosages.</li> <li>Doctors are now starting to accept forecasts and findings provided by an ML model as these characteristics have become more realistic, or it supports them in making better judgements. Data analytics in medical research can enhance public health organisations' capacity to anticipate illness outbreaks, increase disease prevention, improve the quality of life, and lengthen lifespans.</li> <li>Health informatics is essential for a patient-centred approach since it ensures that technology securely keeps and uses data. Clinical informatics may advance patient-centred care by enabling the exchange of crucial patient data with physicians and other healthcare professionals. It guarantees a seamless exchange of reliable data between patients and providers.</li> <li>Healthcare workers may stay current on patient reports and use predictive analysis to examine data. They can lower health risks and improve patients' quality of life. Doctors may use clinical informatics systems to collect patient data and enhance patient outcomes. Health informatics enhances patient-provider communication, further promoting patient-centricity.</li> <li>Data analytics technologies improve research efforts in various health-related sectors by gathering and analysing clinical data from multiple sources. Some of the strongest clinical data resources include EHRs, electronic medical records, personal health records, and public health records.</li> </ul>	94,104,269,288
18.	Enabling real-time transcription	<ul style="list-style-type: none"> <li>The use of digital technology by healthcare organisations has improved AI speech recognition, enabling real-time transcription of provider notes and medical orders. This may reduce data entry time and allow clinicians to communicate with patients.</li> <li>We can locate a speech recognition solution that is accurate and quick using cutting-edge health informatics. Due to the ease of use of</li> </ul>	157,171,179, 192

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Table 2 (continued)

S. No	Applications	Description	References
19.	Managing chronic diseases	<p>electronic data, the information might be used to detect illness risk factors. Promoting community health and developing strategies and measures to avoid illness by identifying the variables or circumstances that put communities at risk continue to be the core goals of public health informatics. Hospital Information supports the hospital management. Clinical, administrative, and financial components make up this system.</p> <ul style="list-style-type: none"> <li>Typically, medical facilities execute all the essential operations they need, allowing room for future IT infrastructure expansion. This large variety of possibilities presents several obstacles for the IT employees who administer, manage, and improve IT systems in medical institutions. Medical informatics generally works with doctors and other healthcare workers to keep them informed about medicine for learning or even as business owners. Consumer health informatics is significant in reaching consumers for health promotion, education, and health literacy information.</li> <li>EHR quick alerts may be a helpful tool for enhancing treatment by alerting healthcare professionals to problems, including screenings, medication interactions, managing chronic diseases, and overdue lab tests. Alarms must be optimised to ensure healthcare personnel are well-rested and focused. Health informatics manages EHR alarms to increase their value.</li> <li>Radiologists often use health informatics software to represent CT and MRI scan results appropriately. Medical image analysis improves scanning technology's accuracy and guarantees more accurate findings. Everything contributes to a more precise understanding of the patient's situation. Healthcare workers profit from health informatics software utilised in hospitals, medical diagnostic programmes, and other platforms.</li> <li>Global activities in gathering healthcare data and the healthcare industry's shift to value-based care are increasing the requirement for biomedical analysts to be educated to handle healthcare-specific use cases. Instead of being restricted to Public Health alone, data-driven informatics</li> </ul>	52,103,263

Table 2 (continued)

S. No	Applications	Description	References
20.	Self-monitoring of diseases	<p>in healthcare is being used to predict clinical outcomes, analyse unstructured text data, classify images, and even prevent illness.</p> <ul style="list-style-type: none"> <li>Physicians and patients may use health informatics software to monitor the distribution of prescriptions and the whole prescription procedure. This reduces the likelihood of mistakes and misunderstandings. Patients' health problems may be communicated to clinicians through wearable technology using data science and ML algorithms. The hospital's administration may visit these patients' homes with their younger physicians, assistants, or nurses.</li> <li>Health informatics technology has made illness self-monitoring easier for patients and is critical to improving patient involvement and health outcomes. Patients pay more attention to their vital signs and follow the doctor's orders. Acute crises might be averted or halted in their tracks. Hospitals may also install several diagnostic gear and devices. These devices may collect patient data such as heart rate, blood pressure, body temperature, etc. Doctors may obtain real-time patient health information through mobile app updates and notifications.</li> <li>Consequently, they can make diagnoses and assist less-experienced medical experts or nurses in treating patients at home. The development of data science has helped the healthcare industry reach new heights. It is helpful in several areas, including the interpretation of medical pictures. Health informatics primarily uses tools like health information systems to collect, store, retrieve, analyse, and utilise healthcare data for diverse goals.</li> <li>Better cooperation and coordination among healthcare providers is one of the most significant uses of health informatics since it enables health managers to plan and govern their companies more openly and decentralised. Hospitals and care facilities often handle sensitive patient information that has to be securely safeguarded. Security might be a problem for these kinds of organisations, given that the data is coming from several sources and that information.</li> <li>Health informatics is essential for data privacy and patient</li> </ul>	67,78,142
21.	Data privacy and patient confidentiality	<ul style="list-style-type: none"> <li>Health informatics is essential for data privacy and patient</li> </ul>	63,151,192

(continued on next page)

Table 2 (continued)

S. No	Applications	Description	References
22.	Assist physicians and patients.	<p>confidentiality. It ensures that concerns relating to compromised data are handled and there are no data breaches. Doctor diagnoses and notes are securely stored on cloud-based platforms.</p> <ul style="list-style-type: none"> <li>• Patients will have confidence in their doctors and be willing to provide important information. The safe interchange of information from several smart devices is supported by health informatics. Businesses employ big data and forecasting to quickly identify and halt fraud or human error to avoid this. For example, by evaluating massive amounts of prescription trend data, professionals can predict pharmaceutical issues before they occur. The same applies to test findings, dosage ranges, and other operations. Doctors make more evidence-based decisions, relying on a wide range of clinical and research data rather than their training and expertise.</li> <li>• Nonetheless, there is always the possibility of human error. Despite their enormous training, physicians are still human, and the wrong prescription or course of treatment might imperil the patient's life. Using big data and technologies, professionals may easily be told when an incorrect medicine, test, therapy, or other treatment has been administered, and they can remedy it immediately.</li> <li>• This may reduce the number of medical errors and improve the facility's image over time. By offering a perfect storm of patient-centric information in one accessible location, medical institutions may encourage cross-departmental harmony while accelerating treatment procedures in a wide range of critical areas.</li> <li>• Health informatics involves collecting, storing, analysing, and displaying data in a digital format to assist physicians and patients in making wiser choices. In practical settings, Informatics principles, theories, and practices are used to improve health outcomes. Healthcare information systems were developed to connect information technology, communications, and healthcare, providing quality patient care with safety.</li> <li>• Using data-driven analytics, we can predict when we will need staff in specific areas while dispersing specialist individuals to other institution sections at</li> </ul>	65,105,153

Table 2 (continued)

S. No	Applications	Description	References
23.	Enhance healthcare quality and safety.	<p>slower times. Big data analytics for healthcare may change how images are perceived because algorithms developed after examining hundreds of thousands of photographs may recognise specific patterns in pixels and transform them into numbers to assist doctors in diagnosing patients.</p> <ul style="list-style-type: none"> <li>• They even hypothesise that radiologists may no longer need to see the images directly instead of assessing the algorithms' conclusions. This will unavoidably analyse and keep many more pictures than they could reasonably recall, impacting radiologists' work tasks, educational qualifications, and skill sets.</li> <li>• Many clients and prospective patients are already interested in smart devices that record their activity, including heart rates, sleeping habits, etc. This vital information may be paired with other trackable data to uncover hidden health risks. Using big data in healthcare enables strategic planning since it provides a better understanding of people's motivations.</li> <li>• The health informatics industry connects individuals with health technology to improve healthcare quality and safety.</li> <li>• Doctors can compare data in a socioeconomic context and change delivery techniques as needed, utilising information access to the general public's health database. It is utilised for early consultations, diagnostics, remote patient monitoring, and training medical personnel. Telesurgery is one of the most unique uses, allowing surgeons to operate on patients while physically separated via robots and high-speed real-time data communication.</li> <li>• Medical data analysis will allow senior staff or operators to deliver the correct support when needed, improve strategic planning, and optimise critical staff and people management operations. Public health professionals depend on data to spot patterns and connections between treatments and results for certain groups, much as doctors do when developing treatment regimens beneficial to individual patients.</li> <li>• Public health informatics may assess the treatment given to individuals with comparable diseases or chronic conditions using data registries to build best practices that result in better outcomes in the fastest, most economical way possible.</li> </ul>	17,57,157,297

(continued on next page)

Table 2 (continued)

S. No	Applications	Description	References
24.	Assist healthcare facilities	<ul style="list-style-type: none"> <li>As providers quickly adopt EHRs designed to store and share information from all providers involved in a patient's care, informatics in healthcare specialists will continue to assist healthcare facilities in implementing new systems, upgrading existing databases, and working towards developing a fully interoperable healthcare system.</li> <li>The goal of using this data and the insights it creates is to enhance individual and clinical patient care and the health of large populations and allow health organisations to offer treatment more efficiently and inexpensively. Because of this optimisation of data lifespan, the multiple healthcare practitioners who serve a patient collaborate more efficiently.</li> <li>Health informatics specialists aim to enhance healthcare delivery by integrating patient care and data. By bringing technology and health together, we can improve patient outcomes. Now that healthcare companies have moved their medical records to digital platforms, health informaticists are investigating enhancing AI voice recognition to digitally transcribe healthcare providers' notes and medical orders in real time. As a result, the time spent on data entry may be considerably decreased, freeing up more time for direct patient engagement by healthcare providers.</li> <li>The IoMT tremendously impacts medicine and greatly helps society. There are now various methods for wirelessly connecting medical devices. Using multiple applications and technology, hospitals may provide information to patients to help them understand and identify concerns. This enables medical professionals to focus more time on urgent situations and those in need. This examines enormous amounts of data in the healthcare industry to identify patterns in frequent symptoms, diagnoses, processes, and other outcomes.</li> </ul>	106,162,195, 245
25.	Lower treatment costs	<ul style="list-style-type: none"> <li>Healthcare analytics can reduce treatment costs, assist patients in avoiding preventable diseases, and improve patients' quality of life overall. Globally, the average human lifespan is increasing, complicating therapeutic delivery techniques.</li> <li>Like business entrepreneurs, health specialists can collect massive amounts of data and</li> </ul>	56,245,272

Table 2 (continued)

S. No	Applications	Description	References
		<p>determine the best ways to use it.</p> <ul style="list-style-type: none"> <li>The IoT has helped the healthcare industry because of its potential to save lives and improve society. It makes integrating health informatics systems more straightforward and makes it easier to link medical equipment to the Internet.</li> <li>Patients may consult with their physicians virtually in real-time and get feedback, information, and guidance without going to the doctor's office. Health and information technology were combined to create healthcare informatics, a system for managing healthcare information.</li> <li>In today's society, connecting the two has become crucial. Health information on a patient is kept digitally so it may be quickly accessed. Although technologies are still in their infancy, they are adaptable and might aid medical practitioners in making the best possible treatment choices.</li> <li>Patients now have access to their information, medications, and test results via patient portals, which have opened up a new contact channel between them and their clinicians. Medical informatics is a kind of information engineering related to healthcare that maintains patient data.</li> </ul>	
26.	Reduce hospitalisation or readmission.	<ul style="list-style-type: none"> <li>Doctors utilise telemedicine to establish personalised treatment plans and avoid hospitalisation or readmission. Such healthcare data analytics applications are connected to previous predictive analytics utilisation.</li> <li>The field of data analytics is proliferating in the healthcare industry to support the creation of cost-cutting, quality-improving care plans and reduce hospitalisation.</li> <li>It helps medical personnel predict acute medical events and prevent patient issues from worsening. It organises health records using information technology to improve healthcare outcomes. Patients, insurance providers, medical staff, and other health professionals have electronic access. Most medical establishments formerly tracked patient information using old-fashioned techniques. Many hospitals and other healthcare institutions still save their data on paper today.</li> <li>Predictive analytics are used in healthcare informatics to sift through massive amounts of data to uncover patterns in</li> </ul>	81,211,295,298

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Table 2 (continued)

S. No	Applications	Description	References
27.	Precise preventive treatment	<p>processes, diagnoses, and other health outcomes. They aid clinicians in early case analysis and mental health issue diagnosis. Health informatics is adaptable and may help healthcare professionals provide better treatments. It also offers precise predictive analytics to enhance population health management.</p> <ul style="list-style-type: none"> <li>• By delving further into data such as medicine kind, symptoms, and visit frequency, healthcare institutions may give precise preventative treatment and, eventually, minimise hospital admissions.</li> <li>• Medical informatics includes implementing techniques to enhance clinical knowledge, demographic data, patient data management, and other patient care and public health information. Information technology is used in clinical informatics to process medical data, including pathology reports.</li> <li>• Wearable medical technology will play an essential role in health informatics in the future, offering high-value data to follow persons at risk and medical diseases. These devices, which may be linked to any system, allow medical personnel to monitor patterns in patient health. Bluetooth connectivity would be added to wearable technology, containing monitors for other metrics, including blood pressure, heart rate, and glucose levels.</li> <li>• The digitalisation of clinical health science informatics systems and personal data collection devices makes it possible to use data to improve treatment methods at all levels with a focus on the patient. Health informatics supports predictive analysis and accurate, extensive data analysis, which may improve patient outcomes and engagement.</li> </ul>	71,129,188,241
28.	Decrease the incidence of medical mistakes	<ul style="list-style-type: none"> <li>• The medical community is increasingly giving clinical efforts greater importance by utilising health informatics technologies to reduce the occurrence of medical errors. This method will benefit the standardisation of diagnostic data and the distribution of prescription drugs.</li> <li>• One prospective treatment currently being studied is using digital technologies to record and assess diagnoses. These technologies may aid in the avoidance of faulty data gathering or wrong diagnoses, which are frequently the</li> </ul>	18,79,206,245

Table 2 (continued)

S. No	Applications	Description	References
		<p>consequence of misreading test results. In terms of minimising medication errors, bar-coded and automated pharmaceutical delivery systems have been shown to lessen the probability of a mismatch between a patient's identity and their proper drug.</p> <ul style="list-style-type: none"> <li>• Healthcare interoperability is the capacity of various information systems, devices, and applications to access, share, integrate, and use patient data, which is necessary for EHR systems to operate efficiently. Informatics application interoperability promotes fast and efficient information transmission and improves population health management.</li> <li>• Healthcare institutions now focus more on improving data security because they continue to desire to digitise patient records to preserve patient data. By enhancing access to data, information exchange, and communication, businesses in the healthcare informatics sector are extending their assistance for transplant treatment.</li> </ul>	
29.	Patient experience	<ul style="list-style-type: none"> <li>• AI supports advancements in patient care results, accessibility to healthcare services, and patient experience. In addition to allowing physicians and medical professionals to spend more time providing direct patient care, it also helps to boost the effectiveness and productivity of care delivery.</li> <li>• The digital-first approach to healthcare, driven by AI, has dramatically increased legitimacy. When necessary, healthcare informatics supports the development of integrated care services. Patients get comprehensive treatment due to improved interprofessional communication made possible by healthcare informatics.</li> <li>• EHRs make data management and storage in health informatics more accessible. Using EHR systems, medical personnel may quickly discover patient information and share medical records to provide collaborative treatment.</li> <li>• Health informatics allows for better communication, access, sharing, and storage of patient health data. IT informatics also provides patients with better treatment, which has several advantages.</li> <li>• Pharmaceutical informatics allows the medical team to be better informed and the administrative team to keep</li> </ul>	31,157,171,256

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Table 2 (continued)

S. No	Applications	Description	References
30.	Rapid conversational replies	<p>track of appointments. Supporting healthcare practitioners in providing patient-centred care is one of the significant functions of biomedical informatics in medicine.</p> <ul style="list-style-type: none"> <li>AI has the potential to improve primary care and triage through chatbots. Chatbots, which deliver quick conversational responses, make engaging with patients simple. Patients may save money by avoiding unneeded doctor appointments.</li> <li>Chatbots may assist healthcare practitioners in meeting patients' expectations while improving patient outcomes. In an all-in-one communication strategy, chatbots encourage people to share their health information proactively, allowing clinicians to enhance patient care quality and cut costs.</li> <li>Healthcare informatics companies use this opportunity to promote data governance, improve health decision-making, and aid stakeholders in getting fundamental knowledge. The use of digital technology to enhance clinical risk management to reduce further issues. Patient-centred outcomes research may benefit those with immune-mediated diseases by using health informatics.</li> <li>Extraction, transformation, and loading are often required for automated data collection. Data must be translated into a machine-readable format and loaded into the system to function as the raw material for automation.</li> <li>Digital health technology has altered healthcare practice management and healthcare informatics. Through secure systems, clinical health informatics has made accessing and sharing patient data easier.</li> </ul>	35,209,273
31.	Managing everyday tasks	<ul style="list-style-type: none"> <li>Practice management software assists healthcare professionals in managing everyday tasks, including scheduling and invoicing. Healthcare professionals, from solo practitioners to hospitals, use practice management systems to automate many administrative chores. Patients and providers need to be made aware of many informatics advancements. Even though technology that is not directly related to patient care is frequently focused on administration, consumer health monitors and data-driven clinical and patient care systems have considerably improved medicine.</li> </ul>	95,155,187,209

Table 2 (continued)

S. No	Applications	Description	References
32.	Remote patient monitoring	<ul style="list-style-type: none"> <li>Clinical predictive analytics assists in identifying high-risk patients. AI systems trained on medical data may be able to predict who may suffer heart attacks and strokes. Patient-centered care is aided by health IT solutions, which increase medical treatment quality. Through digital information systems, consumer health informatics encourages patient empowerment, health literacy, and consumer education. Data inform decisions in medicine and medical research in health data science. Imaging informatics concerns digitally based medical imaging systems' effectiveness, precision, usability, and dependability.</li> <li>Clinical trial informatics helps clinical research in a variety of ways. Informaticists can use IT systems and software platforms to speed up patient recruitment, streamline ethical approvals and renewals, boost participant participation, and expedite data collection and analysis. Informaticists also develop data warehouses, which allow researchers to access databases holding data from completed clinical trials efficiently for secondary analysis.</li> <li>Medical sensors send patient data to healthcare professionals via remote patient monitoring. It frequently examines blood pressure and blood glucose levels in individuals with chronic diseases. The data is intended to detect medical events that require intervention and may eventually be used in population health studies. ML employs neural network models with numerous data layers or variables to anticipate outcomes.</li> <li>The faster processing speed of contemporary graphics processing units and cloud architectures uncovers hundreds of hidden features in such models. One everyday use of ML in medicine is the detection of potentially malignant tumours in radiological images. Radiomics, or the identification of clinically significant patterns in imaging data that are outside the range of human sight, is a field in which deep learning is being used more and more.</li> <li>Automation is the elimination of manual work via the use of AI or information technology. The patient's medical record has various patient and staff education components integrated with healthcare information technology. For</li> </ul>	67,78,126,142

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Table 2 (continued)

S. No	Applications	Description	References
33.	Clinical decision support systems	<p>instance, a patient released to go home needs details regarding a particular drug.</p> <ul style="list-style-type: none"> <li>The healthcare professional searches the EHR for the patient's discharge information page and makes a copy for the patient. Materials for patient education on surgeries, drugs, and illness management are included in the EHR.</li> <li>Clinical decision support systems examine data from numerous clinical and administrative systems to aid healthcare practitioners in making clinical decisions. The data might be used to diagnose or predict medical events, such as drug interactions. These technologies filter data and information to help clinicians provide tailored patient care.</li> <li>By creating advanced healthcare software, advanced health informatics reduces mistakes and avoids rework and delays. The quality of decision-making may be considerably enhanced, and errors caused by incomplete documentation can be reduced when patients and clinicians have access to health informatics.</li> <li>Interoperability, which enables information sharing between providers, independent payers, and reporting organisations like public health, is one of the main advantages of health informatics. Healthcare practitioners should document their work in a precise way when billing Medicare or Medicaid to secure fair remuneration for medical services rendered.</li> <li>Once patients have been confirmed to have received treatment, their medical histories must be electronically stored and recorded.</li> <li>Health informatics allows healthcare providers to transmit information more quickly. It also enhances the standardisation of patient data, making it simple for upcoming healthcare experts to organise their procedures.</li> <li>Health informatics supports fast file submission, which helps healthcare providers promptly pay and notify patients about their treatments.</li> </ul>	41,153,253
34.	Modern technology and innovation	<ul style="list-style-type: none"> <li>It infuses healthcare with modern technology and innovation. Data management innovations should continue as existing and upcoming trends enter the health informatics sector. We may take advantage of various opportunities to help revolutionise healthcare by working with the best health</li> </ul>	115,225,286

Table 2 (continued)

S. No	Applications	Description	References
35.	Enhance the quality of the services	<p>informatics businesses that have been chosen. The market for health informatics is likely to keep expanding. Additionally, as communication technology advances, patients will have more options to have greater access to healthcare.</p> <ul style="list-style-type: none"> <li>Health informatics encourages real-time patient monitoring to spot possible health hazards early on through predictive analytics and EHR alerts. The analysed surveillance may make real-time diagnoses and allow the appropriate safety measures to be taken.</li> <li>Medical informatics may integrate real-time clinical decision support better. IT informatics may improve general public health and reduce the possibility of human mistakes. IoT devices have the potential to boost patient participation and improve workflow, both of which will be future trends in healthcare.</li> <li>Furthermore, IoT devices aid in telehealth and mHealth and provide remote patient care. The usage of IoT devices is expected to increase significantly, allowing providers to monitor patients and improve communication with them.</li> <li>Devices may be coupled with this emerging health informatics trend to provide patient information instantly. As part of the future trends in health informatics, IoT devices with sensors will aid patients' health outcomes, promote preventative treatment, raise patient-doctor interaction, and improve the standard of medical services.</li> <li>It is challenging to obtain timely access to patient data that might help healthcare workers improve their service quality. Concentrating on a few key performance metrics and collecting only the data needed to monitor those indicators can help avoid getting overwhelmed with patient data. To do this, qualitative assessments of patient data must be performed, and metrics must be made available to clinicians and quantifiable over time to indicate increased development.</li> <li>Using health informatics, patients can view their digitised health history and recommendations, allowing them to participate actively in therapy.</li> <li>Patients with access to care portals can better regulate their symptoms and learn more about</li> </ul>	37,59,118,284

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Table 2 (continued)

S. No	Applications	Description	References
		<p>their diseases. Furthermore, these individuals can better converse with doctors and nurses, improving their health. If health informatics is used, patients may feel valued in their care.</p> <ul style="list-style-type: none"> <li>Health informatics, which encompasses health data collection, storage, reporting, and exchange, aims to improve operational performance so that complete care may be given more effectively and patient data can be secured. The field of health informatics is constantly expanding as improvements to processes are made via design, implementation, and configuration.</li> <li>Patients can take responsibility for their care by sharing information with friends, family, and others by accessing electronic medical records or using safe methods to contact physicians and nurses.</li> </ul>	

clinical IT system, ensuring that the correct data reaches the providers and is updated as necessary<sup>317–321</sup>. Improved patient outcomes are one of the significant ways health informatics changes healthcare. Providers can offer safer and higher-quality treatment because of electronic medical records<sup>322–325</sup>. This is so because advances in health informatics promote more accurate predictive analysis, which lowers mistakes and facilitates better diagnosis. Using medical informatics technology, clinicians and nurses may operate more effectively. In this approach, health informatics increases cost-efficiency while automating manual tasks to free up doctors' time with patients<sup>326,327</sup>. The health record is created by health information management systems that combine data from many sources and make it available to all healthcare professionals throughout the care continuum. This guarantees that all healthcare professionals have access to the patient's most up-to-date medical history. Communication between a doctor and a patient is improved by removing the need to repeat information to multiple physicians or trying to recall drugs, tests, procedures, and findings<sup>328–331</sup>.

#### 4.1. Strength of Health Informatics

Medical personnel faced challenges due to growing patient loads, technology constraints, and a quickly evolving understanding of the virus and its treatment. One of its main advantages is that AI and ML can generate comprehensive diagnoses and treatment plans from complicated data. Using ML to cross-reference a patient's list of symptoms with known illnesses, a doctor may enter a patient's list of symptoms into a database and have AI notify them of probable causes, risk factors, and therapies. Because AI promises to improve medicine, employers will value individuals with experience with the newest health information systems, data-gathering strategies, and analytical methodologies. Enhancing therapy is the primary objective of healthcare informatics. Healthcare informatics is constantly changing to improve patient experiences as technology advances<sup>42,169</sup>. The integration of the IoT into the medical industry is a significant breakthrough for the area of healthcare informatics going forward. It is a network of wireless, networked, and linked digital devices that can gather, transmit, and store data without needing communication between people or computers. IoT has the potential to significantly improve patient care by enabling

practitioners to identify and treat patients both in-person and electronically, as well as anticipate health risks.

Clinical communication and collaboration platforms are one innovation. A patient's care team can work well in these designated areas, even if the doctors are from different organisations. Patient portals and telemedicine software, which facilitate contact between patients and physicians, are two ways healthcare informatics technology has improved patient outcomes. Physicians attending to patients and researchers need to obtain information fast and have confidence that the data they get is correct and comprehensive. The adoption of notable advancements in records management, such as cloud-based system deployment, has helped healthcare practitioners. Despite their complexity, healthcare computer networks and software need help with interoperability or the ease with which disparate health information systems exchange data. Many organisations need help to send and receive information promptly, which may harm patient outcomes<sup>205,213</sup>.

#### 4.2. Major barriers towards implementing health informatics

Several issues hamper the integration of socioeconomic determinants of health data. The inability to connect patient, population, and public health data, the lack of standards and tools, the need for health systems to better understand their communities, the sharing of data across sectors, and the identification and development of appropriate technologies are a few of these challenges. Technologies offer a chance to address global health issues in developed and developing nations<sup>4,8</sup>. People may now record and provide meaning to their data using HIT. There is much promise in health technologies, especially mobile health technologies, to get people interested in health promotion and illness prevention. It gives people the instruments they need to capture their data and provide it with context<sup>13,15</sup>. The significant barriers towards implementing health informatics are shown in Fig. 3.

The health informatics business has several obstacles that must be overcome before flourishing. The fact that there are numerous kinds of data and insufficient specialists to handle them all presents difficulty. The absence of standardisation between nations and industries presents another difficulty. Establishing standards for health informatics is the best approach to overcoming these obstacles. Standards contribute to the interoperability of goods from many industries and the usability and comprehension of data<sup>164,182</sup>. Standards also contribute to the accuracy and dependability of data. In addition to lowering expenses, standards may help the industry operate more efficiently. Investigating intricate connections between environmental variables and health outcomes has become feasible because of large-scale data sets and statistical analytic techniques. However, because of these difficulties, there is now more emphasis on creating cutting-edge techniques and strategies for gathering, analysing, interpreting, and disseminating data<sup>211,217</sup>.

Telemedicine establishes distant connections between patients and doctors through video conferencing and instant messaging. Conversely, remote patient monitoring takes vital signs from patients, including blood pressure and glucose levels. Process, workflow, and data management digitisation frees up time for patient engagement by reducing paperwork and burden. Integrating and evaluating biological data, medical imaging, and clinical information is the primary goal of biomedical informatics. Research, diagnosis, and customised care are all aided by it. Medication management is streamlined via pharmacy informatics<sup>254,304</sup>. Computerised prescription systems, drug interaction warnings, and medication history data also guarantee the safe and efficient administration of medications. Reducing medical mistakes and improving outcomes are achieved when diagnostic and treatment recommendations are based on the most recent evidence-based guidelines.

Improving the experience of patients and providers by enabling flexible, two-way healthcare exchange is a core objective of the healthcare transformation. An organisation's capacity to foster health relationships by prioritising patients and providers determines its success. Support for change management and clinical transformation

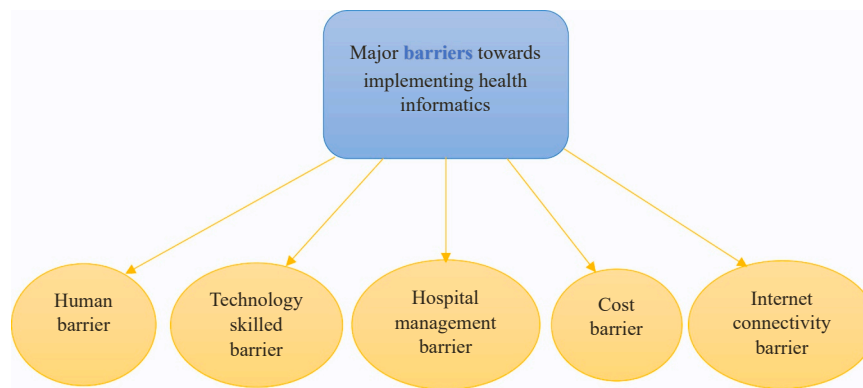


Fig. 3. - Major barriers towards implementing health informatics.

should be provided by parties other than the technology vendor. Technology by itself is unable to address organisational issues and inefficiencies. Instead, the most significant favourable influence on provider productivity and patient care comes from how technology is used. The growing use of digital technology and its capacity to provide health information at scale has made health informatics research more complicated in recent years<sup>314,336</sup>. Furthermore, generalising data across a broad range of groups has become challenging due to the growing diversity of patient populations and the number of diseases and therapies that might be examined.

#### 4.3. Natural language processing for health informatics

Natural language processing (NLP) enables medical personnel to capture information naturally. When done correctly, NLP can facilitate seamless interaction between a doctor and a database. Healthcare providers can organically take notes by using free-form writing. The data is then translated using NLP into a language that doctors, nurses, patients, and their families can all understand. The benefits of NLP technology are endless, as it is constantly being improved<sup>332,333</sup>. Healthcare workers are doing more with efficient NLP than only saving time; they are also improving communication, locating critical information, and expanding the frontiers of healthcare. The possibility of using aggregated healthcare data to create robust models that can automate diagnosis and also enable an increasingly precise approach to medicine by tailoring treatments and targeting resources with maximum effectiveness in a timely and dynamic manner has been made possible by the rapid explosion in AI. Modern NLP technologies reduce the time and resources required for providers to record coded conditions in EHRs manually, improve the accuracy of medical record reviews, and streamline medical record reviews for payers and health systems<sup>333</sup>.

#### 4.4. Role of large language models in healthcare

In the past year, generative AI and large language models (LLMs) have attracted much interest. Intensively trained on large datasets, these models have shown remarkable competence in various NLP tasks, including content creation, language translation, code generation, etc. AI's capabilities significantly increase utility and benefits compared to conventional, rule-based systems. Additionally, they promote inclusive cooperation with patients and physicians. Decision-making, information retrieval, and data management are all improved by LLMs. By effectively summarising lengthy patient notes, reports, and medical histories, LLMs can help healthcare workers swiftly extract pertinent information and insights<sup>334,335</sup>. This improves accuracy while saving significant time compared to manual data analysis and documentation. This allows medical professionals to refocus their attention and resources on providing patients with more unique and effective treatment. LLMs are essential for patient care, medical research, and clinical reporting.

Medical big language models improve patient care by quickly and accurately analysing massive volumes of clinical notes, scholarly articles, and medical literature. They offer insightful information, help with a precise diagnosis, support healthcare practitioners in making defensible decisions, and help with treatment planning<sup>336,337</sup>.

Predictive systems are increasingly integrating LLMs, particularly in medical imaging, to provide pictures with excellent diagnosis accuracy. Integrating LLMs and conversational AI into healthcare is becoming possible, especially in clinical and medical contexts and with systems that properly scan photographs, such as mammograms. The process of finding new drugs is difficult and time-consuming. LLMs may help find promising drug candidates, anticipate medication interactions, and help plan clinical trials by sorting through enormous volumes of scientific data. Precision medicine is improved, and the drug development pipeline is accelerated. LLMs may automatically automate the transcription of medical notes, producing comprehensive patient records. Healthcare practitioners save time and lower the possibility of patient data inaccuracies due to this<sup>338-340</sup>.

LLMs may help create individualised and understandable explanations of medical diagnoses, processes, and treatments. This closes the information gap and empowers patients to make wise choices regarding their care. For LLMs to be helpful in healthcare applications, domain-specific medical information must be required. The models must be trained on enormous medical datasets, including research publications, EHRs, medical textbooks, and clinical recommendations<sup>341,342</sup>. Incorporating medical knowledge improves the models' capacity to provide accurate and contextually relevant medical material. Clinical trial design and execution need careful planning. LLMs may have a positive impact by evaluating current trial data, forecasting patient enrollment rates, and streamlining trial methods. These insights speed up and reduce the cost of trials by facilitating their efficient design and execution<sup>343-345</sup>.

#### 4.5. Real-life benefits of health informatics

A significant shift in healthcare management and delivery has occurred with the introduction of IT. This revolutionary path signifies a change towards a healthcare IT system that is more linked, effective, and patient-centred, going beyond the digitalisation of records. Healthcare IT has emerged as a critical indicator of a new era of better patient outcomes, more straightforward administrative procedures, and improved healthcare delivery in this age of fast technology breakthroughs<sup>33,42</sup>. IT programs save time and money by automating repetitive procedures, streamlining administrative work, and lowering the chance of error. This efficiency benefits patients and healthcare authorities because it frequently results in quicker diagnoses, shorter wait times, and more successful treatments. IT is essential to data management and security in the healthcare industry<sup>158,165</sup>.

Patients and providers now have much more accessibility using

patient portals, providing a new communication channel. Patients may now access their data, medications, and test results. However, many patients may need help with regularly entering a portal. To minimise the time patients or providers spend on the phone or the computer attempting to access their portal, providers are investigating automated options to alert patients through encrypted messages. Thus, to improve patient care, increase efficiency, and lower total costs, health informatics combines information technology, computer science, clinical understanding, and management science<sup>180,185</sup>. The revolutionary Personal Health Record System redefines patient participation and digital health record management. It provides in-depth information beyond typical patient interviews and is essential for patients and doctors to collaborate on decisions.

Health informaticists are exploring enhancing AI speech recognition to digitally transcribe healthcare professionals' notes and medical orders in real time since healthcare organisations have shifted their medical records to digital platforms. This may significantly reduce the time needed for data input and allow healthcare professionals to engage with patients face-to-face. To enhance communication and general satisfaction with their care, patients can also utilise patient portals to make appointment requests, request medication refills, and send secure communications to their healthcare practitioner. Patient portals, which boost patient participation and enhance outcomes, are an essential health informatics tool in the expanding trend of patient-centred care<sup>231, 240</sup>.

## 5. Discussion

The field of health informatics is vast and rapidly expanding. The emphasis on evidence-based therapy, quality improvement, patient data protection, and accessibility in the healthcare industry is increasing demand. Health informatics is changing to keep up with significant data enhancements, data security standards, and AI. Health informatics, often known as health information systems, relies heavily on information technology. To improve treatment quality, field staff arrange and evaluate medical information. These experts develop ways for obtaining, assessing, and implementing patient solutions using readily available tools and resources. They must retain and retrieve all relevant patient data, medical procedures, and outcomes. They create communication protocols inside the workplace infrastructure. Researchers may get insight into widespread illnesses affecting the general population and newly emerging public health problems by using data science on improved, more accessible health records.

Utilising real-time data and health IT systems, telemedicine, and mobile medicine increases the accessibility and efficacy of medical treatments. To enhance healthcare outcomes, the multidisciplinary area of health informatics employs information technology to organise and analyse patient data. Health information management experts hold a range of positions and work environments. Clinical, operational, and administrative tasks are connected via Health information management. At every stage of the healthcare delivery process, these professionals impact the quality of patient care and information. Health information management specialists manage patients' medical data as part of patient care. The security, accuracy, and reliability of patient health information are the responsibilities of health information management experts. HIT, which is based on health information, is the framework for managing health information and the sharing of health information in a digital format. HIT focuses on the technical side of handling medical data, such as working with the technology and software required to handle and store patient data.

The science of health informatics describes what may be electronically recorded, transferred, and utilised. Health informatics focuses on information systems, concepts, and technology related to the ongoing administration of healthcare delivery. One of the key elements in predicting how a patient's treatment will turn out is early diagnosis. The diagnosis-treatment-recovery cycle for many patients may be

significantly shortened by AI's ability to quickly absorb vast information and determine the most probable causes of symptoms. Most medical institutions employ manual techniques to keep patient data on hand for a long time. This is still true today for many healthcare organisations dealing with mountains of documents and paperwork every day. Health informatics may help solve this critical issue in contemporary healthcare. By making data available, healthcare informatics enables clinicians to obtain appropriate information rapidly. This takes time, but it aids in quick case diagnosis. Clinical informatics also controls the administrative burden and enhances the effectiveness of their operations. Predictive analysis using health informatics also alerts providers to possible health hazards.

Because of the increasing specialisations in healthcare, most patients receive treatment from many healthcare professionals within a single hospital stay. The development of specialists increases the necessity for cooperation. Health informatics addresses this issue and provides a solution. Professionals in health informatics act as a bridge between the clinical side of healthcare and health IT departments by collaborating with clinicians, providers, and industry leaders to ensure that technology improves rather than complicates workflow, financial reporting, efforts to improve quality, and the development of operational and clinical best practises. The successful interchange of EHR data depends on interoperability, enabling real-time patient data transfer across various networks and systems. The use of genetics in HIT allows for the assessment and comprehension of a population's health. Genomic data may be used to track health and technological developments to control population health. This breakthrough in nursing informatics enables the secure transfer, storage, and analysis of genetic data. Given the improvements in HIT, a dependable system for transferring and evaluating complex information is required.

While treatment-related innovations garner the most attention, a more technological revolution in healthcare is occurring behind the scenes, mainly in informatics, which it and data science drive. The use of enormous amounts of data produced by the healthcare sector is the main focus of healthcare informatics. Still, informatics is capable of far more than just increasing access to necessary medical treatments. Individuals may also benefit from faster access to the treatment they require. Wearables and data-driven patient education programmes make it simpler for patients to care for themselves outside of hospital settings, strengthening the relationship between patients and providers and improving results.

Healthcare professionals may make educated judgements and deliver better treatment using EHRs, making comprehensive and current patient information easily accessible. EHRs can simplify patient record management by reducing the time and effort needed to input, retrieve, and distribute data. It is a communication tool between healthcare practitioners, facilitating real-time sharing of critical patient information and improving collaboration. By offering notifications for possible drug interactions, allergies, and other crucial details, EHRs can help lower the risk of mistakes and enhance patient safety. EHRs may be used to monitor and evaluate population health data, giving medical professionals the ability to see patterns and trends that can guide the creation of interventions that will be more successful. Patients may participate more actively in their health and well-being by accessing their health information and tools for managing their treatment through EHRs.

## 6. Limitations of health informatics in healthcare

Incorporating health informatics technologies into the healthcare system has improved patient care, reduced costs, and store medical records in better condition. However, despite all of the advantages of technology, these technologies have some limitations. Any interpretable model may be integrated with any black-box model. AI holds great potential to transform several industries, including manufacturing, healthcare, and space exploration. AI is expanding and becoming more

and more popular. High-quality data is used to fuel and improve AI systems. For this reason, the first step in the AI implementation process should be collecting the appropriate data. Most AI applications require extensive data to learn and make decisions. The disadvantage of using data is that it might prevent enterprises from running into storage issues. Furthermore, data security problems arise from automated corporate procedures using data<sup>164,182</sup>. Many readers may be surprised to learn that most firms need help integrating AI into their current business processes. Most firms encounter this as one of the most frequent difficulties when using AI. Table 3 provides significant limitations of healthcare informatics for healthcare.

The cost of technology is high. There will be updates in software and methods of operation. Hospital workers must stay updated with new developments to maintain a competitive edge. Some people may need help with this, especially the more senior employees. For moral and legal reasons, patient medical records and other health information should be kept private. Although security measures undoubtedly protect the healthcare system's network, network hacking is still possible. Because new technological improvements are made constantly, technology is more present in our lives than ever. Like any other business, the health and medical industries have radically changed. There are undoubtedly benefits and drawbacks to technology in healthcare, even while each

**Table 3**  
- Major limitations of health informatics for healthcare.

S. No	Limitation	Description	References
1	Technical problems through computer	<ul style="list-style-type: none"> <li>• Technical computer system problems are common and apply to healthcare informatics systems.</li> <li>• A shared information system links the hospital's departments together.</li> <li>• Several departments are impacted when one becomes unavailable.</li> <li>• This will be highly inconvenient; it may even negatively impact the patient's health.</li> </ul>	4,64,73,137
2	Cost of technologies	<ul style="list-style-type: none"> <li>• The cost of health informatics technologies is high.</li> <li>• Small healthcare systems generally refrain from employing these technologies.</li> <li>• Moreover, a higher level of skill is required for the proper implementation of these technologies</li> </ul>	8,85,112,146
3	Required update	<ul style="list-style-type: none"> <li>• There will frequently be new updates, software, and methods of operation.</li> <li>• Hospital workers must stay updated to maintain a competitive edge.</li> <li>• Some people may need help with this, especially the more senior employees.</li> </ul>	15,70,98,164
4	complexity	<ul style="list-style-type: none"> <li>• Health informatics must be updated with security, given the complexity and range of online crimes.</li> <li>• It increases the possibility that unauthorised parties might obtain data.</li> </ul>	36,99,116,182, 217
5	Network hackers	<ul style="list-style-type: none"> <li>• For moral and legal reasons, patient medical records and other health information should be kept private.</li> <li>• Security measures undoubtedly protect the healthcare system's network, but hacking is still possible.</li> <li>• Thus, there is no doubt that this is a weakness in health informatics.</li> </ul>	59,103,211

invention may appear to be a step forward. By using EHRs, there might be a chance of technical issues or system outages. Concerns about privacy and data security could exist during its implementation. By using the system, healthcare practitioners may receive some training. Not all medical professionals may have access to the electronic record system, which might affect the standard of care given to the patient<sup>70,116</sup>.

Patients' linked medical equipment might be accessed to change functionality if the proper security mechanisms are not in place. In the worst-case scenario, a significant gadget breaks down in a circumstance where life is at stake. It increases the possibility that unauthorised parties might obtain data. Several examples of patient data falling into the wrong hands, whether through deliberate hacking or unintentional exposure, have come to notice. Those without significant cybersecurity skills may be putting the patients who utilise their systems in danger by depending on outside cloud service providers to maintain their data infrastructure. Correct and accurate datasets are essential for patients and healthcare providers who rely on data to make treatment decisions<sup>64,99,114</sup>. Erroneous diagnosis, improper treatment, and other unfavourable outcomes might result from the deletion or alteration of data.

### 6.1. Ethical considerations associated with AI in healthcare informatics

Healthcare practitioners must guarantee that decisions made using AI technologies are in the best interests of their patients. Healthcare workers must rigorously assess the suggestions made by AI tools to ensure they are consistent with clinical competence, and human oversight of AI technologies used in healthcare must be maintained. Several laws and ethical frameworks now govern the application of AI in healthcare. Nonetheless, these policies must continue to be developed to handle the quickly changing environment. Healthcare judgements may be biased due to data used to train AI algorithms<sup>346-349</sup>. This may give rise to moral problems in which AI systems may worsen or maintain differences in healthcare outcomes across certain demographic groups. Patients and healthcare providers must know how AI systems arrive at choices. Building confidence in AI systems requires encouraging algorithmic openness and ensuring providers and developers are held responsible for their choices. Patients should be informed about their healthcare practitioners' use of AI in their treatment<sup>350,351</sup>.

Additionally, if patients feel uncomfortable with AI being used in their diagnosis or course of therapy, they should be free to refuse it or provide their approval. Healthcare providers, application developers, and data aggregators have opposing interests when deciding who owns and controls the healthcare data utilised by AI systems. This can be an ethical dilemma. AI in healthcare raises ethical concerns about privacy and monitoring, prejudice and discrimination, and the value of human judgement. Inaccuracies and data breaches are a constant concern in any technological environment, and errors in the medical field can have grave repercussions for patients. The application of AI in healthcare gives rise to worries about potential data breaches and accuracy issues<sup>352-354</sup>. Although the use of EHRs can be beneficial for clinical care optimisation, scientific research, and enhancing healthcare quality, there is a chance that data will be compromised and shared inappropriately. The ownership of a person's medical data and patient history, who will see them, when, and if consent is required are further ethical issues<sup>355,356</sup>.

The incompatibility of data formats and protocols makes comparing and sharing information between various healthcare providers difficult. This restricts the potential for insights gained from large-scale data analysis and impedes cooperation. One major obstacle to incorporating AI in healthcare is the need for data normalisation. Increasing the efficacy of diagnosis is one justification for implementing AI in healthcare. The likelihood of human error in healthcare settings may be increased by heavy caseloads and incomplete medical histories<sup>350-357</sup>. AI algorithms can identify and diagnose illnesses more quickly and accurately than medical professionals. AI makes a name in healthcare robotics by

providing unique and efficient surgical assistance. Patients benefit from less blood loss, lower chance of infection, and less discomfort following surgery because of AI's capacity to execute less invasive surgical operations that typically need open surgery<sup>351,352</sup>.

The application of AI in healthcare faces more than just technological difficulties. The expanding organisational boundaries across several locations and data sources create exponential growth that IT professionals need to safeguard. Developers and physicians work together to explore how AI algorithms improve patient care to close various gaps. They can use decision curve analysis to evaluate the accuracy of AI models. By comparing the datasets and calculating the likelihood that an AI model would succeed in the real world, they may utilise this technique to assess the clinical utility of a prediction model. Healthcare companies already benefit from AI and ML-based technologies that streamline their operations. Therefore, AI in healthcare has a bright future. Thus, individuals wanting to start a successful career in this industry must keep up with the latest developments<sup>353,354</sup>.

Serious repercussions may result from data breaches or illegal access to protected health information. AI in healthcare also brings up ethical issues that call for caution. Recognising that AI should support human judgement rather than replace it is critical. Instead of delivering patient-centric care, AI should be utilised to prioritise it. Getting patients' permission and educating them about how their data is used to create AI models is crucial. Typical AI errors in the healthcare industry are frequently not all that dissimilar from errors resulting from human error. AI-driven medical equipment, for instance, could misdiagnose a patient or fail to accurately identify a tumour because of its limited comprehension of voice recognition for various languages and accents. It is critical to remember that AI is a creation of humans; thus, maximising its potential in the healthcare industry will require ongoing oversight and input<sup>355,356</sup>.

Data is essential to the application of AI in healthcare since it is a game-changing technology. Inaccurate, consistent, and complete data on healthcare is common. An inconsistent data set introduces biases and mistakes. This might have severe ramifications for an AI model educated on such unprocessed data. Inaccurate and biased data can impact patient outcomes and sustain healthcare inequities. An AI problem statement is a concise, unambiguous explanation of a business issue that AI is to be used to solve. It describes the intended result and the information that may be used to solve the issue. Cost issues will arise from an unclear characterisation of the AI problem. Doctors and nurses will be better positioned to offer advice, support, and feedback as technology advances and new medical uses are found. AI in healthcare can analyse scans and photos, make clinical diagnoses, develop treatment plans, and enhance patient care in the future<sup>350,353</sup>.

AI in medicine has the potential to decrease avoidable human mistakes by identifying abnormalities, supporting surgeons by comprehending the grammar of surgery and anticipating readmissions by creating an algorithm that calculates the likelihood that a patient will return. An additional financial difficulty arises from an inadequate data approach. The number of iterations needed to prepare data and correct biases can be expensive and time-consuming. Longer time to market and more costs will result from this. Increased implementation costs may result from several variables, such as infrastructure expenses, under-utilisation, imprecise problem characterisation, and insufficient data strategy. Healthcare companies may expedite the introduction of AI by proactively tackling these problems<sup>357,358</sup>.

## 6.2. Role of health informatics to address various challenges

Healthcare has been enhanced and revolutionised by digital health technologies. Technology may assist in staying on the cutting edge and help to establish itself as one of the leading suppliers of technology healthcare. By using wearables and smartphones to measure health, telemedicine hopes to improve healthcare through mobile solutions. The application of technology in healthcare has expedited the creation of

goods by experimenting with other technologies, like AR and VR, holography, AI, and machine learning. Sharing information safely across various healthcare stakeholders, including physicians, insurers, plan providers, and patients, is essential to providing a comprehensive and satisfying patient experience<sup>24,39</sup>.

One reliable option to address the inefficiencies of the conventional pen-and-paper data administration method is to employ cloud-based data management tools. The most recent advancement in resolving this issue with healthcare administration is exchanging and storing patient details in a blockchain-based database. By removing vulnerability, this trend in healthcare technology can protect patient data's integrity and privacy. Mismanagement and an overabundance of data frequently result in incorrect diagnoses, breaches in data security, inappropriate care, missed appointments, inability to monitor changes in the patient's health or its regression, etc.<sup>157,167</sup>. Both physicians and patients may suffer significantly as a result. Mobile portals and cloud-based data systems are the answers to this problem in healthcare technology. Healthcare workers now have instant access to patient-related information such as registrations, medical histories, diagnoses, treatments, appointments, and more using technologies. Additionally, because the records are stored and retrieved via the cloud, they are adequately protected and updated in real-time<sup>182,199</sup>.

Technology has the power to completely transform the healthcare sector by offering cutting-edge fixes for persistent issues. Technology provides many tools and applications that may increase patient outcomes, cut costs, and improve healthcare delivery, from expediting administrative processes to enabling remote patient care. The rapidly rising cost of healthcare is one of the most significant issues facing the sector<sup>222,231,236</sup>. For many people and families, the costs of medical care, prescription drugs, and insurance premiums have become an overwhelming financial burden. Errors can occur in paper-based systems and manual data entry, harming the healthcare industry. Data processing and collecting are automated by a data management system providing instantaneous quality feedback. The healthcare sector is highly regulated, and breaking the law carries steep penalties and drawn-out legal proceedings. Data management systems offer a centralised way to track and manage information linked to compliance<sup>263,272</sup>.

Patients may obtain follow-up treatment and medical consultations remotely via telemedicine, eliminating the necessity for in-person appointments. By enabling remote patient monitoring, medical professionals may monitor their patient's vital signs and health issues, enhancing patients' access to treatment and lowering hospital readmission rates. Applications for AR and VR exist in patient care, education, and training in the healthcare industry. Surgeons can practise complex surgeries in a virtual setting using VR to imitate surgical procedures<sup>249,259</sup>. During surgeries, it can help medical practitioners visualise the anatomy of their patients. Medical mistakes remain a significant issue in healthcare despite patient safety being the primary focus. Patients may suffer grave repercussions from drug mistakes, hospital-acquired infections, and misdiagnosis. Improving patient safety protocols and lowering medical mistakes are critical to bettering healthcare results<sup>272,276,180</sup>.

Precision medicine aims to customise therapy for each patient by considering their genetic makeup, way of life, and surroundings. Healthcare professionals may discover genetic variants and create individualised treatment programmes for individuals using genomic sequencing and analysis. Accurate information about inventory levels and consumption trends is available in real time through a data management system<sup>224, 305</sup>. By using this data, healthcare organisations may optimise inventory levels, reduce waste, and guarantee the continuous availability of essential goods. Healthcare environments may become more efficient using robotics and automation technology to simplify repetitive processes. They can help with surgery, physical therapy, and medicine administration, giving up time for medical personnel to concentrate on more challenging and essential duties<sup>277,292</sup>.

## 7. Future scope

In the future, data will be gathered by decision support systems, which will then utilise analytical models and visual aids to enhance the results of decision-making processes. Along with access, storage, and administration of data, it will enable the acquisition, transmission, processing, and interpretation of scientific data for rapid application. When data analysis is helpful for research that may be documented and saved for future research initiatives, laboratory data collection and analysis occur. Programmes for analysing health data are included for present research and data storage for future initiatives. By improving laboratory equipment interactions, laboratory services can better gather, evaluate, and exchange data. However, many patients may need help to enter a portal regularly. To save time on the phone with patients or on computers attempting to access their portal, providers will begin to explore options to inform patients through encrypted SMS that may be automated. Health informatics will combine communication, information, and healthcare to improve patient care. Physicians, nurse practitioners, or therapists will see treatment gaps and make necessary adjustments to enhance patient outcomes by being aware of how the patient is doing. Robotic surgery will allow medical practitioners to perform a wide range of complicated procedures with greater accuracy, flexibility, and control than is currently achievable. Robotic surgery is frequently associated with minimally invasive surgery, which comprises surgeries performed through tiny incisions.

In future, health informatics technologies can improve patient engagement and workflow optimisation to increase patient happiness. IoT is one of the newest developments in health IT that can enhance provider-patient communication and free up more time for doctors to spend with patients. IoT devices facilitate remote patient care and assist virtual health practices like telehealth and mHealth. These devices with sensors will assist in improving patient health outcomes, promote preventative care, raise patient-doctor engagement, and improve the calibre of medical services. Wearable medical technology will play a significant role in the future of health informatics, providing high-value data for tracking individuals at risk and medical disorders. Physicians may see patterns in patient health using these devices, which can be linked to any system. Bluetooth-enabled wearables would have sensors to track various metrics, including blood pressure, heart rates, and glucose levels.

The fast-expanding field of medical informatics is revolutionising healthcare. It enhances patient outcomes and treatment by fusing medical expertise, technology, and data analysis. Healthcare professionals may identify and treat patients more quickly and precisely using medical informatics. Medical informatics may give healthcare professionals a more excellent knowledge of a patient's condition through data and analytics, enabling more precise and prompt treatment. Health informatics uses data security and healthcare automation to streamline the healthcare business's operational procedures, such as medical billing and appointment scheduling. Health informatics mainly focuses on an electronic system that stores and allows patients and doctors to access patient data and other information, such as training materials or brochures. Patients can access pertinent health information for clinicians inside the healthcare informatics technology system.

Informatics technology will help administrators and organisations plan and provide safe and effective services by giving them instant access to vital information. Informatics enables medical practitioners and healthcare institutions to meet community health needs and connect with patients in remote places. Technology assists healthcare professionals in maintaining accurate and dependable patient data and lowering service mistakes like prescribing contradictory medication. Furthermore, it facilitates the exchange of health information with other organisations, enabling healthcare practitioners to act quickly and with solid evidence. Drug discovery powered by AI will find promising molecules for a broader range of illnesses more quickly. As a result, new medications and therapies may receive approval more quickly. AI-

powered telemedicine solutions will make it possible to monitor patients remotely, guaranteeing prompt interventions and lessening the workload for medical institutions. This technology can evaluate population health data to forecast disease outbreaks, monitor trends, and effectively distribute resources, improving public health management. With further advancement, minimally invasive surgeries will become more precise and need less recovery time using robotics and AI-assisted surgical equipment.

## 8. Conclusion

Health informatics combines data analytics, data science, and information management to gather, examine, and use data to enhance health outcomes. Informaticists design and assess data collection and data usage systems to improve efficiency in healthcare organisations. This paper explores health informatics's evolution, technologies, benefits, roles, and challenges. The ultimate objective is to discuss how it helps to improve patient outcomes, reduce costs, and improve healthcare services. This examines the interface between information science, computer science, medical informatics, and health care informatics. It is used in numerous scientific fields, including public health, dentistry, and pharmacy. Health data management is made more accessible by health tracking software. In essence, businesses may utilise or create various health informatics software. It demonstrates how the health informatics business is developing and how a health informatics company has a wide range of alternatives for providing goods and services to clients. The use of advanced analytics techniques and the ongoing geometric growth in the amount of data that can be analysed will impact nearly every aspect of healthcare, including the automation of administrative procedures, the accuracy of insurance rates, and the application of AI in diagnostics. Patients can use patient portals to obtain personal health information such as medication information, appointment data, and test results.

Data analytics will revolutionise how healthcare services are delivered in as diverse areas as treatment, prescription research, and sickness prediction. The clinical IT system makes essential information sent by either side available to guarantee that the correct data reaches the providers and is updated as needed. Concentrating on current demands when purchasing a health informatics system rather than planning for future objectives is advisable. Persistent problems need to be addressed by an adequate health informatics system. From diagnosis to therapy, medical informatics can assist in simplifying the healthcare process. Medical informatics can help healthcare professionals save time and money by automating some processes. Medical informatics can help cut costs for patients and healthcare providers by optimising the healthcare process. While better diagnosis and treatment can lower the cost of care, automating some operations can also save administrative expenditures. By giving medical professionals access to a patient's prescription history, medical history, and other pertinent data, medical informatics can improve access to treatment. This can assist medical professionals in making better judgements and giving patients better treatment. Healthcare organisations are emphasising the integration of informatics for health professionals into their operational strategies as the field advances with forward-thinking innovations like predictive analytics and EHR system interoperability. Medical informatics assist healthcare practitioners in enhancing patient care, safety, and cost-effectiveness by utilising technology.

## CRedit authorship contribution statement

**Mohd Javaid:** Writing – original draft, Resources, Investigation, Conceptualization. **Abid Haleem:** Writing – review & editing, Supervision, Conceptualization. **Ravi Pratap Singh:** Writing – original draft, Conceptualization.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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