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Pervasive Healthcare

A Compendium of Critical Factors
for Success

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We dedicate this book to our parents.

Preface

Pervasive computing is a technology paradigm which enables information services available anytime and anywhere while making the presence of the system invisible to the user. Pervasive computing is expanding its applicability in various domains like Education, Medical, Transport and Sport by allowing much more robust local as well as remote monitoring.

Pervasive healthcare provides solutions for a lot of issues in the healthcare system and is currently a hot research area. The purpose of pervasive healthcare is providing quality medical assistance anywhere and anytime by improving medical information access using ad hoc networks. Pervasive healthcare is a scientific discipline which counters the challenges faced by traditional healthcare system like increasing population, increase in the lifestyle-related diseases, and lack of medical professionals. It helps in providing personalized healthcare monitoring (both long term and short term). The task of pervasive healthcare ranges from incidence identification and management, alarming and handling the emergency situations, monitoring the patients and treat them remotely.

Emerging Need

With the advent of Information and Communication technologies many sectors have started to make use of them. Healthcare industry is way behind in applying sophisticated technologies to support patient as well as medical staff. The use of handheld ICT devices as well as sophisticated tools based on IoT and other sensor devices is increasingly encouraged however, due to issues like lack of technical knowledge of these systems/methods, complex processing, robustness and reliability of applications, fear of information being compromised or loss, lack of time for training to adapt such complex tools/applications. Furthermore, many healthcare providers and hospitals prohibit the usage of sensors or wireless devices within their buildings in fear of interference to more critical medical devices.

Although most of the experts in the healthcare industry believe that with the help of sophisticated techniques, wireless devices, and sensor technologies we can better facilitate the medical staff and give personal care to patients, even effectively monitor patients remotely.

There are several challenges that need to be addressed to make pervasive healthcare a reality.

Purpose

This book will provide in-depth knowledge about critical factors involved in the success of Pervasive Healthcare. The book will deal with the important aspects like challenges, needed infrastructure and security concerns for pervasive healthcare. It will give insights into the pervasive healthcare information system and key consideration related to remote patient monitoring and safety. This book will provide an in-depth discussion of the security issues and protocols for pervasive healthcare.

Audience

This book will explore the concepts/techniques behind the successive Pervasive Healthcare Systems by providing in-depth knowledge about patient empowerment, remote patient monitoring, network establishment, and protocols for effective pervasive healthcare. It will assist individuals as well as organizations in understanding and implementing the smart healthcare system. It will be an ideal resource for researchers, students, and healthcare organizations to get insights about the state of the art in Pervasive Healthcare system.

Emphasis

The proposed book will deal with various aspects of the successive implementation of Pervasive Healthcare in the current scenario including network, information system, protocols, safety and privacy issues, etc.

What You Will Learn

By going through the material presented in this book, you will learn:

- The concept of pervasive healthcare, how it can contribute in providing better record management, patient care, chronic and preventive care.
- The applications of pervasive healthcare techniques.
- Challenges in pervasive healthcare.
- How we can improve the health critical infrastructure of public healthcare system.
- The data privacy in pervasive healthcare.
- How you can apply machine learning approaches and data mining techniques for effective pervasive healthcare system.
- What are the latest trends in pervasive healthcare?
- Use of latest machine learning approaches for different applications like diagnosis of patients, prediction of diseases, and providing remote monitoring of patients.

Book Organization

The early chapters of the book are organized in order to provide conceptual background, starting with an introduction to pervasive healthcare, its importance, the objectives of pervasive healthcare, pervasive healthcare as a scientific discipline, and the current challenges (Chaps. 1–4). This is followed by a chapter on how we can improve the healthcare infrastructure using soft computing techniques (Chap. 5). After this, in the following chapters we discuss the state-of-the-art machine learning approaches which can be applied to solve problems like computer-aided diagnosis, disease prediction, security and privacy. It also provides insights into how we can make use of body sensor networks (BSN), Internet of Things (IoT), cloud infrastructure, machine learning and artificial intelligence in enabling effective pervasive healthcare infrastructure (Chaps. 6-21). Three chapters provide a case study of COVID-19, the pandemic the world is suffering from (Chaps. 10, 19 and 21).

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We thank our reviewers from renowned institutions to spare time from their busy schedule and put a lot of efforts to provide time-constrained impartial and critical review which is very crucial in maintaining the quality and standard of the book and helps us to finish the book in time.

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This acknowledgment will not be complete until we pay our gratitude and regards to our parents and family members for their unflinching support and encouragement to us in all our pursuits. It is the confidence of our family members in us that has made us the person that we are today. We dedicate this book to them.

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Last but not least we are heartily thankful to almighty God for showering His blessings forever during our entire life.

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Chapter 1
Pervasive Healthcare Computing and its Contribution to Hospitals, Chronic and Preventive Care

Abdullah, Hagos Yirgaw, Solomon Aregawi, Haftay Gebrezgabiher, and Mahfuzul Huda

1.1 Introduction

Pervasive healthcare computing has the prospect to make a key influence in cumulative overall access as well as superiority of healthcare facilities though containing expenses [1–3]. Pervasive computing offers solutions for hospitals, doctors, clinicians, patients, as well as a range of additional caregivers to facilitate them using these problems together with uses and apparatuses to make the recording easy. The following is an observation of fitness data/information:

– Permit message, association also management among the various participants.
– Inspire clinical devotion as well as disease anticipation.
– Facilitate the roaming effort of clinicians and the whole integration of the real as well as digital worlds.
– Allow the expansion of innovative medicinal plans.

In addition, pervasive computing furthermore decreases the paper work by way of removing the requirements of paper-based records and increases the managerial productivity [4–6]. It increases the healthcare services by means of reducing medicinal mistakes by a guarantee that all the healthcare workers have perfect as well as appropriate information [7, 8]. Pervasive healthcare computing in common is progressively more regarded as the greatest encouraging instrument for increasing the total superiority, security, and effectiveness of the health distribution method [9].

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In excess of the previous few decades, the implementation of pervasive healthcare computing and health information technology has develop progressively shared in healthcare backgrounds [2, 10]. The healthcare sector has a continuous trust on machineries and technologies [2, 4]. The emphasis is to avoid relatively than cure an illness through surveillance of circumstances as well as the advancement of strong performances. This may possibly only be attained once the data associated with the health of the society touches the associated doctor's healthcare authorities, hospitals, policy creators, as well as managers at an exact time wherever and at what time they requisite [3].

1.2 Pervasive Computing for Hospital Care

The wish an increase in patient care initiates the proposal and implementation of novel wireless network and information technologies in the healthcare environment [11–14]. In the previous two decades, there has been a huge investment worldwide in pervasive computing and pervasive healthcare systems [15]. Even although pervasive healthcare systems are frequently leisurelier than other sector industries in accepting novel information and communication technologies, healthcare system has relocated rapidly in the direction of the use of technologies to increase overall patient care and decrease budgets as well as medical errors [11, 16, 17]. Pervasive computing plays a key role in relation to achieving quality healthcare goal to deliver appropriate services that reply directly to their users and backgrounds and in setting up of healthcare main services [3, 5, 18]. The furthermost common are:

1.2.1 Context-Aware Services and Awareness

Medical doctors make decisions that are extremely prejudiced by background information, such as timing, locality, as well as obtainable resourcefulness. Intended, for instance, access to a patients' medicinal information is additionally significant once the physician or doctor is in the obverse of a patient's cot. Consequently, a physician's or doctor's locality is valuable in the decisive kind of record she/he may call for at a given moment [19, 20]. Field trainings of doctor work have been publicized that doctors keep a peripheral device consciousness of persons at work in direction to preserve the temporal outlines or "rhythms" [21–24] of job which is frequently used to organize activities as well as donate to the steady temporal association of the hospital.

Fig. 1.1 Hospital information system (https://drdollah.files.wordpress.com/2014/07/his2.png)

1.2.2 Hospital Information System

The "hospital information system" is visualized as it comprises dual wide-ranging systems, i.e.:

1. Information system for patient care.
2. Managerial information management system (Fig. 1.1).

Information System for Patient Care

The hospital information management system can be wide-ranging distributed into dual folds:

1. The system intended for the patient care purpose.
2. The information management system intended for managerial purpose.

   Conceptual division of systems for patient care (Fig. 1.2).

1.3 Major Goals and Purposes of Patient Care Information Systems

Being a system for supporting processes, these groups of subsystems as well as applications are probable to make use of automation and information technology optimally to appreciate anticipated goals in the subsequent extents:

- Output
- Usefulness
- Suitability
- Competence
- Excellence
- Protection
- Confidentiality and secrecy of information

Fig. 1.2 Patient care information system (https://drdollah.files.wordpress.com/2014/07/pcis1.png)
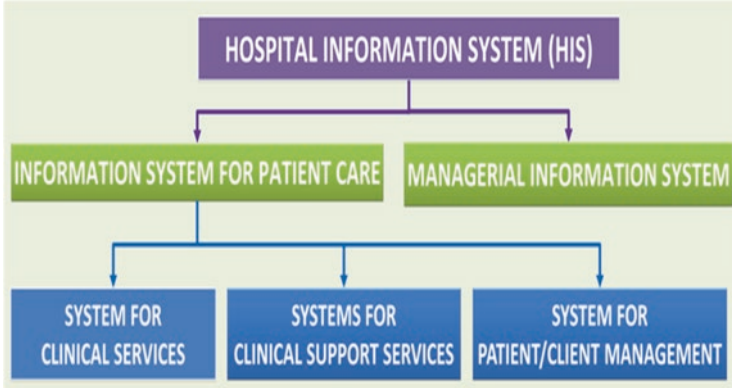
1.3.1 The Associations of the System Are Shown in the Graphic Representation Underneath: Healthcare Information Management System

All the above developed systems are used by healthcare/hospital persons to take care for related patients. Care is here precise as all work doings to provide facilities to patients in reply to their requirements (Fig. 1.3).

Clinical Information System

The clinical information system comprises application units that allow the following:

- Preparation of carefulness (procedure of care plans)
- Setting up of clinical decision support system
- Medical data records (data entry system)
- Quality control mechanism
- Record storing for further use
- Record retrieval and display

Major modules of the clinical information management system (Fig. 1.4).

Clinical Support Systems

Clinical support system mentions facilities that:

- Perform related tests
- Provide supplies timely

Fig. 1.3 Hospital information system (https://drdollah.files.wordpress.com/2014/07/pcis.png)
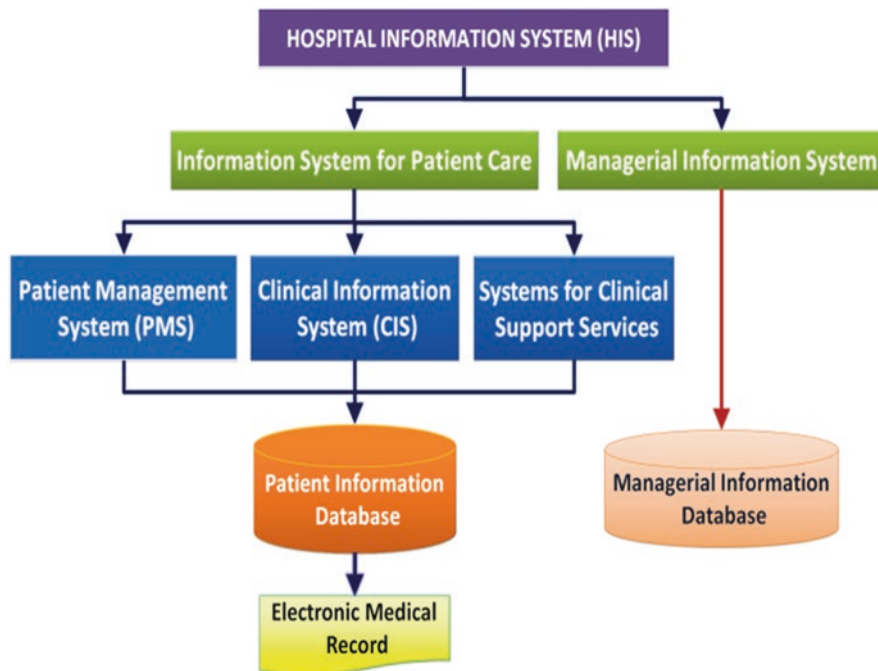
Direct healthcare providers demand in lieu of these service areas over the instruction entry functionality. Examination outcomes are submitted to the database management system on or after where they are ready to be available. Prescriptions, sterile supplies, blood products, as well as foodstuff are supplied to persons demanding them. The supplies they received are documented in the database management system (Fig. 1.5).

1.3.2 Electronic Medical Record (EMR)

The electronic medical record provides medical doctors with simultaneous access and retrieval to patient records [2, 4, 25], for example, patient health condition, official visit to health providers, images as well as reports of investigative processes, timetable of facilities, reactions as well as communication information to caregivers, and a whole longitudinal data of care indication founded on judgment support apparatuses that can be applied to support healthcare persons in decision-making.

Fig. 1.4 Clinical information system. (https://drdollah.files.wordpress.com/2014/12/cis-latest.png)
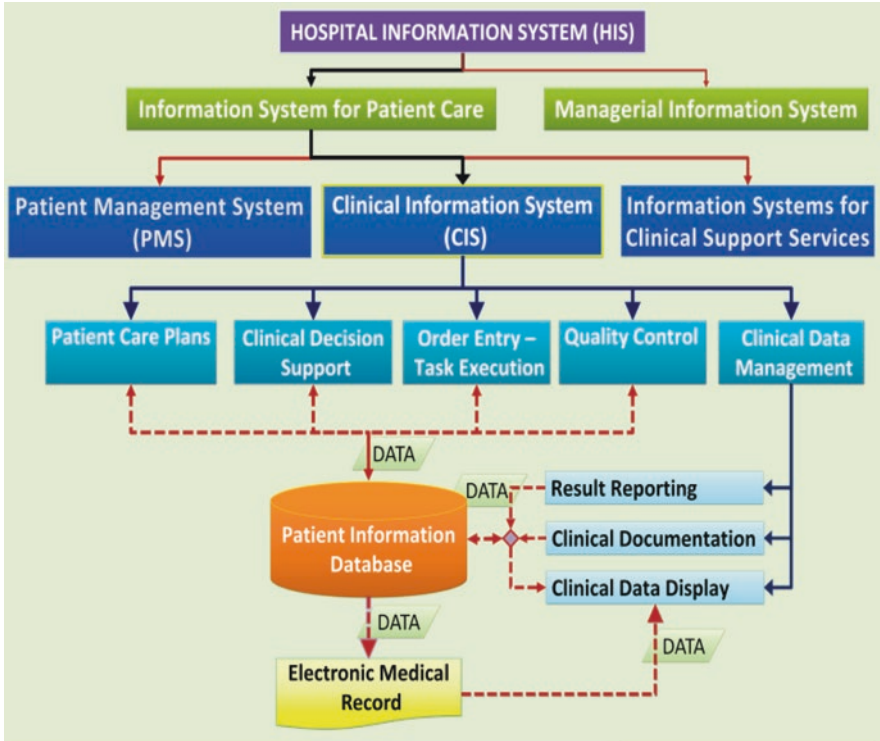
1.3.3 Computerized Physician Order Entry

Electronic physician order entry system is a technique of computerized entry system of medicinal physician recommendations for the treatment of related patients underneath his or else her proper care [5, 16, 26, 27]. These instructions are transferred in excess of a computer network to the medical professional or to the related department (like drugstore) accountable aimed at accomplishing the instruction [2, 23]. Computerized physician order entry reductions delay in order completion, decreases an error associated to handwriting, permit order entry at point of proper care or off- site also, offer fault inspection for identical or inappropriate dosages or examinations, and shortens inventory management as well as posting of responsibilities.
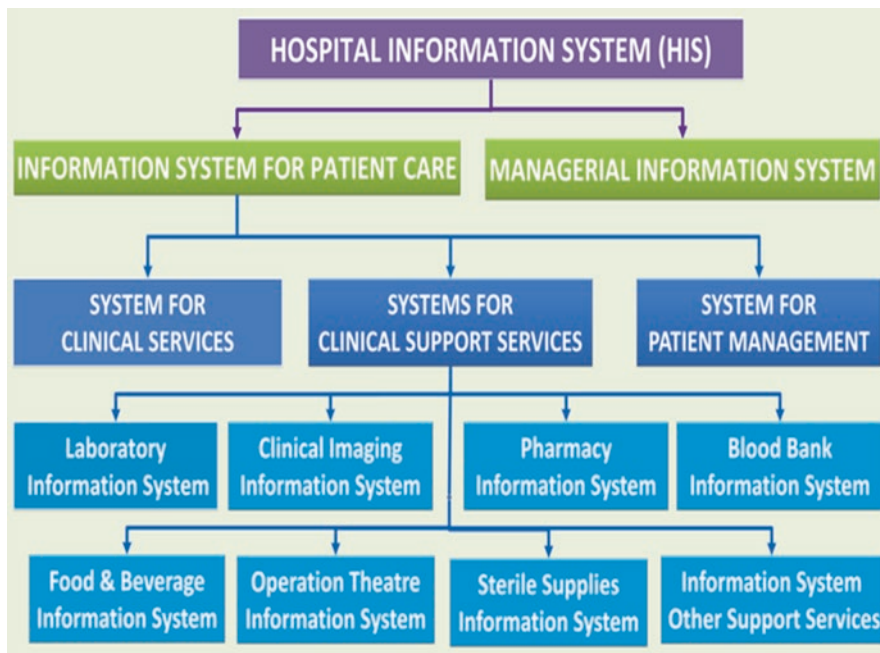
Fig. 1.5 System for clinical support services (https://drdollah.files.wordpress.com/2014/07/support-services.png)

1.3.4 Remote Monitoring

Remote monitoring system is the automated broadcast of healthcare-related information either one entered straight through a patient, otherwise by the use of a medicinal device to a physician's electronic record system, or a related patient's individual health record system [9, 28–30]. The capability for a medical doctor to monitor patient record around analytical, prescription tracing and activities of day-to-day living assessments, apprehended distantly is a significant able for the supervision of chronic health related issues as well as supervision of new circumstances [31, 32].

1.4 Overall Impact of Pervasive Computing on Hospital

Pervasive computing technologies have a superior influence on healthcare-related services as well as study and research [2, 5, 26, 33]. The underneath stated fact deliberate the effect of pervasive computing technologies in the hospitals, patients, service providers, management, investigators, and academician.

Patient-oriented technology is a supporting module to the distribution of health facilities in excess of spaces, offering important apparatuses and systems [4, 9, 34]. Development and acceptance of automatic health records as well as computerized health record system have also enhanced the distribution and also the actual time access of patient record at an assumed fact of time. [22, 35–37]. Clinician-oriented technologies offers trustworthy, important, latest, acceptable, as well as rationally comprehensive data for healthcare providers at all levels to progress the healthcare supply and attainability of countrywide objective [2, 5, 32]. Administrator-oriented pervasive computing technology offers health administrators a means intended for data gathering, processing, and investigation also appropriate for the reportage of the record to their direct level and others.

1.5   Chronic Care Supervision and Supported Cognition

In this unit, we firstly discuss clarifications in facilitating actual time observation, supported steering, as well as community connectedness intended for maintaining bodily as well as psychological happiness of people with chronic disease. Formerly we deliberate current solutions that deliver phase-by-phase assistance to increase the completion of activities of daily living supporting individuals with cognitive disabilities. We lastly précis the pervasive chronic care supervision as well as solutions.

1.5.1   Pervasive Monitoring for Self-Management

One considerable test in lieu of a singular by means of a chronic disease who is living individually alone is the capability to observe physical also social signs at a distance. Developments in pervasive healthcare expertise must allow improvement in observing methods that can constantly identify a person's rudimentary metabolic as well as social factors such as vigorous ciphers, happenings, group collaborations, slumber patterns, as well as other health pointers [38, 39]. Some of these researches [24, 32, 38, 39] have recommended the use of wearable sensors, smart clothing, as well as progressive integrated sensor systems to shape personalized health profiles and quickly inform families and specialized caregivers about the health complications.

1.5.2   Computerized Algorithm-Driven Care

An effective care model should facilitate all the essential components of a chronic care model, namely, a competent delivery system, self-management support, clinical information system (CIS), decision support system, trust on community

resources, and health system to improve patients' awareness and increase their engagement and experience [2, 4, 40]. Nowadays, for patients to flawlessly transition between dissimilar facets of chronic care management, effective care delivery systems or an instinctive healthcare platform is necessary to increase coordination among providers and patients [2, 33, 41].

1.5.3   Remote Patient Monitoring

To ease the problem for patients with chronic diseases, remote patient monitoring system makes it stress-free for care teams to track, manage, as well as involve with patients who want extensive and constant care [2, 28, 42]. This evidence-based method can transform primary care crossways to different practice backgrounds to improve consequences. Such program enables and produces actual interactions between care team and patients for real assessment of the patient's health on the genuine time basis. In addition to this, we have a number of health related apps, wearables and in-home devices which are dedicated on general health, workout, wellness and diet [24]. These instruments authorize patients and providers to record the vitals on a systematic basis to produce insights for appropriate advice. The incorporation of such technology with an effective chronic care model makes the wheel rolling for remote care [13, 35]. Inventive technology affords a low price, flexible means to enhance healthcare and reshape chronic care. This kind of mediations can be a powerful way to increase provider practice and support patients with chronic disease like diabetes to live more magnificently [3, 16, 27].

1.5.4   Cost-Effective Treatment

By integrating chronic care through telemonitoring, wearables, and home health clinical devices, patients can decrease the healthcare charge [18, 43]. As there is a shift in the direction of home health, providers have a chance to assimilate digital health tools into treatment plans as well as remote monitoring to support and manage patients with chronic settings and provide proactive care addition to lower the cost. With the help of telemedicine, patients can rapidly consult with their care provider about the new symptom as it seems in real time and in return get recommendation to change the treatment [28, 44]. This confirms that the patient gets the care they want on a timely basis and decreases the chances of a gap in treatment and hospital readmission. This also decreases the cost of care for both patients and care providers [17].

1.5.5 Improved Patient Experience

With an optimum chronic care model, patients do not need to take time off from their job, find conveyance to the doctor clinic, as well as spend money for parking or any of the other loads related with attending a health center appointment. The assimilation of mobile health application in home medical devices can act as a catalyst for effective management of chronic diseases to improve the patient experience and result [42, 44]. The patient appointment tool allows the patient to upload all their medical records/information and episodes. He can view his treatment strategy to comprehend his medication, insulin schedule, or any tests that he wants to take along with his workout regime and food plan.

1.6 Pervasive Computing for Preventive Care

As earlier stated lifespan expectation in developed countries is growing every single year [41, 45–47] as well as along with this bigger long life is a rising "prevalence of chronic conditions and their related pain and disability" [46]. As a result, averting these long-lasting diseases as evolving firstly at home is flattering an added considerable importance. To be sure, numerous nations have shaped defensive plans inspiring well behaviors in an effort to control healthcare budgets on a big gauge. A lot of pervasive computing uses for separate informatics focus on medicine obedience and devotion (e.g., [41, 48, 49]) or convincing technologies aiming at illness deterrence as well as wellness supervision (e.g., [24]). Additional uses highlight on recording therapeutically noteworthy actions designed for long-lasting patients (e.g., [46, 50]) as well as on social health problems. In this section, we discuss several schemes that emphasize on pervasive technologies to assist the automatic and discerning storing of health-related data. We likewise deliberate convincing expertise to facilitate self-monitoring as well as community health to avert cognitive weakening and to uphold bodily as well as mental happiness.

1.6.1 Automated and Selective Capture and Access of Health Information

Handling individual health-related record can be chiefly stimulating for long-lasting patients whose positions length years in addition to are frequently complex [51]. The development of approaches as well as tools used for recording and handling particular health records at hand is still a quantity of exposed queries around in what way persistent technologies can assist the capture, supervision, and handling of health-related information [52]. For that reason, numerous investigation plans have been dedicated on emerging imprisonment and handling tools [40] to assist the

administration of health record via numerous stages of physical and programmed capture [53].

1.6.2　Patient Electronic Portals

A patient website is a safe online web-based application that offers patients control as well as access to their personal health record and two method automatic communications by way of providing proper care via a computer system or else a moveable devices [54]. Various research works [21, 55] revealed that patient web-based portals increase the results of defensive care and also disease consciousness and self-management. On the other hand, there is no indication that they increase persistent care consequences.

1.6.3　Persuasive Technologies for Self-Monitoring

Investigators and academicians have initiated toward scrutinizing the usage of convincing technologies [56] intended for inspiring persons to the takings on the accountability of managing, taking, and examining their personal health data and activities. Persuasive tools is normally well defined such as tools that are intended to and developed toward modification of approaches or else overall activities of the handlers via persuading also community inspiration, but not via force [57]. Such type of tools is frequently used in community health, rummage sale, international relations, governments, faith, soldierly exercise, and management as well as may possibly be used in a slightly range of humanoid-to-humanoid or humanoid-to-computer communication [58].

1.6.4　Direct Interaction vs. Mediation

Persuasive technology can also be characterized through whether they amend approaches and activities via straight communication or else over an arbitrating role, on behalf of the instance via human-computer interactions or computer-mediated communications. The illustrations previously stated are the earlier, but there are numerous of the concluding [24, 29, 57, 58]. Communication technology can encourage or else intensify the persuasion of another by renovating the community collaboration, as long as it is a joint feedback on communication, otherwise a rearrangement of communication methods [29, 52, 56, 58].

1.6.5 Persuasion by Social Motivators

Previous researcher works has too used on community instigators alike struggle for persuading[30].By means of relating a handler with other handlers, his/her social group, associates, families as well as other relatives. A convincing solicitation can smear social persuaders on the handler to care personal behavior changes [15]. Social networking sites such as Facebook, LinkedIn, as well as Twitter similarly ease the expansion of such type of systems [59]. It has been revealed that community influence can consequence in better performing vicissitudes than the situation where the handler is out of the way.

1.7   Conclusions

The healthcare area is quickly varying very fast. To begin with, the necessity intended for better efficiency, overall health quality, less cost, as well as safety and security in hospital backgrounds is motivating the requirement for improved connection among record keeping, observation, and patient care systems. Next, there is an increasing movement to enable the patient to control their health in a supplementary active way, welcoming the expansion of a range of individual fitness applications designed for movable devices and home-sensing platforms plus applications. Finally, there is an increasing focus on giving additional active precaution in lieu of patients through long-standing chronic environments and speaking about health as well as wellness matters above long-life parts that are mostly agreeable to the solicitation of unescapable healthcare tools. This chapter has covered pervasive computing methodologies to facilitating several features of health deliveries, in specific concerns. We have defined the usage of universal healthcare tools in favor of hospital care system, to care for supported alive as well as long-lasting illness management and as part of individual health plus wellness management in lieu of preventive care.

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