Health Informatics: Challenges and Opportunities

Chapter · October 2020

DOI: 10.1007/978-3-030-54932-9_10

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Chapter 10
Health Informatics: Challenges and Opportunities

Mehedi Hasan Raju, Mosabber Uddin Ahmed, and Md Atiqur Rahman Ahad

Abstract Health Informatics (HI) imposes informatics concepts, theories, and practices to real-life circumstances to attain improved health outcomes, which incorporate not only collection and accumulation of data but also data analysis and presentation. A plethora of research activities has been going on in the field of HI due to the widespread of its probable applications. This chapter presents a comprehensive treatise on HI, its potential challenges, opportunities and some recommendations as the future directions for HI. All the pertinent aspects are discussed in this chapter with a view to relating their significance in HI and its applications. On the whole, the chapter ensures the fundamental information one needs to step into the world of HI.

Keywords Health informatics · Health IT · EHR

10.1 Introduction

Informatics is an extended type of information science and information engineering branch. In this field, information processing and information systems engineering are addressed. This field relates to the human-information relationship as well as the integration of boundaries, connections, experiences, emerging technologies, and controlled networks. This led to the appraisal of informatics with computational, statistical, natural, subjective and social perspectives, including the investigation of technology's social effect. Hence, the field of informatics is exceedingly wide and includes numerous subareas, including data science, information systems, and statistics.

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M. A. R. Ahad and M. U. Ahmed (eds.), *Signal Processing Techniques for Computational Health Informatics*, Intelligent Systems Reference Library 192,
https://doi.org/10.1007/978-3-030-54932-9_10

In the medicinal sector, the use of computer is not new and it is developing at a very high rate. Healthcare system utilizes innovative technologies to improve medicinal services. Health Informatics (HI) has grown as an advanced science with the extension of electronic health records (EHRs) and health data analytics systems. It has additionally developed with the establishment of health data exchange standards, such as HL7 (Health Level 7) and FHIR (Fast Health Interoperability Resources) [1]. Nowadays, healthcare system organizes, analyzes, and deals with health records by using information technology. It manages the assets, devices, and strategies to use attainment, storage, recovery, and utilization of data in health and medication. It affords to grant access to medical records for patients, specialist doctors, nurses, hospital administrators, caregivers, and the stakeholder related to the system. For that reason, HI is also called the health information system, or biomedical informatics.

It should be mentioned and noted that HI focuses on information related to health, not technology. In HI, health data has been collected, processed, used, analyzed, shared, and stored (Fig. 10.1).

To abridge, HI is an evolving specialization aspect of informatics that connects information technology, communications and healthcare to improve the quality and safety of patient care and ensures higher quality, higher efficiency, lower cost, greater availability, and new opportunities to the existing health care system. It incorporates a set of methodologies for the management of information in the health sector [2, 3].

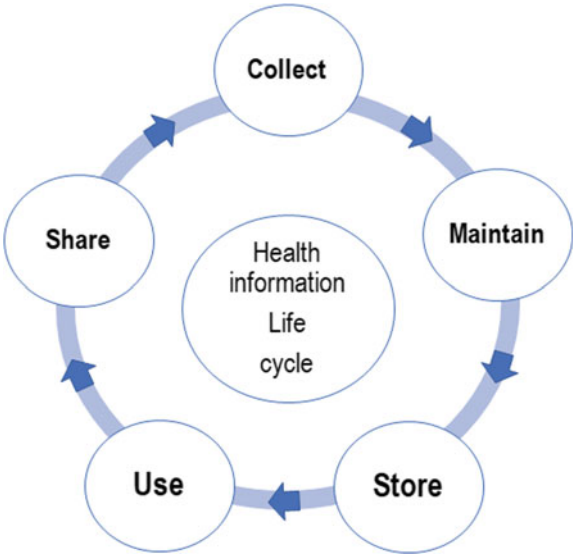

Fig. 10.1 Health information lifecycle

10.2 Aspects of Health Informatics

HI brings state-of-the-art technology in healthcare sectors. Both patients and clinicians are depending on new electronic technology and information system. Several ways of keeping the patient engaged and then being allowed to treat by more informed and prepared clinicians are addressed below:

(1) **Electronic Health Records (EHR)**

Patients visit several doctors because of their several health-related issues. Paper-based records were a matter of hassle for the patients. Similarly, doctors also failed to learn about the patient's health history properly. Electronic Health Records (EHR) makes this situation easier. Patients no longer have to sum up their personal history in case of emergencies. When they consider moving to other clinicians – patients and their families no longer need to worry about forgotten pediatric names or lost records of medicines. Instead, the medical staff will have much of the information available for review in the EHR.

(2) **Decision making support to improve patient care**

For a patient, proper assessment/diagnostic and treatment is the most important of all. HI ameliorates the standard of treatment to patients by healthcare sector. HI helps data to be processed and recovered easily and effectively, but can also be a resource of decision-making. Computerized protocols offer advantages that help make better decisions for physicians and clients. With this, it is possible to maintain high quality care.

(3) **Reduce treatment costs**

Due to medical errors, every year a huge amount of money has been wasted. HI can reduce that cost at a larger amount. Because using Electronic Health Records, patient's information is in safe and reliable hands. EHR not only minimize such mistakes but also work to take most productivity-intensive tasks out of the preoccupied hands of medical personnel. Such procedures are streamlined to save extreme expenses for the health sector and consumers.

(4) **Standards**

HI's involvements in healthcare sector are changing the traditional way of researching on public health and ailment, and are providing better treatment [4]. HI is transforming the standards of thinking and clinician's activities. Doctors are now using different wearable and contactless technologies for patient monitoring as well as remote treatment [5].

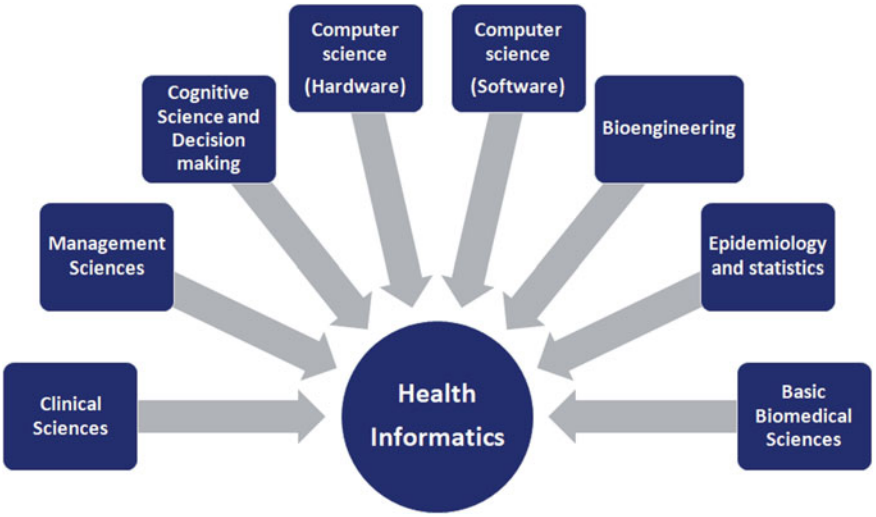

Fig. 10.2 Health informatics with other disciplines

10.2.1 Interdisciplinary Nature of Health Informatics

HI is a multidisciplinary study in identifying, implementing, incorporating and integrating information and technology-based advancements in the distribution, administration, and preparation of public health and health care (Fig. 10.2). It has attachments with clinical science because of clinical research works, cognitive science and decision making. These aid to evaluate the situation based on the statistics. Similarly, the multidisciplinary nature of HI brings together different aspects of biomedical science, bioengineering, computer science, management science, etc.

10.2.2 Health Information Technology (HIT) Versus Health Informatics (HI)

In spite of the fact that the idea of Health Information Technology (HIT) incorporates the utilization of technology in healthcare, HI is not synonymous with HIT. There exists a fine line of difference between these two domains. While the two fields are related, there are distinct differences between health information technology and HI. Health information are exchanged and shared with HIT. This field implements the process that generates electronic health records and electronic prescribing, ensures data security and privacy and interoperates the records across multiple organizations.

On the other hand, HI utilizes the available data to secure, organize and evaluate data related to patient care. HI does so with the help of HIT directly. HI deals with electronic health records in an interdisciplinary approach to create new solutions

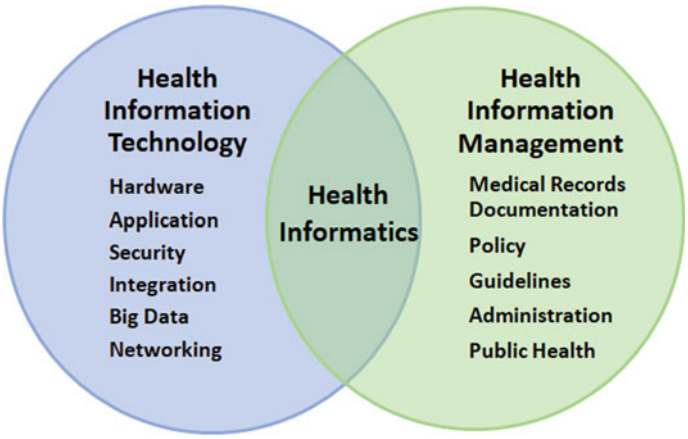

Fig. 10.3 Relation between HIT and HI

intended to improve the delivery of public and private healthcare services. It designs patient data systems, manages information database and analyzes patient data using health information technology. Figure 10.3 demonstrates a relationship between HIT, health information management and HI.

10.3 Application of Health Informatics

10.3.1 Translational Bioinformatics (TBI)

Bioinformatics functional related to human health and disease is termed as Translational Bioinformatics (TBI). It utilizes and expands the ideas and techniques from bioinformatics to support the act of translational medicine, for example, the interpretation of natural disclosures into real effect on clinical consideration and human health. TBI links up the gap between bioinformatics and HI. Translational bioinformatics includes the advancement and utilization of computational techniques that can reason over the tremendous measures of life science information being gathered and put away to make new instruments for medicine [6]. Translational bioinformatics can be defined as "the development of storage, analytic, and interpretive methods to optimize the transformation of increasingly voluminous biomedical data, and genomic data into proactive, predictive, preventive, and participatory health" [2] (Fig. 10.4).

American Medical Informatics Association (AMIA) considers the translational bioinformatics as one of its three major fields of informatics. It is a sub-domain of HI, which integrates molecular and clinical data to facilitate a new translational propositions between the field of biology and medicine [7, 8].

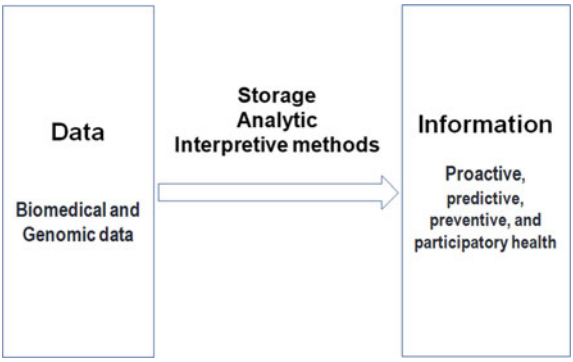

Fig. 10.4 Translational bioinformatics

10.3.2 Clinical Research Informatics (CRI)

An energetic and emergent sub-discipline of informatics has risen at the convergence of biomedical informatics and clinical research, which we will allude to as Clinical Research Informatics (CRI). CRI has added to upgrade the quality, proficiency, and convenience of clinical research. It is associated with developing, analyzing and applying computer theory, processes and applications to amend the scope and conduct of biomedical research and to distribute the acquired information [2]. Clinical research is a science that promotes the assessment of the efficacy and safety of medicines and devices, surgical techniques and differential diagnoses. Therefore, clinical research informatics is a branch of the informatics that advocates all these research activities, especially information gathering, procurement and evaluation for diverse types of claims [9, 10]. The United States describes clinical research as "The range of studies and trials in human subjects that fall into three subcategories: Patient-oriented research, Epidemiologic and behavioral studies, Health services research" [11].

10.3.3 Clinical Informatics

Clinical informatics is the utilization of HI and IT to convey medical services to mass people. It is often alluded to as applied clinical informatics and operational informatics. Clinical informatics offers a wide range of subjects involving medical decision guidance to visual information; from patient records to prescription management systems, and from management to execution and acceptance concerns [12]. When used for health care, American Medical Informatics Association (AMIA) assumes informatics to be practically the same regardless of the community of health professionals' involved. Clinical informatics examines, develops, incorporates and reviews systems information to improve quality of life for the mass people, ameliorate patient care, and reinforce the relationship between doctor and patient. Due to the practice of

clinical informatics, electronic health records are being used to carry out medicinal research, public healthcare services, etc. and it is increasing day by day. Moreover, clinical informatics is raising the standards among consumers about how the computer tools communicate [11–13].

10.3.4 Consumer Health Informatics

Considerable growth has been visualized in the consumer health informatics sector for the last 25 years. Consumer health informatics services can promote quality care and can integrate care for patients, modify medical behavior, maintain information and make decisions [14]. It is a subdivision of the health informatics that scrutinizes the needs of users; researches and executes processes of rendering information widely available; and models and strengthens the connection among specialists and patients [15]. Wireless as well as wearable devices have influenced the evolution of consumer health informatics at an early age [16]. Consumer health informatics remains at the intersection of different fields, for example, nursing informatics, healthcare advancement, proper health training, etc. Probably, it is the most tested and quickly extended field in medicinal informatics. Consumer health research helps individuals with noncommunicable diseases to manage the complex healthcare environment with real-time tracking, new devices, and quick access to substantial guidance to endorse risk management [17]. Patients face many problems while seeking health services. Consumer health informatics could guide the care seeker for getting proper treatment and run the system from the patient's perspective [18].

10.3.5 Public Health Informatics

Public health services have implemented health information systems and information technology as a potentially transformative tool for developing processes of real-time reporting, coordination, and knowledge sharing through different institutions. Public health informatics is assigned to protect and enhance community health by delivering efficient and productive training, sound ways of life, just as an anticipation of ailment and damage [19]. The effective and reliable assortment of data and knowledge on quality public health is complex. It is the cornerstone of the roles of public health, such as inspection, analysis for public health, and evaluation [20]. When personal data gathering and processing is rapidly being used, there is an overemphasis on information management systems [21].

It factors in the need for public health teams to be able to design and execute these programs of Public Health Informatics (PHI) specialists. PHI professionals refer to the principles of information technology to support technological advances that enhance the quality and efficiency and dissemination of information used only

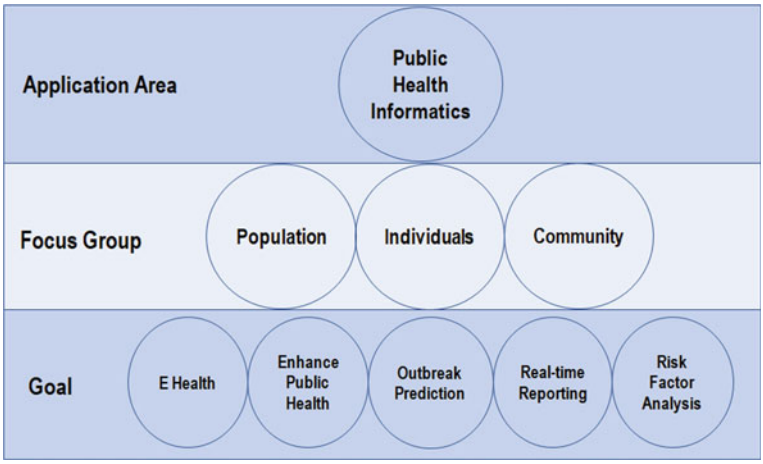

Fig. 10.5 Various aspects of public health informatics

to ameliorate public health and its services [22, 23]. In creating and sharing electronic data, both medical care services and public health organizations are increasingly using public health informatics. Such initiatives reflect substantial growth in a variety of health-centric exchanges of information and insights [24]. Figure 10.5 depicts various aspects of PHI, covering the focused group and goals. PHI focuses on the individuals as well as the whole community with the objective of E-health, improvement of medical facilities, and preparing the community for any kind of pandemic/outbreaks.

10.4 Privacy Issues and Challenges for Health Informatics

Research on health informatics has several interesting challenges to face [25]. Important challenging aspects are highlighted below:

(i) **Conventional healthcare environment**

Embracing new models of reliable information epoch might be a troublesome adventure given the present timetables from production to execution and use. The existing administrative condition encompassing conventional medical devices implies so. Trusted and reliable connections among a range of devices are critical aspects that are required to excel in HI. The expanding connectedness and the reduction of authoritative limits however present data security concerns.

(ii) **Infrastructure issue**

HI brings new security problems and challenges. The issue of dynamic versus static network, with no fixed end focuses implies that a considerable amount of the existent communication mechanism for moving messages safely may not work properly. This implies that there are critical difficulties in the security and administration of this information, just as its assurance and security. At present, these associations are profoundly dependent on trust. If the medical device engineer does not consider cyber-attack threats while designing the devices, it can be termed as technical debt [26]. The faulty devices showed unpredictable and unusual behaviors in their functionalities. The significant concern is the effect of misuse as opposed to the abuse itself.

(iii) **Device diversity, interoperability and vulnerability**

Different types of medical wearable devices have been used in the health informatics system. So, interoperability between those devices is a big concern. It has to be an interoperable system where data need to be transferred both one-to-one and one-to-many connections, including information exchange across multiple interfaces where the devices need to be compatible with one another. It is mandatory to consider that in any communication between multiple systems, the combination of interfaces is almost double. There is no collection of information regarding the capability of the devices. Device registry requires indexes of devices functionality, conventions, phrasings and standards. The system's interoperability made the system invulnerable to different threats.

(iv) **Data integrity and consistency**

Data integrity is a matter of concern for HI. Data integrity means preserving the original data even in the case of any alterations. Ensuring integrity in a HI system guarantees the correctness of data which leads to minimizing errors and improving the safety of patients. As of now, approved clients are also making mistakes because of their inadequate knowledge about the system. Everyone is using the different features of the system without proper knowledge which makes the system inconsistent. Dealing with huge number of data is a challenge for HI [27]. Moreover, for every information exchanging system, heterogeneous data is another issue to face [28].

(v) **Privacy concern**

The utility of information is expanded when a significant number of people in the area use it. A few information or datasets are openly accessible, while numerous different sorts of information have various degrees of privacy concerns. Medical information is considered the most private sorts of information and access to this information is profoundly sensitive and must be approved to be accessed by assigned experts [29]. Privacy in the healthcare sector may make different results to the patients including the refusal of the administration to death. For specialist co-ops, privacy breaches can prompt legitimate authorizations, financial loss, or loss of goodwill [30]. Besides, health data must be audited in regular intervals [31].

(vi) **Data access control**

Information access to information control is considered as topmost constraints for ensuring privacy and security to any data. For HI, it is mandatory to control access over the whole system. The whole system supposed to have different access segmentation. While guaranteeing CIA triads, protecting patients' vital pieces of information from unauthorized divulgence is fundamental under any conditions. All in all, the patient is characterized as the maker of the data. Building up the responsibility for data is essential for securing the system from unauthorized access and manipulating the patient's health-related information. Other than patients, staff who are taking care of the patients can be termed as the supervisor of the health information of the patients [32]. Authorization is mainly carried out by a security mechanism called access control. Medical data are stored in the cloud which is distributed covering a larger area. Sometimes it makes a challenge for the system.

(vii) **Human factors**

Human being becomes a crucial factor while using a system like HI as we have a huge role to play. Staff training is a prerequisite for developing a technology-based health system. Because, as per the research conducted by KTH University, a human factor is considered as the ultimate challenge in 76% of the time [33]. So, a usability study is required before developing and adopting a whole new system of HI.

(viii) **Laws and ethics**

Laws and ethics sometimes become the reason of privacy breach. Hospitals and governments provide records about the patient and his/her diseases to the research agencies so that research agencies could help, in case of a disease outbreak. The government supposed to ensure that the research agencies dealt with that information in the best way without causing any misuse of it.

(ix) **Data authenticity**

Authenticity is simply the validness of the data. Authenticity depicts the accuracy, truthfulness, and specifications related to data. It establishes or confirms that all the claims are true and authentic. Due to the lack of authentication of information, attacks like man-in-the-middle (MITM) could take place. To prevent this kind of attack, endpoint authentication is required in the cryptographic protocol.

(x) **Confidentiality and availability**

Confidentiality includes a lot of rules so that the private information could not be accessed by general mass. The facility to protect the information in the HI system so that it can only be accessed by authorized subjects is called confidentiality. Authorized subjects receive access based on their working role. Thus, nothing about the patient's health record should be shared without their consent.

The system ought to have the option to be accessed whenever required by approved ones, for instance, on account of any crisis circumstance a particular doctor needs access to the patient's record to complete analysis and favor prescription to a patient. The system ought not to be obliged to a particular time generally; a patient may require a doctor's support any time. Thus, the system needs to be available 24/7.

(xi) **Site recruitment**

Different difficulties, for example, issues with site recruitment, are critical to talk about, yet cannot be resolved legitimately through HI alone. Community health centers engage themselves in a network and showed interest in an active collaborative network in order to have a mutually beneficial relationship with other sites and users of the network. The whole process is termed as site recruitment [34].

(xii) **4 V's**

There are 4 V's which are challenging for HI [35]. Those are volume, variety, velocity and veracity. Here volume means lots of medical data, which due to variety of sources with high velocity to process creates complexity because of veracity. It is difficult and daunting to deal with large quantities of healthcare data, coming from varied data sources. Moreover, it varies in its eminence and intricacy and also it is difficult to generate and process such amount data [36]. Health care sector dealt with data that are often biased, full of clatter and anomalies that create a potential threat to proper decision-making processes and treatments for the patients.

10.5 Opportunities and Future Goal of Health Informatics

If we could overcome the challenges mentioned above, there are a lot of opportunities for the HI sector. Let's have a look at those opportunities.

Personalized treatment: Within a very short time, HI will be able to provide personalized treatment to everyone. It will improve the standard of treatment; patients will receive the best practice form the specialists, while doctors will be able to detect any diseases before a patient shows any symptoms. In HI, the recommender system will be used, which realizes a few chances to the healthcare sector in particular in personalized healthcare as they give significant data to the patients [37].

Public health service standards: Through using information science in the healthcare sector, a large number of general people can be benefitted. With the help of a nationwide database for patient's health records, contagious diseases and outbreaks can be prevented easily, consequently benefiting the whole population [38]. Health equity can be achieved through HI [39]. For example, vision-based action analysis like monitoring, rehabilitation treatments are the outcome of improvement of public health standard as well as healthcare sector [40, 41].

Remote monitoring: Caregivers do not require sitting the whole day by the side of patients to monitor his/her health status. HI will allow the clinicians to monitor the patients remotely and observe multiple patients at a time.

Telemedicine: Telemedicine is providing health services from remote distance through electronic signal [42]. HI is a part of telemedicine umbrella that covers distance healthcare service [43]. More specifically, telemedicine can extends its dimension through HI as the use of computerized database, records, information access as well as decision making based on medical data can revolutionize the healthcare sector [44].

Heredity analysis: Heredity analysis is a hot opportunity for HI. HI can incorporate genome analysis in the conventional decision-making methods of health care by designing innovative and reliable tools for gene sequencing. This will create a whole new way of public health treatment. The genomic advancements are capable of facilitating inference, treating especially inherited infections and multi-faceted diseases [45].

10.6 Some Representative HI Service Providers

Eclinicalworks, LLC [46] is a pioneer in healthcare IT, giving thorough EHR and Practice Management (PM) arrangements utilized by more than 850,000 medical professionals in 20 nations. Their service includes telehealth, EHR, population health management, patient management, etc. It offers unified and integrated healthcare IT solutions for medical professionals.

NextGen healthcare [47] is a leading EHR and healthcare practice management software solutions for ambulatory care providers. Their service includes care coordination, EHR, electronic data interchange, health information exchange, population health, patient management, tele solution, etc.

McKesson Corporation [48] is a multifaceted company distributing pharmaceuticals and providing health information technology, medical supplies, and care management tools to the users. Through their services, McKesson ensures improvement in healthcare sector. However, there are other partners and in this chapter, we are not enlisting them. These three examples are mentioned to provide an overview of the few HI service providers.

10.7 Recommendations for Advanced Health Informatics

HI is extremely important in improving quality and minimizing health care costs. Thus, efforts to protect the privacy of patients will focus on finding ways to protect confidential digital medical information in an electronic world. Some recommendations are made for advanced health informatics for the future:

- While considering the improvement of the safety and security of HI, healthcare organizations need to take a more active strategy. HI is lagging due to a lack of active managerial incentives. Strong management and trained manpower/staff will help the system to adopt strong approaches [49].
- The main concerns about patient data privacy emerge from the open exchange of information across the healthcare sector and the dysfunctional central and provincial regulatory system for the careful security of health information. The regulatory sector needs to be more effective and careful regarding the patient's information [29, 50].
- Different countries of the world are getting HI services through many companies. However, it is a matter of concern that the developing/underdeveloped countries are lagging behind. So, there is a lot to develop in this sector in a cost-effective way so that developing/underdeveloped countries could be a beneficiary of HI.
- Government institutions like the ministry of health or other non-profitable health organizations should work actively with the objective of proper health informatics development [24]. The policymakers should develop a sustainable economic model for the healthcare sector incorporating health informatics and initiate infrastructure for HI.
- Health insurance companies should have decisive coordination with health informatics service providers to improve individual health conditions and healthcare care sectors as well.
- Unauthorized access to information should be monitored. The healthcare organization itself should take initiatives to control and design the system as per privileges. Last but not the least, when resolving privacy and security issues, physicians, as well as patients, have vital roles to play.
- Telemedicine has a vital role to play in this modern life; specifically, COVID-19 pandemic makes it clear for us. Integrating HI in telemedicine will add a new dimension to the healthcare sector.
- System and device compatibility are recommended for HI advancement. Transition from conventional to advanced HI cannot be achieved overnight. Ensuring compatibility will make the process smoother.
- Adequate learning opportunities for doctors as well as medical staffs are recommended for developing a new system and for the improvement of the sector as a whole [49, 51].
- There are lots of signal processing techniques for HI. However, all techniques have some flaws or some restrictions to work on [52]. So for advancement of healthcare, advancement in processing techniques is mandatory.

10.8 Conclusion

HI focuses on real-life circumstances, informatics principles, hypotheses, and procedures to produce better health benefits. It collects data, compiles them and does the proper analysis. Because of its possibility of extensive uses, a multitude of research

practices has been taking place in the area of HI. In this chapter, the basic concepts of HI have been discussed. Its difference from HIT and other fields of informatics has been stated clearly here. This chapter depicts the widespread activities of the sub-branches of HI and the potentiality of HI as a whole. Challenges and privacy issues are a concern for HI. We stated those issues and provide some potential recommendations for improving the situations. Health informatics with the current groundbreaking improvements has the prospect to further improve the healthcare system in the future.

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