TELe-Health

Series Editors: Fabio Capello · Giovanni Rinaldi · Giovanna Gatti

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Gopi Battineni *Editors*

Information and Communication Technology (ICT) Frameworks in Telehealth

Springer

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Recent advances in technology and medicine are rapidly changing the face of health care. A revolution is occurring in diagnosis and treatment thanks to the implementation of instrumentation and techniques deriving from engineering and research. In addition, a cultural conversion is taking place in which geographical and social boundaries are about to be overcome, resulting in enhanced availability and quality of care. Telemedicine has been considered a possible means of improving health care worldwide that is likely to change the way in which doctors deal with patients and diseases. While various restraints continue to limit the application of telemedicine in different settings and different areas of health, the innovations emerging from eHealth and telecare could stimulate a great leap forward for medicine, provided that some basic rules are taken into consideration and followed. In this series, diverse aspects of tele-health – preventive, promotive, and curative – will be covered by leading experts in the field with the aim of realizing the full potential of the new and exciting technological solutions at our disposal.

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Editors

Information and Communication Technology (ICT) Frameworks in Telehealth

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ISSN 2198-6037 ISSN 2198-6045 (electronic)
TELe-Health

ISBN 978-3-031-05048-0 ISBN 978-3-031-05049-7 (eBook)
https://doi.org/10.1007/978-3-031-05049-7

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This book aims to address the obstacles faced by healthcare providers and patients in rural areas that are vastly different from those in urban areas. It also presents the necessity to develop telemedical systems with integration of ICT, which will help patients in interior areas through the use of contemporary technologies. In this book, we also intend to explore the inputs with regard to individuals and companies who have developed technologies and innovative solutions, bioinformatics, datasets, apps for diagnosis, etc., which can be leveraged for strengthening medical systems, especially during medical emergencies like the COVID-19 pandemic. Besides, this book focuses on technology solutions and systems to help remote-area people in order to improve medical care.

Organization of the Book

The book is composed of four different sections and consists of 16 chapters that mainly focus on the transformation of digital health using ICT frameworks. In addition, it focuses on the necessity of telemedical systems during the pandemics. A brief description of each chapter is as follows.

Telehealth in Rural Healthcare

Chapter 1 aims to explore the current use, challenges, and opportunities of the telehealth system. The lessons learned from this study are used to determine important factors to consider when attempting to advance and expand telehealth programs in remote communities in Italy.

Chapter 2 identifies core elements that should be considered when implementing telehealth applications with the purpose of supporting medical practice in rural and remote regions. Decision makers need to be aware of the specific conditions that could influence telehealth integration into clinical practices and healthcare organizations.

Chapter 3 describes the more complex and diverse ethical and legal concerns in telemedicine. In this chapter, an analysis of scientific literature is carried out to identify the ethical and legal challenges of telemedicine.

Chapter 4 explains the efforts that have been ongoing in understanding the role of Internet and communication technology (ICT) frameworks for over a decade as well as specific programs to target the rising needs of emergency care in both developing and developed countries.

The Power of ICT in Telemedicine

Chapter 5 proposes a proactive strategy for digital mental healthcare utilizing ICT-based telepsychiatry services to forestall cognitive diseases during the COVID environment. These ICT-based telepsychiatry services such as monitoring, digital mental healthcare, and prevention of cognitive diseases would improve accessibility and adaptability, self-monitoring, and treatment during the COVID environment.

Chapter 6 compares the operations being practiced in the current pandemic with those of previous pandemics when the ICT tools did not exist at all. Finally, the limitations of ICT-driven tools and knowledge during pandemic emergencies are discussed, and their scope and possibilities in the post-pandemic world are explored in the light of the probable future pandemic situations.

Chapter 7 discusses the severity of the current pandemic and the necessity of advanced telemedical systems to mitigate the severity risk. Besides, it proposes the execution of telemedicine frameworks for seafarers to check gentle or asymptomatic cases that would decrease the high volume of mild symptomatic cases.

Chapter 8 provides a discussion on a mobile application that allows a seafarer to choose the appropriate activity based on his/her physical characteristics, fitness level, and quality of life. Seafarers' typical physical activity and sleep cycles are hampered by long ocean trips.

Exploring and Illustrating the Current IoT Applications

Chapter 9 handles changes in medical facilities that happened because of COVID-19. Besides, it explores how they are administered as technological advances are being accepted and adopted in the medical field broadly, and especially facilities like telemedicine and virtual care are gaining wider acceptance.

Chapter 10 discusses one of the popular articulations in information technology, the Internet of Things (IoT), and explains how natural language processing can help the IoT along with cloud computing for data storage.

Chapter 11 presents a detailed overview of the emerging technologies of smartphone applications; the Internet of Things and artificial intelligence are being used for personalized care in the present times. Moreover, we discuss the crucial challenges associated with personalized healthcare solutions along with the expected trends that could further enhance the quality of personalized care in the future.

Chapter 12 discusses the use of smartphones for activity recognition, enabling sensors, a fusion of sensors for activity recognition, artificial intelligence methods for activity recognition, and implementation of activity recognition methods in IoT/fog computing scenarios.

Progression of Internet Technologies in Healthcare

Chapter 13 discusses the android application that will transmit the various biomedical signals to the Web server, thereby enabling the connection of biomedical sensors to android-based smartphones.

Chapter 14 explores smart wearables to handle patient health through taking care of a wide range of health management needs, which are highly customizable to cater to individual circumstances.

Chapter 15 discusses the importance of endodontists explicitly in the current situation, importance of teledentistry applications in endodontics, and change in the current protocol for endodontic intervention.

Chapter 16 presents the employment of EMD influenced by wavelet thresholding. The suggested method's efficacy is assessed using a variety of metrics, including the artifact rejection ratio (ARR), root mean square error (RMSE), change in SNR (ΔSNR), and correlation coefficient (CC).

We are very thankful to all the members of Springer, especially Ms. Donatella Rizza, for providing us the opportunity to edit this book.

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Telemedicine in Rural Regions of Italy: Opportunities and Challenges

Syed Sarosh Mahdi and Alessandro Peretti

1 Introduction

Italy presents unique challenges due to its geography and sociopolitical system when it comes to provisions of telemedicine-based healthcare systems. The challenges Italy faces are also down to its mountainous and rugged terrain and hard-to-reach smaller communes. Italy is a densely populated country compared to other European nations. However, population density varies across the various regions of Italy; for example, the alpine region of Valle d′Aosta has 39 inhabitants per km^2, whereas the area consisting of the Bustling city of Napoli (Campania region) is thickly populated with an average of 339 people per km^2. Other thinly populated areas with an average of less than 100 people per km^2 include the mountainous northern region of Trento, the southern regions of Basilicata and Molise, and the isolated island of Sardinia [1].

ECG results were transmitted between Massachusetts General Hospital in Boston and the Logan Airport Medical Station [2]. Following that landmark event, the fundamental idea behind the use case of telemedicine has not changed much, and the telemedicine framework entails the patient not having to travel to any healthcare facility yet receiving medical attention at home through technological advances in

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_1

information technology and healthcare tools. These services have been adopted by several medical subspecialties including in the management of cardiovascular disease [3, 4], coronary artery disease, and neurological disorders among others [5–7].

Home to one of the oldest telemedicine centers in the world (Centro Internazionale Radio Medio) C.I.R.M., Italy is a formidable socioeconomic powerhouse of the European Union and the entire world. C.I.R.M. (Centro Internazionale Radio Medico) was established in 1935 with the objective of providing medical consultation to seafarer's onboard ships of all nationalities circumnavigating international waters. The headquarters of C.I.R.M. is located in the Italian capital Rome. C.I.R.M. provides basic medical assistance free of cost. One resident doctor is available 24/7 at the C.I.R.M. headquarters in Rome to deal with all medical requests [8, 9].

The presence of the oldest telemedicine center in the world theoretically gives Italy an advantage over the provision of telemedicine-based services. In Italy, teleconsultation services are mostly supplementary rather than alternative. Physical distances between primary and secondary care center in Italy are usually longer than those in most European countries. In Italy, many admissions to the emergency room (ER) departments are unnecessary and could be avoided if telemedical services are available for consultation. The mountainous terrain of Italy and presence of small rural communities in the thousands of small communes in Italy make it ideal for provisions of telemedicine-based services.

Italy is one of the few countries in the world that have formulated a national policy on hospitals in rural and far-flung areas. Italy is divided into 20 regions, which have the right to draw up autonomous healthcare policies. Rural areas in general have a shortage of healthcare professionals and services, and Italy is no exception. The problem is compounded by the fact that Italy has hundreds of communes with population of less than 500 inhabitants, which makes the presence of specialized healthcare problematic in remote regions. A recent research published in BMC Health Services Research journal by Zanaboni [10], which collected telemedicine-related data from the mountain valleys of Lombardy region between 2006 and 2008, found that out of the total 957 teleconsultations, 927 of these requests were by the GPs for cardiovascular related issues. 18 calls were made to discuss skin-related issues, and 12 calls were made for diabetes and assorted complications arising from diabetes. Cardiovascular disease-related telemedicine inquiries are the chief complaint according to most of the data gathered. Fifty-six thousand medical doctors will go into retirement in Italy in the next 15 years, and the healthcare system is not robust enough to absorb the shock of such an exodus [11]. Furthermore, 14 million Italians will be without a medic [12]. There will be inequalities in the access and provision of healthcare in remote and understaffed hospitals. This trend suggests that Italy needs a robust telemedicine policy to improve access to healthcare in rural areas with understaffed hospitals. The Italian national healthcare system is decentralized, and local regions have autonomy through the Italian local health authority of each of the 20 regions. The authority is known as the "Aziende Sanitarie Locali" (ASL). It is the autonomous local public health administration of each region responsible for provisions of healthcare. ASL is a fundamental part of the national health service of Italy [13, 14]. The national and regional governments in Italy have recently increased their participation and focus on telehealth-based initiatives and telemedicine-based services for ECG, spirometry, and Holter measurements for cardiac and blood pressure, which are readily available even in local pharmacies [15]. Pharmacies are present in every small town and commune in Italy and hence could serve as a focal point of telemedicine services in some remote regions. Most telemedicine interventions aim to improve the provision of healthcare services in far-flung and rural areas by attempting to enhance communication and interaction between primary and secondary healthcare centers. Lombardy is considered as the most advanced region in terms of telemedicine-based healthcare interventions. A close interaction exists between GPs and multi-specialty through application of telemedicine-based technologies [16].

Italy's experience with telemedicine goes back over 70 years, and hence the country despite its difficult terrain is well equipped to deal with the challenges presented with its geography and topography. Apart from having one of the best healthcare systems in the world, Italy has world-class emergency and rescue services and massive experience in dealing with natural calamities in remote locations.

2 Challenges in Data Protection and Privacy in Remote Locations and Role of GDPR

One of the biggest challenges presented by any telemedicine- or E-health-related services is data security. The challenge is compounded even more when the data is related to remote and rural outposts like the ones found in rural Italy. Hence, we will now discuss protection of data transmitted during telemedicine and E-health sessions. We will specifically focus on the General Data Protection Regulation (GDPR) of the EU in Italian context.

The General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679) is a novel legislation to enhance the level of data privacy in individuals. Since nowadays bioinformatic data for processing and research is extensively increasing and data access is possible from everywhere via the Internet, this regulation focuses on data security, data privacy, data deleting, and portability across Europe.

These days, most of our information and data are stored in cloud computing and so they can be accessed via the Internet everywhere. Formally, cloud computing represented the delivery of computing in remote locations through the ICT approaches [17]. This was considered very useful and made mandatory in 2017 with the globalization because most of the time, it is required to retrieve such data remotely. In this respect, the General Data Protection Regulation (GDPR) is an important document for protecting the personal data of individuals in the European Union and hence is applicable in Italy. It was adopted by Regulation (EU) 2016/679 of the European Parliament in April 2016. The regulation envisions to safeguard the privacy of European citizens in relation to data processing, confidentiality, storage, and free availability of such data under repealing Directive 95/46/EC (General Data Protection Regulation; Official Journal of the European Union L 119/1) and shall apply across the European Union (EU) from 25 May 2018 [18]. Data protection and privacy will emerge as a key concern regarding medical data obtained during telemedicine consultation in remote and rural areas due to the barriers and limitations placed by the geography of these areas.

The GDPR will replace the Data Protection Directive adopted in 1995 (2. Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the data privacy of private citizens in relation to the processing of personal data and on the free mobility of citizen data) (Official Journal L 281, 23/11/1995 P. 0031-0050). This new regulation has many goals including harmonize data privacy laws across Europe, protect and empower all EU citizens' data privacy, and reshape the way organizations across the region approach data privacy, and hence is applicable on all health-related data transfers in Italy [19].

The principal actors involved in this regulatory process are supervisory authority (SA), data processors, data controller, data subject, third countries and international organizations, and third parties.

SA is a public and independent regulating body, which is elected by each member state, and it checks whether the regulation is effectively executed in the state. It can cooperate with SAs of other countries. Data processor could be a legal and natural person, regulating authority, or organization, which has the legal right to process confidential private data on behalf of the controller. It is able to process data when the controller requests it. Data controller is an organization/entity, regardless of being public, private, nonprofit, etc., that determines the manner and purpose of collecting personal data. So, a data controller defines the final purpose of those data. Data subject represents a natural person, and the GDPR protects his/her rights and freedom. Actually, through the GDPR, the data subject is the owner of his/her personal data, and he/she is free to move the data elsewhere or delete them. Third countries and international organizations represent the countries outside the EU, and if there is a necessity to send data subject to them, a condition is mandatory to guarantee the protection of the personal data that would be sent. In this category, there are some third parties as lawyers, solicitors, or members who are able to execute a data subject's rights. Moreover, they can process the data on behalf of the data subject.

Recently, there have been many developments in bioinformatics for using personal health data for different purposes like processing and research. These have increased focus on the protection of personal health data in the digital environment. The GDPR covers many aspects of the rights of personal data besides the research and public health purposes. Due to the fact that the amount of digital information has massively increased and the old protocols that were deployed to manage those data are no longer suitable, the GDPR plays an important role in solving this problem. It will change the method of organizations for handling their information of customers in the best way. There will be a massive overhaul for both private and public companies and organizations that process private information. The GDPR will be a kind of revolution for data privacy laws across Europe as well as to give greater protection and rights to individuals. This is even more important for rural areas of Europe including Italy, which has mountainous and hard-to-reach remote locations spread throughout on both sides of the Apennine Mountains. The main aim of shedding light on the GDPR protocol is to clarify the new European Union regulations in order to analyze the new guidelines from bioinformatic perspectives in relation to rural Italy. In other words, relevant information about data security, data portability, and data deleting is analyzed since these are fundamental concepts in bioinformatic and computer science-related fields.

3 Data Security

Data security in healthcare context entails the protection of personal data against illegal and unwarranted actions as well as safeguarding against unexpected disappearance or damage of citizen data, employing legally protected organizational and scientific methods [20]. It is one of the most significant subjects in bioinformatics. According to Article 31, the controller should establish requirements for the protection of personal data. These requirements must be compiled before and during data processing. During the designing stage of requirements, they should consider the cost of implementing them because the cost of meeting these requirements must be equivalent to the expected risks [21].

Hiring of a permanent data protection officer has been made mandatory in large public and private organizations through Article 35, where the main activity involves processing activity requiring periodic systematic monitoring through, furthermore Articles 36 and 37, sets the position and his/her core tasks.

The controller must implement strategies and mechanisms to ensure that they process personal data according to the specific purposes. Personal data should not be retained after completing the defined process.

An unlimited number of processors or unlimited processes cannot have access to personal data. In addition, each part of personal data must be made available only to the process that requires that part, as well as to the processor who needs this part of the data to complete the specific process.

This amendment is very important because it ensures that any third party who requests personal data for a specific process cannot receive all the personal data of a data subject. For example, if a medical institution requests a person's personal data for medical treatment purposes, the controller can send just the medical part section of that data and he/she does not have any permission to send parts of political or philosophical opinions. To achieve this relevant objective, an implementation of different kinds of authorizations inside the system is needed. This key point could be expanded to all information included in the electronic record of the user [Article 23].

According to this regulation, the controller and the processor must enact strategies and use suitable techniques to make sure that the personal data of the data subjects remains secure. These strategies and techniques should be appropriate to the potential risks, the nature of the data, the purposes of the process, and the implemented process on that data.

In addition, they have to guarantee an appropriate level of encryption, confidentiality, and reliability. The processor and the controller should ensure data access and availability in the case of any data breach or malfunction.

Finally, the processor should check, test, and evaluate any strategies and techniques that he/she used to protect personal data. He/she should guarantee that those techniques and strategies are appropriate to protect the personal data. This regulation also pays great attention to the risks resulting from personal data processing, specifically the unauthorized modification or destruction, as well as data loss, data revealing, or illegal access during data storage or transferring. As determined, it is the responsibility of the controller and the processor to take appropriate steps to avoid the abovementioned risks. Among these techniques and strategies, it is possible to count data encryption, authorization, confidentiality, non-repudiation, integrity, identification and authentication, and storage provider verification. These techniques together should be able to prevent all the common issues about data in cloud computing [22].

One of the new additions to this act is to set out codes of conduct in one of its chapters, through which it is possible to determine that the processor and controller have complied with data protection requirements [Article 32].

Personal data breach is defined as a breach of security, which may lead to physical, material, or nonmaterial damage to natural persons [20]; the processor must notify the controller of any breach of any personal data once he/she is aware. The controller has to report the occurrence of the breach to the authorities within 3 days. The communication must contain a thorough description of the breach, as well as the number of the affected records and persons. He/she must also describe the consequences and damages of this data. The controller must mention the steps that he/she has taken or should be taken to minimize the consequences of a data breach. The breach must be documented, with its causes, all the facts associated with it, and the steps taken by the controller. After notifying the breach to the authorities, the controller must notify the data subject to the owner of breached data. The controller can bypass notifying the data subject only in the case that he/she had applied appropriate techniques to protect his/her personal data before the occurrence of the data breach, or if he/she took steps that had reduced the damages of the breach. However, if the breach has taken too many of the data subjects, and it is difficult to notify each individual, the controller can communicate to them publicly [Article 33].

3.1 Data Deleting (Right to Be Forgotten)

Nowadays, the bioinformatics world recognizes secure data deletion well because "its data" is more sensitive; for example, health personal data have to be deleted securely once it is no longer needed. In some conditions, personal data is not accurate, so it is important to take reasonable measures to delete them. A data subject will have the authority to delete his/her private data, in case of the termination of purposes for which he/she has given his/her consent, or when his/her personal data has been processed illegally, or in case that such data is no longer useful for the purpose for which it was collected, or in the absence of a legal base for processing that data, or if the laws of the EU obligate the controller to delete that data. The controller must delete a personal data requested to be deleted by its data subject immediately, except in case that he/she has provided convincing legal justifications for not deleting that data.

This chapter intends to analyze the effectiveness of the data protection law for increasing it as it does not leave unnecessary data or because the processor has processed it in relation to medical data. This gives more privacy to the data subject, the risks of theft data, infringement or unauthorized access, and avoiding illegal or unauthorized use [23]. At the end of the processing process, on behalf of the controller, the processor must, at the request of the controller, either delete personal data or return the data. The only exception is when there is a requirement to store the data under local, regional, and national laws.

3.2 Portability

One of the important additions to this directive is the right of data portability. Based on Article 18, the subject will have the permission to share the personal data and other demographic details by the data subject. It will let a user to have the right to request a copy of his/her personal data from an institution, agency, or a system in a format that can be used by them and transmitted via any electronic means to another data processing system [24].

This means that the controller who has received private data of a data subject should store data in a structure or a format that is compatible with the common systems and readable automatically. Therefore, it does not constitute an obstacle to a data subject in case he/she has decided to transfer his/her data to another institution or another system. For example, if a user decides to transfer a medical file from a clinic to another one or from an association agency to another one, the controller must have stored that file in a manner consistent with the other clinic or agency systems. Consequently, the new clinic can include that file automatically in its system without obstacles.

This amendment encourages the creation of standardized data storage. It also increases the ease of data flow. In the condition where, regardless of the user's right of data portability, data is stored in a manner consistent with common systems, it leads to the speed and ease of receiving these data from other parties and including it in a new system. In consequence of the right of portability, it would enhance the quality of services offered by companies and the competition between them [25]. Data controllers should implement different data portability opportunities; for example, they should offer a direct download for the data subject or should allow them to directly transmit data to another data controller [26].

4 Discussion

The GDPR is a new EU data protection that sets the stage for unification of data protection rules across the EU for extending the EU data protection law. After this analysis, we can certainly affirm that the GDPR affects customers and citizens of the EU as well as people from European countries that have stored data outside the European borders. The difference among this regulation and other regulations is that companies will be forced to be compliant because of the sanctions [27].

The biggest advantage of this is that a unified set of rules will apply across every EU member state, which means that the data controller, processor, or data subject is established in the EU. Every member state should create a neutral SA to investigate and mitigate complaints and punish administrative offenders. SAs in every member country will cooperate with other SAs in the provision of mutual assistance and arrangement of joint efforts. A company with multiple establishments in the European Union will require a single SA. Thanks to these rules, a sort of top-level standardization takes place. The GDPR could be considered as an interface that all the people or entities involved in data protection care should comply with. This approach lets the entities to be very independent but comply with the GDPR pillars.

Data security contains factors that could be accessed to identify private citizen info including social, medical, genetic, and even psychological profile of people. Member states should formulate policies and take action to decrease the information they store and ensure that information is stored only as long as it is required. About data deleting, in order to ensure that they do not take the data longer than necessary, the controller should determine time limits for erasing or for a periodic review [27].

The GDPR creates novel right to data portability that is similar in some aspects but also differs from the right of access in many ways. This new right empowers the data subjects and provides more control over the personal data. It also makes switching between different service providers easier.

Each private or public body needs to have a data protection officer, so the controller and the processor shall design this. In previous drafts of the Regulation, data protection officer was a requirement for companies with more than 250 employees. In the final publication of the legislation (which was ratified in 2016), this limitation was changed and it includes companies of all sizes [28]. If any system contains "high-risk" privacy-related information, a privacy impact assessment is also required.

According to AMPLEXOR'S GDPR Workshop [29], there are four essential keys which can help companies prepare for the GDPR before it is implemented and enforced on 25 May 2018. These four keys include accountability, physical archives, acceptance testing, and local implementation. Accountability entails that companies should clearly define and describe every system that is related to privacy, personal data, and information. This is one of the goals of the new GDPR. The relation of the physical archive and the GDPR is privacy because still some companies have paper archives, which include personal privacy data and make that information available for use so it could fall under the GDPR rules. These days, there are many organizations that require production data in their systems to anticipate the events in production. In these cases, they should obey the rules of the GDPR perfectly. All EU countries are legally required to lay down detailed and specific GDPR implementation guidelines, so due to this fact local implementation is also important. The GDPR will have a huge impact on how data is stored, regulated, and transmitted; rural telemedicine users in Italy will be empowered through these regulations. We hope that incorporating of the GDPR and shedding light on them will be useful in the context of Italian telemedical services. Rural areas are more vulnerable due to limitations of geography, transmission, communication issues, and manpower. The GDPR will help resolve some of these issues.

5 Conclusion

Italy is a country tailor made for telemedicine-based services due to its unique geography, unequally distributed population, and hundreds of small and slightly habituated towns. Italy has the infrastructure and technical know-how going back 75 years in the field of telemedicine and remote health assistance. What Italy lacks is the political will and organization when it comes to nationwide coverage of telemedicine. Another limitation is the North-South divide, where the North fares better in almost every social indicator which obviously includes the provision of health including telemedicine-based interventions. Another critical area when it comes to rural areas of Italy is data protection and privacy. The authors have envisaged to use the recently enacted GDPR to regulate the data privacy and security of telemedicine users in rural Italy.

References

1. Rechel B, Džakula A, Duran A, et al. Hospitals in rural or remote areas: an exploratory review of policies in 8 high-income countries. Health Policy. 2016;120:758–69.
2. Citoni B, Figliuzzi I, Presta V, Volpe M, Tocci G. Home blood pressure and telemedicine: a modern approach for managing hypertension during and after COVID-19 pandemic. High Blood Pressure Cardiovasc Prevent. 2021:1–14. Advance online publication. https://doi.org/10.1007/s40292-021-00492-4.
3. Mahdi SS, Allana R, Battineni G, Khalid T, Agha D, Khawaja M, Amenta F. The promise of telemedicine in Pakistan: a systematic review. Health Sci Rep. 2022;5(1):e438. https://doi.org/10.1002/hsr2.438.
4. Battineni G, Sagaro GG, Chintalapudi N, Amenta F. The benefits of telemedicine in personalized prevention of cardiovascular diseases (CVD): a systematic review. J Pers Med. 2021;11(7):658. https://doi.org/10.3390/jpm11070658.
5. Piotrowicz E, Piepoli MF, Jaarsma T, Lambrinou E, Coats AJ, Schmid JP, et al. Telerehabilitation in heart failure patients: the evidence and the pitfalls. Int J Cardiol. 2016;220:408–13. [PubMed] [Google Scholar].
6. Koehler F, Koehler K, Deckwart O, Prescher S, Wegscheider K, Winkler S, et al. Telemedical interventional management in heart failure II (TIM-HF2), a randomised, controlled trial investigating the impact of telemedicine on unplanned cardiovascular hospitalisations and mortality

in heart failure patients: study design and description of the intervention. Eur J Heart Fail. 2018;20(10):1485–93. [PubMed] [Google Scholar].

7. Spencker S, Coban N, Koch L, Schirdewan A, Müller D. Potential role of home monitoring to reduce inappropriate shocks in implantable cardioverter-defibrillator patients due to lead failure. Europace. 2009;11(4):483–8. [PubMed] [Google Scholar].
8. Rizzo N, Amenta F. I Cinquanta Anni del Centro Internazionale Radio Medico (Italian). Rome: CIRM; 1985.
9. Amenta F, Dauri A, Rizzo N. Organization and activities of the International Radio Medical Centre (CIRM). J Telemed Telecare. 1996;2:125–31.
10. Battineni G, Nittari G, Sirignano A, Amenta F. Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic? J Taibah Univ Med Sci. 2021;16(3):305–6. https://doi.org/10.1016/j.jtumed.2021.02.009.
11. Pini V. [In 15 years Italy will lose 14.000 physicians]. La Repubblica; 2019. https://www.repubblica.it/salute/medicina-e-ricerca/2019/04/18/news/se_in_italia_mancano_i_medici-224339652/. Accessed 5 Jul 2020. [Links].
12. [Alert about the lack of physicians, 45.000 will retire in 5 years]. Ansa. http://www.ansa.it/canale_saluteebenessere/notizie/sanita/2018/02/09/-allarme-carenza-medici-45.000-in-pensione-in-5-anni-_aaa943db-7592-4649-8c1e-f80f4952e196.html. Accessed 5 Jul 2020.
13. Federfarma. [The pharmaceutical convention]. https://www.federfarma.it/Farmaci-e-farmacie/Farmacie-e-farmacisti-in-Italia/La-convenzione-farmaceutica.aspx. Accessed 5 Jul 2020. [Links].
14. Farmacie Comunali Riunite. [National collective agreement for the relations with pharmacies]. http://www.fcr.re.it/accordo-collettivo-nazionale-per-la-disciplina-dei-rapporti-con-le-farmacie
15. [Starting of experimentation of pharmacy of services]. https://www.ordinefarmacistimilano.it/553-la-conferenza-stato-regioni-da-il-via-alla-farmacia-dei-servizi
16. Scalvini S, Tridico C, Glisenti F, Giordano A, Pirini S, Peduzzi P, Auxilia F. The SUMMA project: a feasibility study on telemedicine in selected Italian areas. Telemed J E Health. 2009;15(3):261–9. https://doi.org/10.1089/tmj.2008.0109.
17. Rawat N, Srivastava R, Pandey BK, Rawat P, Singh S, Sharma A. Data security issues in cloud computing. Open J Mob Comput Cloud Comput. 2014;1(1)
18. European Society of Radiology (ESR). Insights imaging, vol. 8. Berlin Heidelberg: Springer; 2017. p. 295. https://doi.org/10.1007/s13244-017-0552-7, Online ISSN:1869-4101.
19. D. Gabel, T. Hickman. Chapter 10: Obligations of controllers—unlocking the EU general data protection regulation. 13 September 2017. http://www.webcitation.org/6wiDTXzHI. Accessed 24 Nov 2021.
20. Chassang G. The impact of the EU general data protection regulation on scientific research. Ecancermed Sci. 2017;11(709–727):1–12.
21. Privazyplan. Article 4, EU GDPR, 'Definitions', December 16, 2017. https://www.privacy-regulation.eu/en/4.htm. Archived at http://www.webcitation.org/6wiADcpHn. Accessed 24 Nov 2021.
22. Battineni G, Amenta F. Designing of an expert system for the management of Seafarer's health. Digit Health. 2020;(6):2055207620976244. https://doi.org/10.1177/2055207620976244.
23. Official Journal of the European Union. Protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) May 4, 2016. http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679&from=GA. Archived at http://www.webcitation.org/6wiB4nnv4. Accessed 24 Oct 2021.
24. Reardon J, Basin D, Capkun S, On secure data deletion, IEEE Security & Privacy Magazine; May 2014.
25. Council of the EU. Data protection reform: Council adopts position at first reading; 8 April 2016. http://www.consilium.europa.eu/en/press/press-releases/2016/04/08-data-protection-reform-first-reading/. Archived at http://www.webcitation.org/6wiBPE71f. Accessed 24 Nov 2021.

26. European Commission. Article 29, Working Party 12 December 2017. http://ec.europa.eu/justice/data-protection/index_en.htm. Archived at http://www.webcitation.org/6wiByCtPU. Accessed 24 Nov 2021.
27. Intersoft Consulting. General Data Protection Regulation (GDPR), CISA. https://gdpr-info.eu/chapter-2/. Archived at http://www.webcitation.org/6wiEm0Mlp. Accessed 24 Nov 2021.
28. Information Commissioner's Office. Preparing for the general data protection regulation on 12th May 2017. https://ico.org.uk/media/1624219/preparing-for-the-gdpr-12-steps.pdf. Archived at http://www.webcitation.org/6wiDA2Dff. Accessed 24 Nov 2021.
29. Willems B. 4 key conclusions from amplexoràs GPDR workshop, 25 April, 2017. http://blog.amplexor.com/enterprisecontent/en/4-key-conclusions-from-amplexors-gdpr-workshop. Archived at http://www.webcitation.org/6wiEOCHxm. Accessed 24 Nov 2021.

Successful Conditions in Implementing Telehealth Support to Remote Areas

Ahmad Tasnim Siddiqui

1 Introduction

As per the definition given by the NEJM Catalyst journal, telehealth can be termed as "*The delivery and facilitation of health and health-related services including medical care, medical provider and patient education, self-care and health information services (HIS) via telecommunications and digital communication technologies*" [1]. Telemedicine and telehealth are being used vis-à-vis in most circumstances, but the meaning may not always be the same. Telehealth has gained much popularity in healthcare services. According to the Center for Connected Health Policy (CCHP), there can be no single definition of telehealth, and COVID-19 has caused more confusion. In some cases, audio-only telephones were allowed to provide healthcare service and facilities to the people in need. As per the definition of the CCHP, telehealth can be given as "a collection of methods and technologies to enhance the healthcare and health education by using ICT" [2]. In general, we use telemedicine to refer to the traditional way of diagnosis and monitoring, which is carried out by technology. Some researchers use the term "connected health" while others use the term "digital health," which describes the use of technological applications in healthcare. Telemedicine has become the thing of past. According to research done in the last few years, telehealth provides excellent results when we compare it with the traditional way of healthcare system without losing patient and medical professional's bond. It also enhances patient satisfaction. Due to the pandemic of COVID-19, people have opted for more and more teleconsultations. Patients and medical practitioners safeguarded each other by using telehealth facility. In the light of this scenario, we can say that telehealth is a technology-oriented healthcare framework that provides facilities like real-time consultancy, remote

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_2

patient monitoring (RPM), in-person virtual visits, mobile prescriptions, diagnosis, and management.

According to the American College of Obstetricians and Gynecologists (ACOG) committee opinion [3], the satisfaction of women patients was considerably higher by using online visits, but the complete differences between face-to-face visits and online visits were consequently small as to be of questionable importance of clinics. As per the criteria given by the CCHP, key components of telehealth modalities are real-time consultancy, remote monitoring, store and forward, and mobile health. These can be carried out in one of these ways:

- *Synchronous*—It is the way by which the medical specialist interconnects with the patient in real time through computer or telephone.
- *Real-time audio-visual consultancy*—Real-time audio-visual consultancy allows the patients and medics to virtually see and listen to each other, discuss their problems, and provide solution.
- *Remote patient monitoring*—It allows to collect (weight, blood sample, or blood pressure) and use personal health records (PHRs) from an individual, and then it transfers the collected information to the medical practitioners located at different places in the world. Remote patient monitoring can be formed by devices such as wearable devices by using wireless technology when they are away from the health center.
- *Mobile health (mHealth)*—Mobile health or generally called as mHealth is a self-managed mobile application system, which can be carried out by using smartphones or any other wireless devices. The main task of mHealth is to order medicines, book appointments, set reminders for medicines, and many more to manage a particular person's health.
- *Asynchronous or store and forward*—It is the way in which images, data, or messages are recorded and shared with the doctors. This model is used to provide the facility of exchanging medical information among healthcare personnel and patients: tasks like sending CT scan reports, X-ray images, ultrasound images, and other medical data from one remote location to the specialists for examining, medications, and future consultations.

Due to the continuous progress in ICT, the field of applications of ICT is ever changing and the healthcare sector is the one who is getting benefitted with all the innovations. Health ministers from 192 member countries of the World Health Organization (WHO) met for the 58th gathering, and they supported the eHealth resolution number WHA58.28 in Geneva [4]. In this assembly, members recognized the potential and contribution of ICT in the field of eHealth, and health system management has a great prospect for the development of public health. Telehealth is more useful where health services are rarely available. In short, we can say that telehealth is a combination of a broad set of elements which works with ICT to support long-distance health centers, health education, research, and many more functionalities in remote areas.

Experts divide telehealth services into three isolated categories. These categories are synchronous, asynchronous, and RPM. Synchronous services allow for direct association between a health expert and the patient by using mobile, telephone, video, or data sharing, e.g., text messaging. Asynchronous services allow healthcare professionals and patients to save and send information to the other party with an anticipation that they may meet in the future. The sharing of patient's images for examination purpose is mostly applicable in asynchronous services. In case of RPM, it allows a mixture of both synchronous and asynchronous messaging to allow healthcare professionals to assess a patient's condition over time [5]. Refining rustic behavioral healthcare systems and staff development must effectively address ways to recruit and train a diverse and culturally comprehensive team of remote physicians, nurses, psychologists, social workers, and licensed counselors familiar and well versed with best practice approaches [6].

To improve the healthcare system, governments should have strong willpower and very importantly a big heart. It does not matter which party or parties are in ruling government; they must continue the healthcare and other programs of public interest and make enhancement and advancement for the common people's benefits. In India, politics play a crucial role over policies and implementations. There are many factors like leadership politics, budget politics, and bureaucratic politics, which derail the actual goal of any policy and their implementation at ground level [7]. A culture has taken place when the new government comes in power and they put the schemes in scrap started by another government, especially the opposition party's government. So, making a policy and successful implementation of that policy have a number of challenges. Policy implementation is a complex process, and every stakeholder should only focus on certain important aspects.

2 Telehealth in India

India took almost 30–35 years after independence to announce and start the first National Health Policy (NHP) in 1980s. The main focus was to design the healthcare system. Our policy makers are making policies by keeping an eye on present laws, which talk about international boundaries. In developing nations, there are shortages of trained health workforce, and they are trying to get rid of shortages and very eager to improve their current healthcare system [8]. India has seen a good rise of public investment in the health sector after the declaration of the first health policy. It is sad that India ranked second highest in maternal deaths worldwide [9]. But India has looked into this problem and created and implanted policies, and the result is that the country now has low number of maternal deaths in the range of 100–299 [10]. India already has telemedicine infrastructure since long time back [11, 12]. The country was already working on telehealth services to provide better medical support in remote areas. The main focus was to improve primary health services [13]. Apart from the focus of PHCs on telehealth in remote areas, India has great potential on health education, nutrition, surgical consultation, and professional advice, and these are the growing areas of pan-India outreach [12, 14–18]. The Indian Government, state government, nongovernmental organizations (NGOs), and private people have taken great steps to facilitate health services to the people who are living in remote areas and the areas which lack development of healthcare system. Though telehealth services were not so promising before COVID-19 scenario to achieve their goal and development of proper infrastructure to serve large population and rural areas [19, 20], it was observed that telehealth technology has a great potential to provide important support. During the COVID-19, telehealth has saved the lives of thousands of people around the world. World has seen a paradigm shift in healthcare service and support with the advancement of telehealth technologies. Mathur, Srivastava, Lalchandani, and Mehta [21] also reached to a conclusion in their research that telehealth could be utilized utmost in the field of public healthcare. So that the most useful system can be expanded in health promotion including knowledge enhancement, beliefs, and attitudes of the medical clients.

2.1 Indian NGOs and Their Roles and Functions [22]

After the independence, India has made swift growth in the socioeconomic domain in the last seven decades. Millions of people have been taken out of poverty, literacy has improved, literacy rate has almost tripled, life expectation has improved, and people are getting better access to healthcare services. Yet, given the hugeness of India, both in terms of population and geographical area, and diversity in its social and cultural elements, millions of people are still not living a decent and healthy life. Even nowadays, plenty of people are struggling to get basic requirements, e.g., primary healthcare, home, nutritious food, and literacy. India's economic development has not been uniform. There is extensive economic dissimilarity between regions. And this is the area where NGOs arise to participate in the development of system. Their function is to fill the gaps left by the government and government agencies by improving the lives of the most sidelined people and societies.

2.2 Smile Foundation

Smile Foundation has its head office at New Delhi and regional offices at every big city in each region. It has covered 478 remote villages through 32 working projects to provide healthcare services to 541,835 people last year during COVID-19. More than 10,000 children got benefit with its school health program. It has conducted 142 multispecialty camps to provide immediate support to over 37,000 people. Total benefits were over 70% to women and girls.

2.3 Nazdeek

Nazdeek is an NGO which works as a legal empowerment organization. It was established in the year of 2012. As part of their project, tribal (Adivasi) women volunteer workforce was identified, and they reported cases of healthcare violations to mothers and infants in the tea estate areas in Sonitpur, Assam, India. Women volunteers could inform any such incidents using short messaging services, using numeric codes equivalent to exact places and types of incidents. All the cases were recorded onto a publicly reachable Ushahidi platform, i.e., endmmnow.org. Locations comprised of amenities provided by tea estate managers, who are officially obliged to provide primary healthcare to the workers, as well as public amenities, such as ration shops, hospitals, and Anganwadi centers, i.e., community centers which provide food and health services to children and women. To make the project a ground reality, Nazdeek teamed with a local body and an international partner [23].

2.4 SAHAYOG

This is another organization, which is actually a women's rights and health organization in Uttar Pradesh, India. It was formed in 1992. It has a long-lasting partnership with community-based organizations (CBOs) in the entire UP and with a public women's forum named Mahila Swasthya Adhikar Manch (MSAM). It covers roughly 12,000 poor, remote women activists from Dalit, tribal, and Muslim societies. In 2011, the government introduced a scheme to guarantee free complete maternity care, and the Uttar Pradesh Government demanded that civil society organizations should watch its execution autonomously [23].

CARE is another NGO which has been working in India since almost seven decades to provide benefits and upliftment for women and girls with its 53 programs in 18 Indian states and more than 130 districts. CARE is a nonprofit organization which is working on donations. CARE has its vision of 2030, which aims to impact 100 million people from poor and marginalized communities to achieve social protection by 2030. It also works for health, education, livelihood, and disaster management.

Each of the above nongovernmental organizations conducts additional activities at local and national level beyond the project boundaries. It is also essential to recognize that ICT projects are executed in the context of ongoing engagement with the groups, societies, and local and national governments addressed by the information and communication technology [23].

NGOs in India work for a vast range of causes. Their task is to improve the lifestyle, education, and health services at areas beyond the reach. They utilize the existing resources and the funds raised from donations. Some other important causes include education, poverty, child rights, environment conservation, human rights, social injustice, care for old-aged people, women empowerment, animal rights, sanitation and hygiene, wildlife conservation, humanitarian relief, health and nutrition, refugee crisis, literacy, disease control, and many others. When India entered the lockdown in the very first week of March 2020 to control the COVID-19 pandemic, the Prime Minister of India called upon all NGOs to support the regime—by providing primary need to the needy and neglected people; by supplying foods, medicinal aids, and protective gears; and by starting awareness movements on social distancing.

During the COVID-19 pandemic, NITI Aayog has contacted over 92,000 nongovernmental organizations and civil society organizations (CSOs) in the beginning of May 2020, seeking support in distributing services to the needy people along with health and community workforces to boost cross-sectoral partnership. NGOs face many challenges but work on many other levels from feeding hungry people to supporting local administrative bodies by providing health and hygiene kits.

The Honorable Supreme Court of India, on a very similar message, much admired the involvement and role played by NGOs in helping migrant workforces by distributing water, food, and juice and providing transportation during the pandemic. The role of NGOs can be seen with expert's comment. In their words, it is hard to believe that government alone can manage the pandemic in India without the help of NGOs. NGOs played a very crucial role in helping and supporting to develop and reach the last-mile people in need [22].

Performance of NGOs, local organizations, and civil society and the role they played in fighting the COVID-19 were praised by the Secretary-General of the United Nations, António Guterres, during the pandemic. He pointed out everything in the recent report on the socioeconomic effect of COVID-19.

It is not easy to find out the exact number of NGOs working in India, but according to a workout by the Government of India, at least more than 30 lakhs of NGOs function in our hugely populated country. In India, plenty of volunteers work for different social causes like animal rights, child rights, education, disaster relief, and women and girl empowerment. Some of the NGOs and societies like CRY: Child Rights and You, Lepra Society, HelpAge India, Smile Foundation, SEEDS, Goonj, Pratham, CARE, Rural Health Care Foundation, PRIA, Udaan Welfare Foundation, Yuva Unstoppable, Deepalaya, Sounds of Silence, Uday Foundation, and many others work truly hard to serve the humanity. All of these NGOs are continuing to achieve elevations in their respective work. It is overwhelming to see that all NGOs and societies are bringing the change in people's life in our great and diverse nation [24].

3 Services that Can Be Provided via Telehealth

The healthcare sector is going through a transitional face. It aims to help medical practitioners with ICT infrastructure. ICT is a great tool which has much potential to support in efficiency, safety, quality, effectiveness, and remote patient monitoring [25]. There is a chance of higher acceptance rate of telehealth care in both patients and health professionals. Due to the COVID-19 pandemic, people are afraid of going in crowd and specially visiting hospitals and clinics.

In case of emergency due to a chronic disease when medic's consultancy is necessary, telehealth can support in-time care to remote communities. It is a predominantly valued means for the reform of the healthcare system in remote areas. To improve the quality of health actually requires improved availability of health data. If a health professional has better, accurate, and up-to-date information, they can treat patients with good diagnostics. They may reach faster to diagnose the needy person. A computerized healthcare system and a secure communication network can provide opportunity to exchange information over electronic highway. It may include email communication between patient and medics, remote patient monitoring, telemedicine, and robot surgery.

Other services provided via telehealth are the following [26]:

- Reduced travel time by pre- and postoperative assessment care, so that the patient comes to the hospital only for surgery.
- Monitoring of old-aged people at home to make sure that they are having proper food on time, sleeping, and taking medications as per timetable.
- Experienced surgeon can support procedures and surgeries.
- Monitoring of daily hemodialysis rounds.
- Experienced health professional can lead point-of-care ultrasound by a local person remotely using videoconferencing.
- Can check the test results, communicate with your doctor, schedule an appointment, or request medicine refills.
- Assessment and psychotherapy of mental conditions.
- Remote resuscitation using videoconferencing.
- Diagnose and manage intraocular eye injuries, heart failure, fractures and dislocations, pneumonia, pericardial effusion, pulmonary edema/acute respiratory distress syndrome (ARDS), intraperitoneal fluid/bleed, cholecystitis, pancreatitis treatment, renal stones, intrauterine and ectopic pregnancies, etc.

4 Impact of Information and Communication Technology

Everyone knows that ICT is getting advanced day by day. Due to the advancement of ICT, the Internet and connectivity have become very fast and reliable as compared to earlier days of ICT. The solutions to provide connectivity between healthcare professionals and patients are plain old telephone service (POTS), optical fiber system, Wi-Fi loops, point-to-multipoint systems, time-division multiple access (TDMA), and satellite communications.

Earlier, the technology used POTS as bidirectional communication, using analog signals to produce voice over twisted wire cables made of copper. POTS network was invented to provide voice communication that was crossing countries. In the beginning, it was known as post office telephone service because in early days people were fully depended on post office operators to connect the calls. It used pulse and dual-tone multifrequency signaling (DTMF). The range of this service was 2–5 km. It can be understood with Fig. 1.

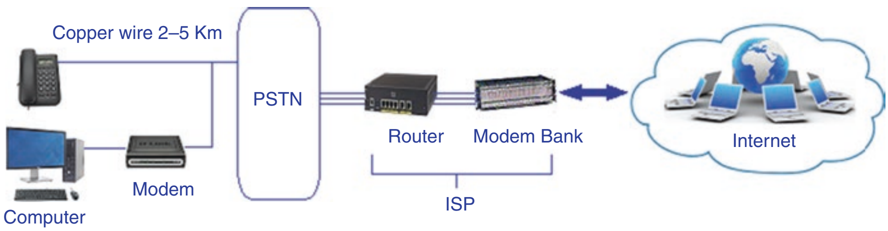

Fig. 1 POTS internet

It was very popular because of the very easy connection settings and its lower budget, if copper wire is already existing in that area. A user uses a telephone line, with a fully equipped desktop (personal) computer and a modem. The user dials an Internet service provider (ISP) to connect to the Internet. After that, the ISP connects the user to a router, which is already linked to another router over the Internet. POTS used 64 Kbps bandwidth and a circuit switching dedicated line for each extension. Cost was based on distance and time.

4.1 Optical Fiber System

POTS was the commonly used technology, but it had drawbacks like short distance limitations and inadequate quality. To overcome this problem, the invention of optical fiber took place. Optical fiber system is another wired arrangement, which has been established and used for long-range higher capacity networks. Generally, it is known as fiber Internet or fiber broadband connection which has speed up to 1 Gbps [27]. It is used to facilitate higher bandwidth connectivity between all important places in both urban and remote areas. This technology uses fiber-optic cable, which can send data with an amazingly high speed at around 70% of the speed of light. Fiber Internet is currently faster and reliable than any other Internet connectivity. A typical system for trunk route is shown in Fig. 2.

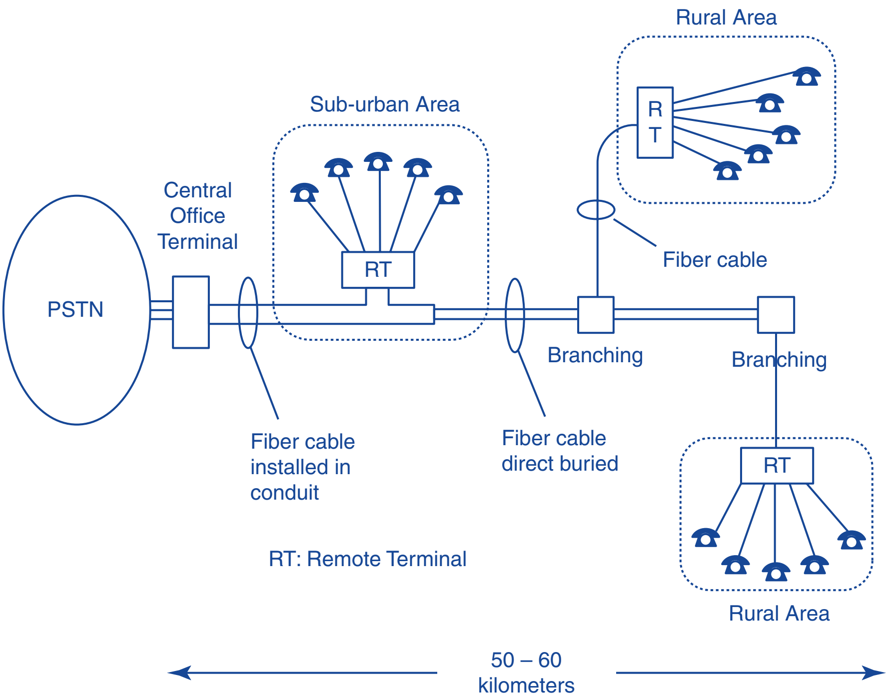

Fig. 2 Optical fiber system

4.2 Satellite Technology and Telehealth

Telehealth is the most important and crucial application of satellite technology. The impact is very important. Satellite plays a very crucial role in implementing and providing healthcare services to remote and rural primary health centers and hospitals by integrating ICT and medical science. Satellite technology facilitates more innovative and reachable health services due to the cost-effective ICT, which allows the implementation of various systems under the health sector like health planning, research and development, health education, and expert exchange program. But still the most important application in the health sector is to provide facilities and support in culturally diverse and geographically challenging areas. There are regions where communities live on top of an isolated hill or deeper inside a valley which is not easily accessible, and another big problem is of culture; only a female can see and touch the female patient [28].

In India, the Indian Space Research Organization (ISRO) started its telemedical program in 2001. The ISRO is responsible to connect every hospital and mobile health center working in isolated and rural areas to multispecialty clinics located in cities through satellite. It connects from mainland and islands to hills and valleys. It covers from east to west and north to south of the entire country. Continuing health education is also on the ISRO's network. The ISRO's program is a very innovative procedure of working together effectively to provide the benefits of satellite technology.

Currently, the network of the ISRO covers about 400 hospitals with more than 60 specialty hospitals which are connected to 300 plus rural and remote medical colleges and hospitals and 18 mobile health units. These units cover various areas of radiology, mammography, ophthalmology, cardiology, diabetology, general medication, and women and child healthcare.

The recent actions under this program involved operational nodes which were exaggerated due to unavailability of EDUSAT (GSAT-3) satellite. Most of the nodes active on EDUSAT were moved to functioning satellite GSAT-12. Almost 140 nodes are now functioning on INSAT-3A, and rest of the nodes are on INSAT-3C and INSAT-4A satellites. The ISRO is planning to introduce annual maintenance provision for the telehealth systems to ensure the steadiness of services [29].

For the purpose of increasing the liability of the government for the contentment of the right to health, the ICT is a suitable tool for gathering and distributing the data generated by citizens.

The coronavirus pandemic was an unlikely cause for acceleration in telehealth and thus use of ICT. The pandemic not only was responsible for enhancing the understanding of technology but also provided doctors and patients to use it. Now, after the decrease in coronavirus pandemic, life is going back to some sort of normalcy, but telehealth should continue functioning and providing cost-effective, safe, and secure environment to both the patients and medics.

To understand and utilize the benefits of telehealth, providers should provide the technology to societies which are currently lacking high-speed Internet facility and the use of advanced mobile phones. This type of maximized use of technology will create more varied data, which will produce a range of data to support better telehealth operations. The collective use of technology will also assist to cover healthcare services to remote zones and untouched metropolitan areas also. Medics and patients have to work out for the use of new technologies and integrate them into their routine life. There is a need to reach out to health professionals and patients to provide assistance on how to apply telehealth, as well as provide easy-to-understand educational resources. In order to increase telehealth and to create diverse data for analysis, authorities must endorse telehealth available to the entire nation [5].

5 Challenges to Implement Telehealth

There are many challenges and issues which need attention for successful implementation of telehealth. Before the COVID-19 pandemic, there were already many barriers in place for those who wanted to adopt telehealth. These barriers were for both the urban and remote healthcare providers. Barriers like poor and unclear eHealth strategies are the biggest hurdle to effective investment and implementation of bearable eHealth and formation of an effective and favorable eHealth policy environment.

Planning is the effective and essential force. It is the first vital component that can place countries at the driving seat of their own eHealth destiny. Good strategy and policy are necessary to achieve it [30]. Based on the literatures, we can say that there is a broad gap about the nonexistence of a theoretical framework regarding ICT acceptance in healthcare bodies [11, 31, 32].

According to Elder and Clarke [33], there is a need for more research in ICT acceptance in the area of the healthcare sector.

Carati and Margelis [34] also proposed the finding of hurdles and enablers of telehealth accomplishment in diverse atmospheres. R.K. Chandwani and Dwivedi [11] recommended that more research should be done in ICT acceptance at institutional and other perspectives. Finally, Dodel [31] proposed the need to work on cost-effective and quality research tools and to test the ICT access resources, appropriation, and usage as experimental variables in the researches of information and communication technology adoption of healthcare.

Apart from strategy and ICT, there are few more common but important barriers in implementing telehealth support in remote areas, e.g., reimbursement, licensure, privacy and security, liability, and technology access. Some of the challenges given below are specific to remote areas:

- Reimbursement—It is one of the most concerning areas which need high priority. Due to the pandemic in the United States, the Centers for Medicare & Medicaid Services changed the reimbursement requirement and allowed healthcare providers to extend telehealth support and services to the remote places of patients [35].
- Licensure—Licensure system is a burden to the medics if they want to extend the service and support to remote areas. The system should be designed in such a

way so that genuine and registered medical professionals can get the permission with ease.

- Language—Language causes a big problem when working in remote areas at grassroots level. Remote health programs may focus on communities with a large number of tribals or immigrant population. These programs need to make sure that their workforce understands the languages people use for communication, and they must also understand the importance of providing services or health education in an ethnically appropriate manner.
- Readiness and acceptance of telehealth—The partial acceptance of telehealth services is mostly referable to a medic's reluctance to implement telehealth [21]. There is a need of skilled and trained health workforce who can adopt the telehealth situations quickly in response to emergencies like COVID-19 pandemic. It is very challenging to combat a pandemic like novel coronavirus at the time of crisis.
- High-speed Internet—To get succeeded, telehealth should have the services of high-speed Internet (broadband) available. This will improve the services and quality of healthcare. Due to broadband connection, doctors and patients can share the images, reports, and other required data fast and easily.
- Resources and sustainability—In remote areas, there is a lack or shortage of technology, human resources, and fundings. There are very limited resources available. It is very difficult to generate monetary supports from the communities living in remote areas. If we can get or build a network of partners to provide resources and support for a program, it may be beneficial for the community.
- Recruiting staff—Recruiting expert medical staff in remote areas is a tedious task. Communities that are running remote health programs require medics, nutrition experts, physiotherapists, etc. But they are facing barriers in recruiting appropriate trained workforce. There are some programs working with the support of volunteers, retired health professionals, or students.
- Geographic limitations—Geographic location is a big problem in implementing telehealth services, especially in a country like India where locations are deep in the valley or on top of dangerous hills. A number of factors like weather conditions and isolation are challenging any telehealth program to be implemented and to operate smoothly. This becomes a predominantly important problem when there is inadequate transportation system to reach the isolated communities. In such a scenario, it requires modifications in tactics and program design that take into account prolonged travel times, availability of conveyance, and prospect to offer the program remotely or using other technological ways.
- Keeping the community motivated—Motivation of community is very important. It plays a vital role in running any health program smoothly. An alertness of health concerns needs to be present. At individual and organizational level, mass program on health awareness should be conducted in communities. Some commitments from governmental organizations and nongovernmental organizations are essential toward making the changes required to look at those concerns. It is very important for any program organizers to realize that success will depend on conducting education and outreach efforts to regulate community members' hopes about the program and to motivate them to accomplish improved health results.

6 Pros and Cons of Telehealth

Telehealth is growing very fast because it provides great benefits to the patient and health professionals. According to the American Telemedical Association (2015), there is huge evidence which confirms the significant potential of telehealth that it is providing best quality of care constantly at a lesser expense. Fear of spreading the infection in pandemics has increased interest in telehealth. As per the association, the research has proven that:

- Telehealth provides improved access of healthcare services. We have experienced it recently during the time of COVID-19. Public health has been changed to adopt telehealth system [5].
- Telehealth system is very helpful in saving life especially in remote areas when there is lack of time to get the patient to the hospital.
- Sharing of resources such as patient report, prescriptions, and other important documents is made easier.
- Telehealth provides better facilities to health education. It will improve communities' knowledge and understanding of health.
- According to Dellifraine and Dansky (2008), results of telehealth are mostly found to be comparable or higher than in-person amenities.
- Degrees of patient satisfaction are higher as compared to in-person healthcare (Sucher et al., 2011; Gustke et al., 2000).
- Healthcare services are cost effective. By using telehealth, costs of healthcare are lower than in-person hospital services (Holt et al., 2018; Cryer et al., 2012; Baker et al., 2011; Darkins et al. 2008; Kohl et al., 2007). Doctors are providing consultations around the world from their native country.
- Telehealth offers improved quality of contactless healthcare services because it eliminates the possibilities of disease transmission among health professionals, patients, and other people.
- Telehealth is very useful to avoid contact for stopping the spread of COVID-19.
- Patient safety is higher than in-person visit for elderly patients by providing healthy and safer environment [36].

Although telehealth provides huge convenience and cost-effectiveness by allowing to visit the medical professional without leaving our home, it has some problems like the following:

- It is impossible to go remotely for every type of diseases.
- Security of personal (patients') data is also a major concern when transmitting electronically.
- During COVID-19, insurance companies covered the cost of telehealth visits, but there were some services which were not covered fully. This may lead to loss of money.
- The overall cost of ICT systems, data management equipment, and trainings to medical professionals is higher.

- Telehealth may consume lots of time due to the improper speed of the Internet or sometimes server-related problems.
- A tough legal system must be in place to prevent illegal and unauthorized service providers.

7 A Case Study from India

This case study aims to examine the role of telehealth amenities in India during the COVID-19 pandemic. This study consists of experiences and reports of health services from the remote areas of India. Impact of novel coronavirus pandemic has opened up a new window for the medics and patients to get health facility and other health services in the form of telehealth. Telehealth services increased from 10% to 90% based on the data available. About 90–95% of healthcare professionals have accepted telehealth services as a means of providing consultations. Patients and medical professionals have used various IT services like WhatsApp messaging and video calling, Google calendar for appointment reminders, email services, and other online available applications to consult and get prescriptions [37].

According to the report of the Ministry of Health and Family Welfare (MoHFW), the Government of India's telehealth service exceeds 3 million consultations. As per the data, daily over 35,000 patients used eSanjeevani to seek health services remotely. Top five districts having the largest figures of eSanjeevani consultations are Salem, TN (123,658); Madurai, TN (60,547); Hassan, KA (43,995); Meerut, UP (35,297); and Raebareli, UP (34,642). It illustrates that people residing in tier 3 and 4 cities find eSanjeevani even more beneficial [38].

The health sector in India has witnessed a great change during the novel coronavirus period. One major change is online medical consultations. In March 2021, growth in telehealth reached $163 million [39]. As per the report of a management consulting and advisory service organization, *Praxis Global Alliance*, online consultation with medical practitioners is expected to cross $800 million by the financial year 2024. The report also revealed that the OPD consultation is almost $10.4 billion and the general physicians share more than 60% of consultation. Safety from infection and convenience were the major reasons for growth in telehealth during the COVID-19 pandemic. The report also said that the increase in EHR saturation in clinics and hospitals also increased the use of advanced technologies like artificial intelligence (AI) and machine learning (ML) in healthcare (Table 1).

As per the data available, the leading ten states (in terms of number of consultations) of eSanjeevani can be given as follows: Tamil Nadu (642,708), Uttar Pradesh (631,019), Karnataka (607,305), Andhra Pradesh (216,860), Madhya Pradesh (204,296), Gujarat (195,281), Kerala (93,317), Maharashtra (84,742), Uttarakhand (74,776), and Himachal Pradesh (67,352).

Table 1 eSanjeevani consultations

eSanjeevani consultations				
S. No.	16/03/2021	Total	eSanjeevani HWC	eSanjeevani OPD
	INDIA	**3,000,443**	**879,403**	**2,121,040**
1	Tamil Nadu	642,708	14,933	627,775
2	Uttar Pradesh	631,019	58,087	572,932
3	Karnataka	607,305	134,929	472,376
4	Andhra Pradesh	216,860	202,228	14,632
5	Madhya Pradesh	204,296	202,937	1359
6	Gujrat	195,281	34,013	161,268
7	Kerala	93,317	3	93,314
8	Maharashtra	84,742	52,004	32,738
9	Uttarakhand	74,776	624	74,152
10	Himachal Pradesh	67,352	66,102	1250
11	Chhattisgarh	55,684	55,656	28
12	Haryana	27,834	2952	24,882
13	Bihar	23,562	23,562	0
14	Assam	21,065	12,936	8129
15	Punjab	19,843	17,331	2512
16	Delhi	14,154	0	14,154
17	Rajasthan	8771	9	8762
18	Jharkhand	4338	3	4335
19	Manipur	3071	0	3071
20	Chandigarh	2388	0	2388
21	West Bengal	787	787	0
22	Telangana	431	0	431
23	Mizoram	233	178	55
24	Jammu and Kashmir	232	0	232
25	Arunachal Pradesh	111	0	111
26	Goa	110	45	65
27	Ladakh	66	0	66
28	Meghalaya	46	46	0
29	Odisha	38	38	0
30	DNH and DD	14	0	14
31	Puducherry	9	0	9

Source: MoHFW [38]

8 Recommendations

Even after the COVID-19 is over, governments and organizations should work to form strong policies and guidelines to use telehealth in future. The responsible authorities should come up with a clear and noncomplex regulatory environment for medics, patients, and insurers. Below are some recommendations to use telehealth in future:

- Data during the COVID-19 and pre-COVID-19 period of telehealth administration and programs should be analyzed.
- Telehealth should be flexible to hold the variety of use cases.
- Employers should have the total responsibilities to make sure that all the preventive and protective norms are being followed to minimize the risk to healthcare professionals.

- Educational contribution and realization: Continuing education needs to be supported, and more training should be provided to the medical professionals and other health workforce.
- Governments and NGOs should take actions to increase the social and financial capital of rural and remote nationals.
- Telehealth rules and regulations should be written with a broader sense of the future. It must be much flexible as likely to integrate existing and developing modalities.
- It must be used for primary healthcare to slash service problems.
- All the states and districts should be authorized to back off from existing old models to reduce the telehealth service cost.
- Telehealth facilities must be available to every person who is medically underserved.
- New researches must be carried out to enhance innovation, confidentiality, and data security in telehealth services, and it must be mandatory.
- Data security standards should be of high importance in securing the entire data.
- Remote communities must be made aware to have participation in their health.

9 Conclusions

Telehealth is an important and useful tool to provide support in remote practice where we have negligible or limited human and technician supports. India and other developing countries have limited physical manpower, health workers, and medical experts in remote areas. Most of the hospitals were closed in cities and rural areas, and the situation was getting worse. Telehealth has opened door for healthcare providers to come closer to communities, and it supports patients and health workers in difficult emergent situations like COVID-19, in cities, towns, and areas which are inaccessible. Action taken by government and private sector organizations has eased the limitations of healthcare. Telehealth not only supported in getting prescriptions and treatment but also educated the communities toward the novel coronavirus disease. This was a great use of ICT. To educate communities will put positive impact on health. They will get mentally strong. Educating community will also save them from getting mentally ill. Proper training and setup are required for telehealth to be successful. Apart from training and setup, some actions should be taken in the areas of settlement, liability, technology access, privacy and security, etc. As we are moving past the COVID-19 calamity, regulatory authorities should monitor how organizations are using personal health data, which is being communicated using telehealth technologies. They need to monitor and take appropriate actions on the use of data.

Remote facilities have witnessed a huge impact during COVID-19. Though telehealth care cannot be an alternative for every medical visit to a doctor's chamber, it is also equally important that these services have the opportunity of being an important substitute.

References

1. Article by NEJM catalyst. What is telehealth? 2018. Accessed 14 Nov 2021.
2. Nittari G, Khuman R, Baldoni S, Pallotta G, Battineni G, Sirignano A, Amenta F, Ricci G. Telemedicine practice: review of the current ethical and legal challenges. Telemed J E Health. 2020;26(12):1427–37. https://doi.org/10.1089/tmj.2019.0158.
3. Presidential Task Force on Telehealth. American College of Obstetricians and Gynecologis (ACOG) task force members Curtis Lowery, MD and Nathaniel DeNicola, MD. Published online on January 23, 2020. https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2020/02/implementing-telehealth-in-practice. Accessed 20 Sep 2021.
4. PAHO/WHO. Framework for the implementation of a telemedicine service. Washington, DC; 2016. https://iris.paho.org/bitstream/handle/10665.2/28414/9789275119037_eng.pdf. Accessed 20 Sep 2021.
5. Battineni G, Pallotta G, Nittari G, Amenta F. Telemedicine framework to mitigate the impact of the COVID-19 pandemic. J Taibah Univ Med Sci. 2021;16(2):300–2. https://doi.org/10.1016/j.jtumed.2020.12.010.
6. Mirmoeini SM, Marashi Shooshtari SS, Battineni G, Amenta F, Tayebati SK. Policies and challenges on the distribution of specialists and subspecialists in rural areas of Iran. Medicina (Kaunas). 2019;55(12):783. https://doi.org/10.3390/medicina55120783.
7. Campos PA, Reich MR. Political analysis for health policy implementation. Health Systems & Reform. 2019;5(3):224–35. https://doi.org/10.1080/23288604.2019.1625251.
8. Scott RE. Global e-health policy-from concept to strategy. In: Wootton R, Patel N, Scott RE, Ho K, editors. Telehealth in the developing world. London: Royal Society of Medicine Press; 2009.
9. World Health Organization. Trends in maternal mortality: 1990 to 2015: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. Geneva, Switzerland: World Health Organization; 2015. http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf. Accessed 20 Oct 2021.
10. United Nations International Children's Emergency Fund. Maternal mortality-current status and progress; 2017, February. https://data.unicef.org/topic/maternal-health/maternal-mortality/. Accessed 3 Nov 2021.
11. Chandwani RK, Dwivedi YK. Telemedicine in India: current state, challenges and opportunities. Transforming Government People Process Policy. 2015;9(4):393–400.
12. Meher SK, Kant S. Awareness and attitudes of geriatric patients towards telemedicine in India. Gerontechnology. 2014;13(2):262.
13. Kumar A, Ahmad S. A review study on utilization of telemedicine and e-health services in public health. Asian Pacific J Health Sci. 2015;2(1):60–8.
14. Al-Mahdi I, Gray K, & Lederman R. Online medical consultation: a review of literature and practice. Paper presented at the proceedings of the 8th Australasian workshop on health informatics and knowledge management; 2015.
15. Brindha G. Emerging trends of telemedicine in India. Indian J Sci Technol. 2013;6(supp 5)
16. Gupta SG. Tips for telephone and electronic medical consultation. Indian J Pediatr. 2013;80(11):944–8.
17. Prasad DD, Ray S, Majumdar AK, Mukherjee J, Majumdar B, Paul S, Verma A. Real time medical image consultation system through Internet. J Healthcare Eng. 2010;1(1):141–54.
18. Sivagurunathan C, Umadevi R, Rama R, Gopalakrishnan S. Adolescent health: present status and its related programmes in India. Are we in the right direction? J Clin Diagn Res. 2015;9(3):LE01.
19. Marcelo A, Ganesh J, Mohan J, Kadam D, Ratta B, Kulatunga G, Marcelo P. Governance and management of national telehealth programs in Asia. Global telehealth 2015: integrating technology and information for better healthcare. 2015;209:95.
20. Hu PJH, Chau PYK, Liu Sheng OR. Adoption of telemedicine technology by health care organizations: an exploratory study. J Organ Comput Electron Commer. 2002;12(3):197–221.

21. Mathur P, Srivastava S, Lalchandani A, Mehta JL. Evolving role of telemedicine in health care delivery in India. Primary Healthcare. 2017;7:260.
22. Marwaha P. Celebrating the role of Indian NGOs in combating the COVID-19 pandemic;27 Feb 2021. https://www.downtoearth.org.in/blog/governance/celebrating-the-role-of-indian-ngos-in-combating-the-covid-19-pandemic-75697. Accessed 5 Nov 2021.
23. Schaaf M, Chhabra S, Flores W, Francesa F, Dasgupta J & Ruano AL (2018). Does information and communication technology add value to citizen-led accountability initiatives in health? Experiences from India and Guatemala. Health Hum Rights, 20(2). https://www.jstor.org/stable/10.2307/26542069. Accessed 11 Oct 2021.
24. Pataskar S. 10 NGOs which have revolutionised healthcare in India; December 2018. https://www.giveindia.org/blog/10-ngos-which-have-revolutionised-healthcare-in-india/. Accessed 5 Nov 2021.
25. Institute of Medicine. Quality through collaboration: the future of rural health. Washington, DC: The National Academies Press; 2005. https://doi.org/10.17226/11140.
26. Jong M (2018). How to use telehealth to enhance care in isolated northern practices. Exner-Pirot, H., B. Norbye and L. Butler (eds.) (2018). Northern and indigenous health and health care. Saskatoon, Saskatchewan: University of Saskatchewan. openpress.usask.ca/northern-healthcare. Accessed 23 Sep 2021.
27. Gerencer T. Top 10 advantages of fiber optic internet connections; April 21, 2020. https://www.hp.com/us-en/shop/tech-takes/top-10-advantages-fiber-optic-internet-connections. Accessed 6 Nov 2021.
28. Satellite Technologies and Telemedicine Vol. 2. https://www.geo.university/pages/satellite-technologies-and-telemedicine. Accessed 15 Nov 2021.
29. Tele-Medicine. https://www.isro.gov.in/applications/tele-medicine. Accessed 15 Nov 2021.
30. Scott RE, Mars M. Principles and framework for eHealth strategy development. J Med Internet Resz. 2013;15(7):e155. https://doi.org/10.2196/jmir.2250.
31. Dodel M. An analytical framework to incorporate ICT as an independent variable. In: Chib A, May J, Barrantes R, editors. Impact of information society research in the global south. Springer Open; 2015. p. 125–44.
32. Standing C, Volpe I, Standing S, Gururajan R. Making the most of virtual expertise in telemedicine and telehealth environments. Paper presented at the IEEE ninth international conference on dependable, autonomic and secure computing; 2011.
33. Elder L, Clarke M. Past, present and future: experiences and lessons from telehealth projects. Open Med. 2007;1(3):166–70.
34. Carati C & Margelis G. Towards a national strategy for telehealth in Australia 2013–2018. Paper presented at the global telehealth 2012, Sydney; 2013. aths.org.au
35. RHIhub. Telehealth use in rural healthcare; 2/2021. https://www.ruralhealthinfo.org/topics/telehealth. Accessed 5 Oct 2021.
36. Lee NT, Karsten J & Roberts J (2020). Report—removing regulatory barriers to telehealth before and after COVID-19. https://www.brookings.edu/research/removing-regulatory-barriers-to-telehealth-before-and-after-covid-19/. Accessed 21 Sep 2021.
37. Husain A, Akinola A, Akhtar S. A case study: emerging role of telehealth and local health practitioners during COVID-19 pandemic. Int J Community Med Public Health. 2021;8:2537–9.
38. Press Release. Ministry of health and family welfare; March 2021. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1705358. Accessed 14 Nov 2021.
39. Report by Peerzada Abrar. Doctor consultations exceed 4 billion in India in FY21: Praxis report; August, 2021. https://www.business-standard.com/article/economy-policy/online-doctor-consultations-cross-4-bn-in-india-in-fy21-praxis-report-121082000743_1.html. Accessed 14 Nov 2021.

Ethical and Legal Challenges of Telemedicine Implementation in Rural Areas

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1 The Right to Health as a Fundamental Human Right

The right to health is clearly stated in both the Universal Declaration of Human Rights and in the World Health Organization (WHO) Constitution, both signed in 1948.

Article 25 of the Universal Declaration, adopted by the General Assembly of the United Nations (UN) on 10 December 1948, stated, "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care". In the preamble to its constitution, the WHO states that health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", confirming its importance as a fundamental human right [1].

The WHO definition of health, because of its very high social and moral value, seemingly lacks concrete indications to which the jurist can refer. Likewise, it is evident that the concrete needs for health protection, although they may be *latu sensu* common, are profoundly different depending on the geographical areas taken into consideration. However, it is significant to note, as has been pointed out [2], that the Court of Justice of the European Union (CJEU) expressly referred to the aforementioned definition in deciding the case *United Kingdom of Great Britain and Northern Ireland v. Council of the European Union* (CJEU, Case C-84/94,

Roberto Garetto, PhD (coord.) authored paragraphs 1 and 7; Salvatore Coscarelli authored paragraph 2; Maria Paola Nico authored paragraph 3; Francesca Ferretti authored paragraph 4; Ivan Allegranti authored paragraph 5; Serena Cancellieri authored paragraph 6.

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_3

Judgment of 12 November 1996), which concerned occupational health and safety issues.

In addition to these two documents, we should also take into account the International Covenant on Economic, Social and Cultural Rights (ICESCR), which is an international treaty concluded under the auspices of the United Nations, adopted and opened for signature, ratification and accession by the General Assembly resolution 2200 A (XXI) of 16 December 1966 and entered into force on 3 January 1976 [3]. When it comes to the right to health, the ICESCR Convention has not adopted the WHO definition, stressing instead on Article 12 that States Parties “recognize the right of everyone to the enjoyment of the highest attainable standard of physical and mental health”.

Bearing in mind the definitions contained in these international instruments, we can therefore recognise that the right to health is attributable to the category of human rights. From this it follows that, like most human rights obligations, this right applies to “everyone”, regardless of their legal status. Irregular migrants, detainees and stateless populations are included. Furthermore, like other social and economic rights, the right to health is progressively realised. States ratifying the covenants must “take steps”, through “all appropriate means, including particularly the adoption of legislative measures”, to achieve progressively all aspects of this right, “to the maximum of its available resources” (Article 2, paragraph 1).

As a sociocultural right, the right to health can be defined as a progressive right. This means that unlike other rights, such as the right to life, the right to health cannot be realised immediately, but requires a progressive realisation. In other words, the full realisation of a right belonging to the category of economic, social and cultural rights cannot be achieved in the short term but requires a longer plan of action over time. States are not obliged to immediately implement these rights in their fullest form, but to achieve their realisation in a progressive manner. As pointed out, health is to be considered a fundamental right. As such, it lies at the root of all the other fundamental rights of the human person. The centrality of the right to health gives rise to responsibilities for states and their bodies that go far beyond the mere management of a health system. They should take it upon themselves to detect and identify, through appropriate cooperation, the factors which have a negative impact on collective health and to promote those which are beneficial.

The progressive realisation of the right to health passes through the implementation of specific actions by the WHO. Since the 1980s, in particular, two strategies have been adopted, which go by the names of “Health promotion”, or Ottawa Charter, and “Health for all strategy”, respectively. These actions are aimed at achieving two strategic objectives: health promotion and disease prevention.

In particular, at the First International Conference on Health Promotion, which took place in Ottawa in 1986, strategies were drawn up for a global and concerted action aimed at the psychophysical well-being of the person. The Ottawa Charter, which was signed by the Member States of the WHO, places man at the centre of attention. Starting from a holistic view of the human being and society, the Charter is based on a vision of man as a whole and not the sum of separate parts. In parallel, social organisation is seen as a unified whole. Consequently, everyone must be put in the best possible position to achieve their full health potential. However, this new perspective of equality—based on the right to health—can only be achieved through the active intervention of all stakeholders: governments, public and private health bodies, non-governmental organisations and the media. According to Ottawa Charter, health promotion is the process of enabling people to increase control over and to improve their well-being. Health thus becomes an indispensable resource of everyday life, an element that improves the world itself. Everyone must learn to take care of themselves and of others. The Ottawa Charter thus advocates a social dimension to health that aims to create the best possible conditions for healthy human development in all conditions and at all stages of life.

In the European context, it is essential to refer first to the Council of Europe. As emphasised by Harris et al. [4], the right to health, like the other "social rights", is not expressly recognised in the European Convention on Human Rights (ECHR), which entered into force on 3 September 1953. However, the European Court of Human Rights (ECtHR) has gradually extended the protection of this right through an evolutive and extensive interpretation of other provisions of the Convention, especially Article 3 (prohibition of torture) and Article 8 (respect for private and family life). However, this is a form of indirect protection: the right to health is not protected in and of itself, but only insofar as its infringement results in the violation of rights expressly recognised by the Convention (see ECtHR jurisprudence, inter alia: *Kudla v. Poland*, application no. 30210/96; *Bensaid v. UK*, application no. 44599/98; *Vo v. France*, application no. 53924/00; *Pretty v. UK*, application no. 2346/02; *Tysiac v. Poland*, application no. 5410/03; *K.H. v. Slovakia*, application no. 32881/04; *Evans v. UK*, application no. 6339/05; *Dybeku v. Albania*, application no. 41153/06).

The right to health is stated instead in the European Social Charter, a Council of Europe treaty which was opened for signature on 18 October 1961. The Charter contains a provision—Article 11—expressly dedicated to the "right to protection of health". Article 11 defines the obligations of the States Parties, who committed themselves to the right to health. Specifically, these are 42 of the 43 States Parties to the Charter; Armenia is the only State Party that has not accepted Article 11 [5]. Since in Part I of the Social Charter States, paragraph 11, States Parties recognised that "Everyone has the right to benefit from any measures enabling him to enjoy the highest possible standard of health attainable", in Article 11 they committed themselves to ensure "the effective exercise" of this right through the adoption of "appropriate measures designed *inter alia*: 1. to remove as far as possible the causes of ill-health; 2. to provide advisory and educational facilities for the promotion of health and the encouragement of individual responsibility in matters of health; 3. to prevent as far as possible epidemic, endemic and other diseases, as well as accidents" [6].

As is stated in the text of Article 11 and as remarked by the European Committee of Social Rights in the "Statement of Interpretation on Article 11–Conclusions 2005" (Council of Europe, 2018), the fulfilment of the obligation to ensure the right to health protection essentially requires the adoption of positive measures (of legislative, administrative, educational and technical-sanitary nature) suitable for achieving the objectives established by the provision. In particular, the adoption of action to remove the causes of poor health has been interpreted by the Social Rights Committee as essentially a positive obligation on States Parties. They must therefore guarantee the accessibility and affordability of healthcare to all those who need it. Lack of economic resources must not be an obstacle to such access. States Parties that have signed the Social Charter are therefore obliged to guarantee access to healthcare at no cost to those with no economic resources.

In the context of the right to health, the subsequent activity promoted by the Council of Europe is of particular interest. The most significant result is the Convention for the Protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and Medicine, the so-called Oviedo Convention, which opened for signature on 4 April 1997. Its ratification is not limited to the States that are members of the Council of Europe but is extended to those who took part in the preparatory work. This instrument perfectly embodies the changing relationship between unstoppable medical-scientific progress and risk of its indiscriminate use, which might harm the supreme value it is supposed to protect, namely the health of all individuals. Indeed, Article 2 of the Convention states, "The interests and welfare of the human being shall prevail over the sole interest of society or science".

At the European level, health protection is also guaranteed in the Treaty on the Functioning of the European Union (TFEU). This guarantee is ensured through cross-cutting actions. Article 6 of the TFEU states that the Union shall have the competence to carry out actions to support, coordinate or supplement the actions of the Member States. Among the areas of such actions is the "protection and improvement of human health". In fulfilment of this provision, Article 9 obliges the Union, in defining and implementing its policies and activities, to take into account requirements linked to the promotion of "a high level of (…) protection of human health". More specifically, Title XIV of the TFEU refers to "Public Health". Of particular relevance is Article 168. It ensures a high level of human health protection for all policies and activities of the European Union (EU). As the EU, with the entry into force of the TFEU, has a shared competence in the field of public health, Article 168, paragraph 1, provides that the Union action "shall complement national policies, shall be directed towards improving public health, preventing physical and mental illness and diseases, and obviating sources of danger to physical and mental health". Consequently, the EU is not in charge of defining health policies but has a largely coordinating function. Paragraph 2 of Article 168 furthermore states that the Union shall "encourage cooperation between the Member States" in the areas referred to in the aforementioned first paragraph and, if necessary, shall "lend support to their action". Furthermore, the Charter of Fundamental Rights (CFR), pursuant to Article 35, establishes in the EU Member States the right of everyone to have "access to preventive health care and the right to benefit from medical treatment under the conditions established by national laws and practices". In the same Article, it is also provided that a "high level of human health protection" will be ensured through the definition and implementation of all health policies and activities. In this respect, there is an explicit convergence between the provisions of the CFR and the TFEU.

The European Pillar of Social Rights (EPSR) adopted in 2017 by the European Commission reaffirms the right to health, with regard to the working environment. The EPSR sets out 20 principles on the interconnected determinants of health, including fair working conditions and social protection. In particular, paragraph 10 of Chap. 2 states, “Workers have the right to a high level of protection of their health”.

Among the European States, before the end of the Second World War, only the UK had introduced, in 1942, thanks to the Social Insurance and Allied Services (Cmd. 6404), the so-called Beveridge Report, the first system of public healthcare. It formed in the UK the basis for the post-war reforms known as the Welfare State, which include the expansion of National Insurance and the creation of the National Health Service (the UK is still a member of the Council of Europe but has not been an EU Member State since 2020). The French Constitution of 1946, which was in force for only 12 years, included the protection of the individual’s health as one of the tasks of the State in its Preamble but did not provide any further definition. There is nothing in the German *Grundgesetz* of 1949, which is still in force, or in the French Constitution of 1958, which is currently in force. Only in the post-dictatorship Constitutions of Spain, Portugal and Greece, all of which were approved in the second half of the 1970s, is there an affirmation of a right to health [7]. In the Italian Constitution, in force since 1948, the right to health has found explicit recognition and protection. In this respect, the Italian Constitution is among the first to affirm such a right and can be considered the earliest of those currently in force in the EU context. As emerges from the preparatory work of the Constituent Assembly [8], the Italian Constituent Assembly chose not only to introduce this right into the constitutional framework but also to include it in the ambit of ethical-social relations and to qualify it as fundamental. This characteristic of the Italian Constitution makes it a necessary object of study when one wants to focus on the right to health as a fundamental personal right. In fact, the Italian Constitution is absolutely consistent with the United Nations Universal Declaration of Human Rights, also promulgated in 1948.

The right to health is established in the Italian Constitution in Article 32. The first paragraph of this Article provides that the State safeguards health as a fundamental right of the individual and as a collective interest and states that free medical care is guaranteed to the indigent. The second paragraph of Article 32 stipulates that no one may be obliged to undergo any health treatment except under the provisions of the law and establishes that, in any case, the law may not violate the limits imposed by respect for the human person.

Although health is specifically regulated at the constitutional level in Article 32, the underlying notion of health in the text implies that it should be considered as an inseparable aspect of the human person, determining thus, as emphasised by Perlingieri [9], a unitary value. Article 32 must therefore be viewed in conjunction with Articles 2 and 3 of the Italian Constitution. The right to health must therefore be recognised for all as a human right on a solidarity basis and without any discrimination [9, 10]. As pointed out by Papa [7], in a concise text, four subjective legal situations are thus provided for an individual right to freedom, collective interest and two different social rights.

The former includes not only the right to receive necessary treatment but also the right not to be treated if one does not wish to be treated. Corresponding to this is the duty to abstain from intervention, which is imposed, as D'Aloia [11] emphasised, on everyone in order to allow the individual to self-determine. The second subjective situation is related to what has been emphasised above: the freedom of self-determination with regard to personal health must not constitute a menace to the collective interest in health. According to Papa [7], it is, therefore, the responsibility of the State to determine, with respect for the human person, the reasonable balance of interests in determining compulsory health treatment.

The obligation to receive compulsory medical treatment in the presence of an infectious disease that has already been contracted, in order to prevent it from spreading, is therefore in conformity with Article 32. On the other hand, the question of preventive treatment, such as vaccines, remains open, not only to prevent individuals from falling ill but also to prevent them from causing harm to the collectivity [12]. This highly complex issue requires the application of a precautionary principle. This principle, expressed in Article 191 TFEU, guides the choice of appropriate precautions to ensure safety in the context of health. As pointed out by Perlingieri [13], it is therefore appropriate not so much to react to a possible risk for health as to act in advance in order to prevent the risk itself from arising. This poses complex questions of hermeneutics in relation to constitutional principles, which must be balanced out. However, this balance must be made also in the light of the principle of proportionality, which is essential in a problematic context such as health [13].

The outbreak of Covid-19 [14], declared as a pandemic by the WHO on 11 March 2020, must be related to the above-mentioned issues. It has had an unprecedented impact on collective health since the Second World War [15], negatively affecting the overall psychological well-being [16] and also involving the labour sphere [17], which has special constitutional coverage under Article 1 and Article 4 of the Italian Constitution. The vaccination campaign launched at the beginning of 2021 has been widely and spontaneously supported by individuals but has also generated widespread reactions of refusal to receive the vaccine. In the context of the Italian Constitution, such reactions require a balance to be drawn between the freedom and self-determination of individuals and the collective interest in health. The debate is still ongoing, both in relation to a possible vaccination obligation [18] and with regard to the Covid-19 "Green Pass" being made mandatory for workers [19].

Article 32 of the Italian Constitution also contains, as already mentioned, the recognition of two distinct social rights: the right to receive healthcare treatments, which everyone is entitled to, and the right to use them free of charge anytime, in case of indigence. According to Caravita di Toritto [20], this is believed to be applicable to both Italian and foreign citizens.

The overall framework is therefore articulated, with reference not only to the subjective legal situations referred to in the aforementioned Article 32 but also to the nature of the interventions. They indeed must be aimed not only at treating illnesses but, as emphasised by Perlingieri [10], at the well-being of the person in a broader sense, as an indissoluble psychophysical unit.

2 Healthcare Organisation in the EU and in Italy

The legal system of the EU guarantees, for European citizens, through the health systems of EU countries, the right to use health services based on the principles of equity, accessibility, universality and sustainability.

Pursuant to Article 3 of the Treaty on European Union (TEU), the Union shall safeguard the well-being of its peoples, "shall combat social exclusion and discrimination, and shall promote social justice and protection, equality between women and men, solidarity between generations and protection of the rights of the child" and "promote economic, social and territorial cohesion and solidarity among the Member States".

These issues are closely linked to the organisation of the health system and the effective enjoyment of the right of access to medical care, at least primary care. In order to achieve these objectives, under Article 5 of TEU, "the Union shall act only within the limits of the competences conferred upon it by the Member States in the Treaties", in accordance with the principles of subsidiarity and proportionality, respecting the essential functions of the State and the national identity inherent in the fundamental, political and constitutional structure including the system of local and regional self-government [21].

The right to health services is one of the fundamental rights of the welfare state systems.

Over the last few decades, the organisation of the EU national welfare systems has undergone considerable transformations, which have negatively affected the effective use of essential levels of social and healthcare. For a long time, these services were, to a large extent, secured by a strong direct intervention by public institutions. However, as early as the late 1980s, social and health services began to be organised and provided by private individuals, especially not for profit. The responsibility to ensure the essential levels of social and public health benefits is, in fact, strongly conditioned by the budgetary constraints defined by the Union and by the contraction of health budgets within the EU territory [22].

In European Law, health services have particular legal relevance, both because of the specific public interest objectives which they contribute to achieving and because of their characteristics. The latter, together with the tasks assigned to public bodies, define the organisational models adopted within the individual national health systems [23].

Indeed, in accordance with the principle of subsidiarity outlined in the European Treaties, the planning and organisation of social and health services are entrusted to the competence of the individual Member States (Article 168, paragraph 7, of the TFEU).

However, it is not superflous to point out that the European Treaties, together with the recognition of full organisational autonomy for the individual Member States, has granted the EU institutions the right to exercise coordination and intervention (Article 168, paragraphs 1 and 2, of the TFEU), which affirms the interdependence of the different national health systems.

The fundamental principles that characterise European national health systems are the principle of universality, the principle of equal access to care, the principle of solidarity and the principle of sustainability. They involve organisational models, which must ensure the durability of services and services covered by health systems.

Within the EU, health systems are thus largely based on the principles of equality and equity stated in the UN and the WHO Declarations (see above, paragraph 1), whereby access to healthcare is a right of all citizens despite their income [24].

From an institutional point of view, there are several European bodies dealing with public health. Among the most important are two European agencies and two divisions of the Commission and the European Parliament.

As regards the European Parliament, the first one is the European Medicines Agency (EMA), which is a decentralised body of the EU, and its main task is to protect and promote public health and animal health through the evaluation and control of medicinal products for human and veterinary use. The EMA is responsible for the scientific evaluation of applications for European marketing authorisation for medicinal products (centralised procedure).

The second one is the European Centre for Disease Prevention and Control (ECDC), which is based in Stockholm. The ECDC collects and transmits information on current and emerging health threats and works with the relevant national bodies to develop surveillance and alert systems at the European level.

As far as the Commission is concerned, there is the Health and Food Safety Division which supports EU countries' efforts to protect and improve the health of their citizens and ensure the accessibility, effectiveness and resilience of their health systems.

The panorama of European bodies, institutions and networks is certainly not limited to this list, but the organisational and coordinating contribution of these institutions is certainly significant, considering the difficulty of cooperation between 27 different countries and health systems. Therefore, health systems in the EU are managed in very different ways.

Classifications of healthcare systems have traditionally been based on financing mechanisms or contractual relationships between healthcare providers and payers.

As regards the type of financing of health systems, three main models can be distinguished:

- The Beveridge model
- The Bismarck model
- The mixed model

According to Di Federico and Negri ideally, there are so two management models: on the one hand, the mutual system (Bismarck model), financed by the compulsory contributions of workers and employers on salary, and on the other hand, the national health service (Beveridge model), which relies on general taxation. In the first case, the resources are managed by independent insurance companies or funds that make use of self-employed professionals and offer a limited range of services and treatments; in the second, however, it is the State which administers health funds and offers full coverage to citizens through public health facilities. Di Federico and Negri think indeed that both models have advantages and disadvantages. Privately funded systems entail higher transaction costs (which arise from the separation of purchasers and providers), but overall they tend to ensure a better service quality-price *ratio* through competition between different operators. The contribution model creates a direct link between collection and healthcare and ensures a lower rate of evasion, but risks disincentivising recruitment, does not guarantee full and universal coverage and often involves direct disbursement by the patient, which will then be repaid by the fund or the insurance undertaking [21].

Otherwise, systems based on the general organisation of taxation allow the purchase and direct supply of health services, but, despite the filter constituted by doctors of general medicine (the so-called gatekeeping), they are often inefficient. In the Beveridge model, the reception of health services is independent of the actual contribution of the individual, offers greater protection in terms of quantities and services rendered and does not involve (further) disbursement by the patient, but it largely depends on the proper management of taxation.

In recent decades, these models have evolved and contaminated each other making today sterile any attempt at rigid categorisation. In fact, the Bismarck systems have also used general taxation, and the Beveridge systems have introduced forms of direct taxation. In addition, greater State intervention in the management of mutual systems has been accompanied by greater involvement of private actors in national health services, which, inter alia, have progressively introduced direct payments by individuals. Nevertheless, the two models still constitute a valid paradigm of analysis as regards the (prevailing) methods of financing the system, the relationship between the State and the individual and the provision of health services [25].

The organisation of the healthcare system is strongly influenced by the constitutional structure and the form of government. Irrespective of the model adopted, resources may be collected by centralised or decentralised public or private entities. They must then be allocated according to the needs of the users [26]. Therefore, excessive fragmentation of the relevant bodies reduces the possibility of cross-assistance and, therefore, the sustainability of the system. Otherwise, the centralisation of decision-making centres and centres for the provision of services (hospitals and approved clinics) leads to a progressive removal, including physical, from the individual. This clashes not only with the principle of subsidiarity but also with the holistic (see above, paragraph 1), patient-centric approach promoted at the international level [27].

The choice of the health system model is capable of producing extremely significant economic and social consequences. The acceptability of the rules governing the functioning of the health system is central to the promotion of the right to health. It is the very foundation of the solidarity that should inform all health systems and presupposes the existence of democratic, participatory and transparent procedures that allow the State to make shared decisions and individuals to understand their rights.

Thus, 27 health systems coexist in the EU, which are generally related to five types: Continental, Anglo-Saxon, Nordic, Mediterranean, and Central and Eastern Europe. From the point of view of financing, however, they can all be traced back to the above three organisational models, with all of Bismarck or Beveridge derivation also effectively represented by the Advocate General Geelhoed in the *Watts* case [28].

In this context, also within the health organisation of the EU, it is appropriate to mention "EU4Health", which is a programme of action of the EU in the field of health for the period 2021–2027 and is the EU's largest health programme in terms of financial resources which, with a budget of EUR 5.1 billion, represents the EU's response to the pandemic from Covid-19 and will provide funding to the EU countries, health organisations and NGOs. The EU4Health Programme, proposed by the Commission on May 28th, 2020, entered into force on the 26th March 2021, with the publication, in the Official Journal of the EU, of Regulation (EU) 2021/522 of the European Parliament and of the Council, repealing the previous Regulation (EU) n. 282/2014.

Within the health systems of the European Union, as regards, specifically, the organisation of the Italian health system, the Government of Andreotti IV on the proposal of the Minister of Health Tina Anselmi [29], by the Law no. 833, of 23rd December 1978, abolished the mutual system and established the "SSN"—National Health Service, with effect from the 1st of July 1980.

The National Health Service is not a single administration, but a set of bodies that contribute to the achievement of the objectives of protecting the health of citizens.

It is composed in fact as follows:

- Central bodies of the State: Ministry of Health, Superior Council of Health, Higher Institute of Health, State-Regions Conference, Italian Medicines Agency, Experimental Zooprophylactic Institutes, and National Agency for Regional Health Services
- Regional bodies: Department of Health, Permanent Regional Conference
- Territorial bodies: Local Health Companies and Hospitals, Institutes of Hospitalisation and Care of Scientific Character

With the reform of Title V of the Italian Constitution, implemented in 2001, healthcare in Italy is based on a regional level, enacting a form of regionalism. Regionalism consists of a particular form of organisation of health systems, which combines universality and public financing with the territorialisation of structures operating in the field of health protection. Furthermore, with regard to regional health differentiations, it is not correct to say that, in Italy, there would be as many different health systems as the number of regions, or outright the very high fragmentation of the health framework itself. In fact, the criticality of the Italian regional health system concerns more than anything else the level of effectiveness of the health rules. It does not appear uniform on the whole national territory. That depends certainly on the different organisational choices, but other factors should be considered as well.

3 Telemedicine in Healthcare: Legal Aspects of Maintaining Telehealth Records

In the previous paragraphs, the supranational (international and European) and national (with regard to the Italian Constitutional framework) principles have been outlined, which must regulate healthcare systems. It is now appropriate to focus on how, in practice, the right to health can be guaranteed more effectively in a situation, such as the one we are currently experiencing, characterised by an advanced development of information and communication technologies (ICT). In this respect, attention must be paid to telemedicine—also commonly referred to as health telematics—and robotics.

Health telematics was defined by the WHO in 1997 as "a composite term for health-related activities, services and systems, carried out over a distance by means of information and communications technologies, for the purposes of global health promotion, disease control and health care, as well as education, management, and research for health" [30].

Subsequently, the EU, through the "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on telemedicine for the benefit of patients, healthcare systems and society" (COM(2008)689), provided a definition of telemedicine as "the provision of healthcare services, through use of ICT, in situations where the health professional and the patient (or two health professionals) are not in the same location. It involves the secure transmission of medical data and information, through text, sound, images or other forms needed for the prevention, diagnosis, treatment and follow-up of patients" [31].

In Italy, according to the guidelines of the Ministry of Health, telemedicine is intended as a mode of provision of healthcare services, through the use of innovative technologies, in particular ICT, in situations where the health professional and the patient (or two professionals) are not in the same location [32]. The use of new technologies allows the creation of a "bridge" between doctor and patient overcoming the problem of mobility [33].

The implementation of telemedicine is, therefore, a fundamental objective in line with the recommendations of the European Commission in 2019 [34]. It guarantees equal access to remote healthcare services due to limited travelling opportunities and human resources, also effectively satisfying the therapeutic and managerial needs of the patient who presents various pathologies.

In this difficult pandemic period, it seems more than ever urgent and necessary to rethink the organisation of the overall national health system, which must respond effectively to the peculiarities of the Covid-19 disease, taking note of the necessary social distance, without neglecting the aim of better care of the patient mostly over 65 years of age and with chronic diseases as well as those who are not self-sufficient [35].

Therefore, intelligent technologies are a valuable channel of professional interaction, where qualified health professionals at a national or international level offer their real-time performance with obvious savings in terms of costs and time [36]. To meet the therapeutic and managerial needs of the telemedicine patient, an adjustment of the medical record was firstly necessary. The innovative tool of e-Health for the organic and structured management of health data is precisely the electronic health record (EHR) that allows the digitised management of patient information from the outset. The EHR should not be confused with the computerised medical record, which is nothing more than an editorial variation of the paper folder. This instrument can serve as a medical diary of personal care. It is possible to plan subsequent medical interventions and draw useful indications on the course of a given disease and conduct statistical and epidemiological investigations in the future [35]. The information contained in the EHR like patient details and medical history enables the maintenance of "medical-health traceability" [35] and allows the sharing of the results with a general practitioner and other medical specialists.

As far as the legal nature of the clinical record, in general, is concerned, there have been several conflicting legal aspects. According to a first possible approach, the clinical record is just a simple "clinical memorial", comparable to a rare declaration of science and, therefore, an act of a private nature (Italian Supreme Court of Cassation, Penal Section III, no. 30150, of 21st June 2002). According to another orientation, instead, the medical record would be a private writing with specific evidentiary value also on the administrative level. However, the prevailing case law gives to the medical record the value of a genuine "authentic instrument". It is deemed authentic until proven false. This also concerns reported statements of the parties and other facts attested by the public official to have taken place in his/her presence [37].

Another important tool of the e-Health project is undoubtedly the "Fascicolo Sanitario Elettronico" (FSE), or e-Health Dossier. This is essentially the natural evolution of the various functions of the EHR. Although complementary, the two instruments perform quite peculiar and different functions. On the one hand, EHR is a native digital document created by a specific healthcare facility to certify the therapeutic diagnostic process related to a patient, the FSE; on the other hand, it is a wider and more substantial way of storing online clinical data from a variety of health facilities [35]. The advantages deriving from the latter can mainly be traced to an improvement of the quality and efficiency of services provided in the health sector thanks to a significant reduction in costs and a complete sharing of information and of documents related to patient's health. The FSE is, in fact, able to offer health professionals "a synoptic and multidimensional view of the state of health and the clinical therapeutic paths of the various patients" [35]. This sharing of information, facilitated by a faster circulation of clinical documents, also makes it possible to organise, in a more functional way, the archives of health companies and, therefore, to better meet the increasingly specific requests for medical services—diagnostic and surgical.

As for its historical legislative excursus, in Italy, it is recalled that the first organic intervention is represented by Law Decree no. 179 of 18th October 2012 on further urgent measures for the growth of the country, converted into Law no. 22 of 17th December 2012, followed by the enactment of the Decree of the President of the Council of Ministers no. 178 of 29th September 2015 and, finally, the Law no. 232 of 11th December 2016 ("Legge di Bilancio" of 2017), which introduced the prediction of a centralised system at the head of the AgID ("Agenzia per l'Italia Digitale") to implement the electronic health dossier through an online interconnection of regional files whose patients were identified through the system of authentication of the health card.

Another important intervention of the Italian Government in the matter of FSE imposed by the pandemic phase is the "Decreto Rilancio" (Decree-Law no. 34 of 19th May 2020). Thanks to it, the audience of those who feed the information in the FSE allows the inclusion of data from a type of health and social health generated by present and past clinical events, which also relate to benefits provided outside the national health service, which include health services that the patient receives in private facilities—clinics—medical practices and so on—that do not operate under contract with the "SSN"—National Health Service [38]. Paragraph 3 of Article 12 of Decree-Law no. 221, of 17th December 2012, has been reformulated. The aim of the legislator is clearly to increase the effectiveness of the FSE by broadening the type of information covered. Finally, the possibility of supplying the FSE also with the data of information in the possession of the assisted person is contemplated. This provision, however, raises some doubts as to whether the data should be entered solely on the initiative of the individual. As such input is not subject to prior technical screening or prior examination by a doctor or health establishment, uncontrolled use of such a tool with possible input of erroneous or misleading data could result. It is therefore necessary to assess this possibility with extreme caution [38].

Another important novelty is the elimination of the need for consent to the fulfilment of the FSE—an acceptance that was provided for by Article 12, paragraph 3-bis Decree-Law no. 179 of 18th October 2012. The consultation of the FSE by doctors, however, is only allowed in the event of the explicit expression of consent by the patient under paragraph 5 of Article 12 of the aforementioned Decree-Law no. 179 [38].

Despite the huge functional potential that systems such as EHR and FSE provide, there are several obstacles to their implementation. The difficulties depend on external factors that influence the organisational strategy (difficulties of integration of regulations by governments, the challenge in respect of privacy and refusal by patients to entrust their personal and technology-sensitive data) and internal data relating to the structure and the organisation of the healthcare company as well as the difficulty in defining a shared infrastructure (lack of coordination between healthcare professionals in the management of patient data).

However, the government and the regions promote constant initiatives of support for technological innovation in health, identifying the right synergies, as well as a climate of cooperation between the different professional cultures (health, managerial and technological). It is necessary to remember that the successes in e-Health are mainly linked to the involvement of the protagonists of the health system, through an effective work of "dissemination" to users and training to service providers. This is an essential condition for the success of the changes in the system and such complex organisations.

4 Futuristic Trends in Telemedicine Using Robotics and Artificial Intelligence

The current historical period can be described as a "technological revolution", characterised by rapid and convergent development, in a synergistic key, between science and technology. This now unstoppable process allows the technique to reach, almost incessantly, new goals in the most varied sectors [39]. The health sector has not been unaffected by this involvement [40]: technological innovations have seen multiple applications, each with its own peculiarities and functions, according to an increasing scale of complexity. In the awareness that the set of these highly innovative techniques is intended to modify the current medical method and to give rise to new diagnostic and therapeutic paradigms, it is necessary to adopt a detailed and concrete approach in the analysis of the different instruments used and of the corresponding level of interaction between medicine and technology [41].

In particular, technological innovations, such as robotics and artificial intelligence (AI), can be very useful for telemedicine, in order to accelerate its development, ensure its rapid dissemination and improve access to healthcare by patients, for the benefit of the overall national health system. The Covid-19 pandemic confirmed the universal value of health, considered as a fundamental right [9], and the need for a paradigm shift in healthcare provision (see above, paragraph 1). It is an organisational and structural evolution that, going beyond the current health emergency [42], will give an important role to technology, not as a protagonist, but as a tool in order to support this revolution.

Precisely for these reasons, one of the objectives of the Piano Nazionale di Ripresa e Resilienza approved by the Council of Ministers in April 2021 [43] is the digitisation of healthcare. The "health" mission is structured along two lines: the first, relating to proximity assistance and telemedicine for territorial healthcare, with the aim of implementing local services through the strengthening of territorial structures and more effective integration of all social and health services [44], and the second, concerning innovation, research and digitisation of the national health service, with the aims to enable the renewal of existing technological and digital structures, improve delivery and monitoring capacity of essential levels of assistance [45] and increase support for scientific research.

It is necessary to describe the technological innovations in question, before analysing their impact on telemedicine. From a legal and scientific point of view, however, there are no shared definitions of "robots" or "artificial intelligence". This absence at a linguistic level makes it difficult to identify the exact connection between AI and robotics, which cannot be simplistically linked to a relationship between genus and species [46]. In fact, on the one hand, the progress made in each of the two sectors has had a reciprocal influence on their development [47]; on the other hand, these two technological instruments do not always have overlapping content.

In general, the expression AI means a set of computational technologies whose purpose is to reproduce the cognitive activities of man and his sensory experiences [48]. More precisely, AI consists of a software-based system or is integrated into hardware devices that acts and simulates human intelligence, inter alia by collecting and processing data, analysing and interpreting the surrounding environment and taking action, with various degrees of autonomy, in order to achieve specific objectives [49].

There are two main learning techniques for AI's devices: machine learning and deep learning. In the first case, the input is provided by the man, and the machine merely improves the model on the basis of the experience gained. In the second case, instead, the functioning of the AI is based on artificial neural networks able to learn in an unsupervised way from unstructured and unclassified data. This mechanism allows the device to analyse the information and to reconstruct correlations that will be employed in the final decision-making process [50].

The applications of AI are not characterised by the necessary materiality of a *corpus mechanicum*, even if the presence of a physical architecture is not excluded regardlessly. The interaction between the robotic body and the self-learning algorithm of the AI allows the introduction of the term "cognitive robot", an intelligent type of robot that represents the embodiment of an artificially intelligent entity [51], with inevitable repercussions on the debate on the recognition of a legal subjectivity of the robot [52]. The interaction between the two sectors is fundamental for scientific research: the recorded developments in the field of AI, converging with those on automation systems, have contributed to the birth of the current robotics [53].

Precisely, the coordinated use of robotics and AI has allowed—and will allow—the increasing enhancement of telemedicine tools, both surgical and diagnostic. In the general clinical context, the use of robots has greatly reduced the invasiveness of operations, pain felt by the patient and post-operative complications, in addition to the rate of human error resulting from any inaccurate manoeuvres. The first use of a robotic machine in surgery was at the beginning of the 1980s when in the United States the PUMA 560 system (Programmable Universal Manipulation Arm) was introduced, in order to realise high-precision brain biopsies. Since then, the technology has experimented with increasingly sophisticated equipment, the best known of which is that of the da Vinci surgical system: it consists of a machine that provides the doctor with a high-definition three-dimensional vision together with flexible instrumentation, which reproduces the gestures of the human hand [54]. The main advantage—in the face of high costs of purchase and daily management—is the greater accuracy in the execution of operations, although it is not fully proven that the interventions in "robotic-assisted surgery" ensure better functional recovery than traditional open surgery [55].

With regard to civil liability, the use of this type of device does not pose particular problems, since the robot remains merely an instrument in the hands of the surgeon, who will continue to be responsible in case of damage to the patient. On the contrary, if the robot becomes an autonomous device able to act outside human control, thanks to the process of autonomisation of robotic surgery promoted by the AI, problems may arise with regard to the identification of the responsible person and the attribution of corresponding liability criterion [56].

This is not the place to answer these problematic questions. It is rather evident how the use of robots, even purely auxiliary and not substitutes for human activity, allows to carry out surgical operations at a distance, implementing that branch of telemedicine called "telesurgery". It consists of an operating technique that allows the doctor to perform surgery on a patient who is not physically in the same place. The surgeon performs the surgery using a robotic system that has exceptional surgical abilities, combined with communication technologies that allow the exchange of data between the two stations and the use of a monitor that ensures continuous control of the operating field [57].

The first remote surgery was carried out in 2001, with patients and surgeons over 6000 km away, while the first Italian surgery at a distance was carried out in 2019 in Milan. The report of the operation [58] states that "telesurgery can be indispensable in field hospitals for natural disasters, for example, or in case of a pandemic, or, as now, in case of social distance between surgeon, assistants and patient". Matteo Trimarchi, the otorhinolaryngologist of the San Raffaele Hospital in Milan, in collaboration with the Italian Institute of Technology (IIT) and life from Vodafone Village (Milan), performed the operation of microsurgery removing a polyp from a vocal rope with a perfect cut in real time. In this case, the patient and the surgeon were about 15 km away, and the surgery was made possible thanks to the use of certain electromedical equipment connected to the fifth-generation network for data transmission. In fact, 5G allows to transmit, process and manage a large amount of data collected in a continuous way, in total safety and in real time, and also to share videos and images at very high resolution; moreover, the low latency, that is the required time for the transfer of information, allows prompt intervention in critical situations [59]. These are technical features that greatly encourage the development of telemedicine, as recently confirmed by an innovative system of minimally invasive telesurgery developed by the Polytechnic University of Milan and the University of Calabria through the application of an updated version of the surgical robot "da Vinci" [60].

Technological evolution has also involved diagnostic techniques. First of all, it has allowed the use of robotic microsystems, such as smart medical capsules. They are endoscopic microcapsules, equipped with cameras and used, in particular, for the diagnosis of pathologies of the intestinal apparatus [61]. In this respect too, attention should be focused on the use of technologies for telemedicine enhancement, in order to "move diagnostic information rather than the patient" [62]. These techniques are particularly advantageous for rural areas without medical resources nearby or even for those patients who are unable to travel to meet a doctor. In these cases, telehealth systems and services are used, allowing the doctor to collect and interpret at a distance the necessary data for the patient's telemonitoring.

It is central to remember that there is no obligation to diagnose remotely: the doctor, at the result of a visit carried out with telemedicine, may, if necessary, make a diagnosis and set up a subsequent therapy, but, on the contrary, he/she may also consider that the remote connection with the patient is not exhaustive to solve the clinical question and decide for a visit in the presence. The final decision on which services can be performed in telemedicine and which cannot remains an exclusive medical competence.

There are, however, some critical issues, both technical and legal. As for the first aspect, and similar to telesurgery, the images produced by diagnostic tools (for example, rendering images from 3D CT scan) are heavy, and telematic channels are often not able to read them in a short time, making remote diagnosis almost impracticable. An important role can be played by the AI in order to solve this inconvenience and overcome the deadlock: the combination of digital coding techniques specific for Tac images and the power and speed of 5G networks will allow remote diagnosis, even very complex, at the same time as the collection of the data.

Another important technical aspect is the need to ensure greater interoperability between all national, international and territorial hospitals, to exchange health data in a more rapid, precise and safer way. Data sharing and interoperability, not only technical but also syntactic and semantic, are essential techniques for ensuring progress in digital health, in line with the objectives set out at the European level, where interoperability is considered as a prerequisite for data portability between States [63].

The legal profiles concern above all the protection of data concerning health, which are those "related to the physical or mental health of a natural person, including the provision of health care services, which reveal information about his or her health status", as provided by Article 4 n. 15 of the General Data Protection Regulation (EU) 2016/679 and included in the special categories of personal data referred to in Article 9, deserving of enhanced protection [64]. This high level of safety arises from the fact that the performance of medical activity at a distance produces a large amount of information and involves many professionals, with the consequent distribution of liability from the illicit treatment of the health data or from incorrect execution of medical service between all those involved.

A particular risk of the use of new technologies in telemedicine arises from the fact that the patient's health data are not only acquired at a distance but also constantly monitored by AI systems, which are able to analyse large amounts of data, even for predictive purposes [65]. There may also be, in the future, the possibility that the AI will act not only during the executive phase but also in the previous step, relating to the identification of purposes and means of data processing. In this case, the AI would become the autonomous data controller, with all the possible damaging consequences in terms of controllability of the procedures and accessibility of choices by the people interested in treatment. This situation may determine, from a regulatory point of view, the overlap between the use of AI for analysis and data processing with privacy protection [66].

The rules governing the acquisition of informed medical consent, commensurate with the type of service to which the patient is subjected, also remain in force. In the case of telemedicine, it is always necessary to assess the need or not to repeat the consent for each medical service rendered at a distance. In addition, the patient should be fully informed about the specific risks arising from the application of telemedicine tools, ranging from the lack of physical contact and clinical gaze of the doctor to the impossibility of a complete examination and immediate intervention in case of emergency.

The general risk of a greater evanescence of the doctor-patient relationship should not be overlooked, with the possible crisis of the therapeutic alliance, because of the sense of uncertainty and abandonment of the patient, which is inevitably accentuated by social distancing and by use of advanced technological tools, which connote the essence of telemedicine. However, no kind of intelligent robot seems capable of replacing the work of human health workers, other than at the unacceptable cost of dehumanising medical treatment, neglecting the dialogical and human model guaranteed by narrative medicine [67].

It is necessary to contain the distance between doctor and patient, despite the fact that it is exacerbated by the obstacles inherent in telemedicine, such as physical distance and use of technological equipment. The maintenance and the implementation of the "patient-centred" approach allow us to confirm, also in this context, the centrality of the individual and his/her fundamental rights (see above, paragraph 2). For these reasons, ethics emerges as the main dimension of the dynamics of Italian and European governance, with regard to both robotics and artificial intelligence [68]. Despite the fact that technology and ethics may appear to be distant disciplinary areas, European policy actions also confirm that the constant will to integrate science and values is the most characteristic feature of the European epistemic identity, the peculiar figure of science policy and law in Europe [69].

5 The Marche Region as an Example of Enhancement of a New and Inclusive Right to Health

As highlighted above, in paragraph 2, the health system in Italy has a regional based regulation and that leads to a certain diversification. An in-depth study of the practical applications of telemedicine may be of interest if it refers to a specific regional context, which has the characteristics to lead to the optimisation of the result of this health technology. The Marche region, due to its remote geography, depopulation process and increasing ageing population, can be the perfect sample for applying new ways of curing patients so that no one is left behind.

The Marche region is located in the central-eastern part of Italy. Due to its geological conformation, which consists of a territory mostly composed of hills and mountains, the region identifies itself as having 227 municipalities in a relatively small area of 9401.17 km [70]. This characteristic allowed the Marche region to be defined by Catilino et al. as a "polycentric" region [71]. In fact, the region is typically based on very small municipalities (with less than 3000 residents) located in rural areas, which are followed by bigger city centres. In rural areas, especially those located in the mountains, primary services are mostly not well connected or are far from people's homes [72].

On the one hand, the positive effect of this geographical and topological structure is that in the 1980s it has given birth to the rapid growth of one of the most important economic centres of Italy by creating industrial valleys mostly devoted to the manufacturing sector [73]. On the other hand, the negative consequence of this morphological structure of the region has led to the fact that the regional landscape did not expand or either change its structure [74]. This has resulted that, on the side of the population, the region has found itself in a situation where depopulation has become a huge factor as well as a problem that its governors have to face. In fact, from 31st December 2011 to 31st December 2015, the population decreased from 1,550,010 to 1,538,442 inhabitants [75].

The second characteristic of the Marche region—that needs to be highlighted in this work—is also given by its geological structure, which is the very high risk of earthquakes [76]. In particular, in the past 30 years, the region has faced two major seismic events. The first one with a magnitude 5.9 on the Richter scale was on September 27th, 1997 [77], and the second and most recent seismic catastrophe has taken place between August 24th, 2016, and January 2017, and its magnitude was from 5.1 to 6.0 on the Richter scale [78]. The 2016–2017 seismic events hit four regions of Italy: Abruzzo, Lazio, Marche and Umbria including a total of 140 municipalities. In this regard, as noted by Bertelli et al., before the catastrophic events, 104 municipalities had already seen a decrease of the population by 30%, due to the particular landscape in which they were located [79]. Focusing our attention on the Marche region, 87 municipalities which include 23% of the total population of the region and 43% of the territory have been hit by the events [80].

In light of these events, after 3 years, the population has continued to decrease. On December 31st, 2019, the residents in the region were 1,520,321, thus seeing a loss of more than 18,000 inhabitants [81]. Most of them were those living in the parts of the region affected by the disasters. For instance, as noted by Bazzoli et al., after 3 years from the first seismic shocks, the downward population trend has involved the entire region, which recorded between 2016 and 2019 a loss of 18,441 residents (−1.2%), 10,136 of which in the seismic crater area. This means that the closer to the crater the population was, the bigger the depopulation was. In particular, 58.8% of the total decrease compared with 22.2% of the regional population was related to the events. The decline of the residents of the crater has evidently grown by magnitude between 1st January 2016 and 1st January 2019 reaching a proportion of −2.9% [82].

After the seismic events, the last catastrophe that hit the Marche region—which in this case hit the entire world—has been the Covid-19 pandemic (see above, paragraph 1). The global health crisis has been the *coup de grâce* for the territory which was already in crisis. By December 31st, 2020, the population has dropped to 1,501,406 residents, thus confirming again a loss of circa 19,000,00 inhabitants from the previous year. Besides the population decrease, another major problem that the region has faced in recent years is also the ageing of the population. In fact, in the last decade in the territory of the Marche, the old age rate has increased: from 169 elderly every 100 young people in 2010 to 203 elderly every 100 young people in 2020 [82].

In order to combat the depopulation problem as well as its ageing in rural areas of Italy, on a national level, it has created a plan of action called Strategia Nazionale Aree Interne (SNAI) [83]. The scope of this plan is to apply an integrated approach that will allow the Italian rural areas to develop local areas and the services connected. In this regard, it is worth noting that 60% of the Italian territories can be defined as rural areas, in which there are 52% of the nation's municipalities and just 22% of the national population lives [84].

The SNAI has been introduced in Article 1, paragraph 13, of Law no. 147 of 27th December 2013, which devoted 90 million euros to relaunch the rural areas of the country for the years 2014–2016 [85]. In particular, Article 1, paragraph 14, of the mentioned law states, "The resources referred to in paragraph 13 are intended for the financing of pilot interventions for the rebalancing of the offer of basic services in the internal areas of the country, with priority to local public transport services, including the use of electric transport, educational and health services, in accordance with the criteria and implementing arrangements laid down in the Private Public Partnership Agreement".

The SNAI is a triennial plan that since its introduction has been renovated every 3 years, thus allowing all the regions part of the internal areas to rethink the development of its remote locations. In particular, from 2015 to 2021, for this strategy, the Italian Government has allocated 281.18 million euros [85].

From Article 1, paragraph 14, of Law no. 147 of 27th December 2013, it is highlighted that a priority of the Italian rural areas and of the funds allocated by the government is to develop the healthcare system. Putting this strategy into the Marche region perspective, it is necessary to see how the healthcare structures are located in the territory.

For healthcare organisation purposes, in 2003, the Regional Law no. 13 of 20th June 2003 has established and disciplined the regional healthcare system [86]. For this purpose, the region has been divided in light of Article 9 and Article 13 of the Regional Law no. 13 of 20th June 2003 into 13 districts (zona territoriale); each of them is referred to specific municipalities which envisage the majority of the population of that part of the region.

In 2011, the Regional Law changed. With the new Regional Law no. 17 of 1st August 2011, the 13 districts have been substituted according to Article 12 of this new law with five districts (Area Vasta Territoriale 1; Area Vasta Territoriale 2; Area Vasta Territoriale 3; Area Vasta Territoriale 4; Area Vasta Territoriale 5) [87].

As of today, each of the biggest cities of the region counts a hospital. Those are located in Pesaro, Urbino and Fano (Area Vasta Territoriale 1); Senigallia, Jesi, Fabriano and Ancona (Area Vasta Territoriale 2); Civitanova Marche, Macerata and Camerino (Area Vasta Territoriale 3); Fermo (Area Vasta Territoriale 4); and San Benedetto del Tronto and Ascoli Piceno (Area Vasta Territoriale 5) [88].

Nevertheless, the problem that caused this law on a practical level is the fact that it moved many health structures into bigger city centres, thus moving away from people living in rural areas to their nearest hospital or local health structure that could take care of them if in need of cures. Also because of this transformation *in peius* in the Marche region healthcare system, as noted by Gardani [89], there has been a dissatisfaction in the resident population which can also be a factor for the population decrease the region has faced in recent years.

And while Gardani reported this lack of services in 2016, the situation has not changed yet. Also during the pandemic, the resident population found itself in major difficulties in being cured by a family doctor [90].

In spite of that, a new action plan called Piano Nazionale Ripresa e Resilienza (PNRR) might change the actual situation [91]. The PNRR adopts the Regulation (EU) 2021/241 of the European Parliament and of the Council of 12th February 2021 establishing the Recovery and Resilience Facility. The plan has been introduced in Italy by the Law Decree no. 77 of 31st May 2021. The PNRR for instance is taking a concrete move forward into relaunching not only the Italian economy but also the healthcare system [92]. The reality within the Marche regional healthcare system might change. To be more specific, the sixth Mission of the PNRR will be devoted to the implementation of the healthcare system. These measures will refer not only to the already existing structures but also to creating new ways and paths for resilient locations to improve their healthcare system, thus allowing anyone to have access to the cures they need.

As pointed out, the Marche region can be the perfect territory for applying new methodologies such as telemedicine or robotic technologies, thus allowing to take care of patients who live in rural areas far from healthcare services such as hospitals or ambulatories.

6 Telemedicine as a Tool for "Healthy Ageing" and the Appropriate Planning of Health Services, with a Specific Reference to IRCCS in the Marche Region

The importance of scientific and technological innovation in the healthcare system has been highlighted, with specific reference to telemedicine in all its forms, in particular the provision of distance medicine or the transfer of digitised information [93]. The necessary increase in the use of telematics systems has been configured as indispensable both to deal with the pandemic situation (see above, paragraph 1) and to improve the health condition of citizens after a pandemic emergency, as evidenced by numerous realities, including the richest Western area [94].

Telemedicine, as a means of providing health services, has helped to improve the quality of care. It has allowed, in fact, the recourse to services of diagnosis and cure at distance, enabling the monitoring of the vital parameters in subjects of or suffering from chronic or elderly pathologies and benefiting, in particular, to such categories of vulnerable subjects [95].

Telemedicine is a concretisation of the right to health as provided in Article 32 of the Italian Constitution (see above, paragraph 1) [96]. It finds confirmation in the Legislative Decree no. 502/92 [97] and successive modifications and integrations, more specifically to Articles 3, 5 and 5a of the same legislative text. This Legislative Decree highlights the necessary investment of technological resources by the national health system [98]. In addition to this provision, in 2014, national guidelines on telemedicine were drawn up through an agreement between the state, regions and autonomous provinces of Trento and Bolzano in order to ensure coordinated, harmonious and coherent development of telemedicine within the National Health Service [99].

Especially during a pandemic phase like the one that has been occurring since 2019, the management of technological resources assumes a meaning of proper and constant adaptation of structures and machinery, functional to health services and increasingly faster scientific progress [100]. During the pandemic, telemedicine [101], especially intended as teleconsulting and sharing of clinical information [102], is a tool for managing a sudden emergency that could give rise to a real customary approach and revolutionise the patient-doctor relationship [103]. The pandemic emergency can seriously undermine the situation of those who were previously vulnerable or in critical situations, such as elderly people or those with reduced mobility [104].

In Europe, beyond the pandemic, a debate is taking place on the "decade of healthy ageing" [105], precisely because there has been an increase in the ageing population and it is so necessary to protect this age group. The European awareness of the need for protection for the so-called elderly had its concrete debut in November 2020 with the "Week of Active and Healthy Ageing Week", an EU initiative realised in synergy with the WHO with exponents from all over the world who related to "healthy ageing". In line with the findings related to this study week, on 27th January 2021, the European Union drafted the "Green Paper on Ageing", which promotes solidarity and responsibility between generations [106]. Article 2.1 of the Green Paper, entitled "Healthy and active ageing", refers in particular to preventive telemedicine. On a statistical basis, personalised medicine can help to identify, at an early stage, those people who are at risk of developing particular diseases at a later stage of life through the aforementioned EU4Health Programme (see para. 2). Among the priorities identified in order to achieve the EU4Health's goals is the role of technology for the development and improvement of the conditions of the elderly and those who care for them.

The Member States, including Italy, have acted on the impulse of concrete needs and factual situations that require practical and legislative intervention. In Italy, under Article 117 of the Constitution, regulation of health issues is the competence of the regions (see above, paragraph 2). Specifically, on April 29th, 2019, the Marche region adopted Resolution n. 474 promoting a policy of "healthy ageing", precisely to raise awareness of the population to a new context. The resolution is aimed at promoting actions and funding for this purpose and is an example that combines the need to support healthy ageing and telemedicine in the area of care. In this perspective, telemedicine is a means of implementation and is not a simple recognition. Firstly, the ageing population requires the correct identification of the welfare needs of the elderly population. That requires a strong integration with families and caregivers (formal and informal) and the appropriate planning and implementation of services such as e-Health interventions, assistive technologies, ambient assisted living (AAL) and enhancement of existing database heritage.

In Italy, scientific research in the field of health, in addition to being carried out at the national level, has a regional basis through the "Istituti di Ricerca e Cura a Carattere Scientifico" (IRCCS). They are scientific research and care institutes, regulated by Legislative Decree no. 288 of 16th October 2003. They provide health services (hospitalisation and highly specialised care) but at the same time conduct scientific research according to standards of excellence. Although they operate at the regional level, the law recognises their national importance. The Ministry of Health, in accordance with the Ministry of Finance, supervises and controls the activities of these institutes and periodically confirms their scientific nature.

Among the IRCCS, the one that operates more specifically in the care and the scientific research on active ageing is the Istituto Nazionale di Ricovero e Cura per Anziani (INRCA).

The INRCA and the Marche region have created a synergy to activate and plan a series of services aimed at facilitating the autonomy and life of the elderly and the role played by telemedicine in these structures. With this aim, the Marche region has issued Regional Law no. 1 of 28th January 2019, which promotes social policies finalised at active ageing. The Law recognises and enhances the role of elderly people in the community and promotes their participation within their family and their social life. For instance, Article 1 promotes active ageing in order to enhance the person and produce psychophysical benefits, improving their quality of life. The importance of innovative technologies and telemedicine for improving the lives of older people is highlighted by the Law in Article 11. In this Article, specific reference is made to "domotics" in order to improve the accessibility of elderly people to living spaces and homes, as well as to improve their safety and hopes for access to web platforms by service recipients and their caregivers. The Law establishes a "table for active ageing" (Article 4) at the regional level, in which the INRCA is present and has the task of conducting analyses and elaborating multidimensional evaluation documents of the actions and interventions provided for by the above-mentioned Law.

Among the research projects concerning telemedicine promoted by the INRCA, the one on active ageing, called "Get health", is of particular importance, as provided by the Determination of General Director of INRCA no. 230 of 26th June 2020. The aim of this project is to test a new clinical governance model based on the integration of tools such as health technology assessment, clinical practice guidelines, clinical pathways and health performance measurement for planning. The main objective of the project is to develop a model of geriatric remote management for patients with multi-morbosity, a situation that affects about 60% of elderly people [107]. For this reason, it could be desirable to use a multi-pathological framework remote management tool. Its application would have considerable and numerous benefits for the patient, who would be taken in charge in a "circular" and multidisciplinary way, opting for a holistic view of the patient as a human being (see above, paras 1 and 2). The patient would be so more autonomous on the logistical plane and, due to the holistic approach, would be more aware of his/her conditions.

In the light of these considerations, it is clear how impactful telemedicine can be in the perspective of "active ageing". This is pivotal not only because it is recommended by legislative sources, but also because it can effectively improve the life, not only of the elderly as a specific population group but also of those people who take care of them. A health system must be suitable for young patients but must also—and above all—protect the elderly by making them active as much as possible and for the longest time possible. That would be coherent to the principles of solidarity and substantial equality of the Italian Constitution (see above, paras 1 and 2), with regard to the most vulnerable subjects.

7 Conclusions

The right to health has been clearly affirmed as a fundamental human right in several instruments at the international level since the second half of the twentieth century. The appropriateness of the scope of this chapter, which places the right to health in the framework of the Italian Constitution, can be explained by taking into account that the Italian Constitution is among the first, still in force, to affirm this right. Following a reform in recent decades, healthcare in Italy is the responsibility of the single regions, hence the subsequent choice to focus on a specific Italian region.

The concrete specification of this right on the international plan (since the Ottawa Charter) led to the adoption of a holistic approach, aimed at putting the stress on the patient as the focal centre of attention. The organisation of the health systems in the European Union is important precisely for the full guarantee of the right to health. In general, the health system in the EU has as its ultimate goal the maximum protection of the right to health, in line with the aforementioned holistic, patient-centric approach. In the current pandemic situation, the organisation and financing of health systems, normally based on three models (Beveridge, Bismarck and mixed one), have undergone significant modifications. To be mentioned in this perspective is "EU4Health", a programme of action of the EU for the period 2021–2027 that provides relevant financial resources to the Member States.

The holistic approach is perfectly suited to the use of telemedicine techniques, which guarantee the provision of remote healthcare services. Despite the physical distance between doctor and patient, telemedicine strengthens the therapeutic alliance and confirms the patient-centric approach: Its aim indeed is to strengthen the protection of the right to health through the use of the most advanced technologies. Among them, digital archives for data collection are just some of the tools used (e.g. EHR and, in Italy, FSE). But robotics and artificial intelligence are also of fundamental importance to implement the spread and effectiveness of telemedicine.

Due to the regional organisation of healthcare in Italy, the geo-social conformation of the territory has strong repercussions on the health service provided. With this in mind, we chose to analyse telemedicine applications in the Marche region. The territory, characterised by scarcely inhabited inland areas and an elderly population, has suffered and is experiencing the double disaster of the seismic events of 2016–2017 and Covid-19. This region constitutes an interesting test case for the concrete implementation of telemedicine, particularly in "active ageing". An important research institute operates in the Marche region on this very subject: Istituto Nazionale di Ricovero e Cura per Anziani (INRCA), an institute for research and care of the elderly. The INRCA provided information and data that formed the basis of our analyses at the regional level. We thus found confirmation of the validity of telemedicine in the treatment of the elderly patient in a holistic view that places him/her constantly in relation to the territory and the surrounding social environment.

References

1. Kühn S, Rieger UM. Health is a state of complete physical, mental and social Well-being and not merely absence of disease or infirmity. Surg Obes Relat Dis. 2017;13(5):887.
2. Ellis E. Case C-84/94 United Kingdom of Great Britain and Northern Ireland v. council, judgment of 12 November 1996, not yet reported. Common Market Law Rev. 1997;34(4):1049–60.
3. United Nations. International covenant on economic, social and cultural rights; 1976. https://www.ohchr.org/Documents/ProfessionalInterest/cescr.pdf. Accessed 26 Oct 2021.
4. Harris D, O'Boyle M, Bates E, Buckley C. Harris, O'Boyle, and Warbrick Law of the European Convention on Human Rights. 4th ed. Oxford: Oxford University Press; 2018.
5. Council of Europe. Second report on the non-accepted provisions of the European social charter Armenia; 2019. p. 4. https://rm.coe.int/second-report-on-the-non-accepted-provisions-of-the-european-social-ch/16809661b1. Accessed 26 Oct 2021.
6. Council of Europe. Digest of the case law of the European Committee of Social Rights; 2018. p. 128–136. https://rm.coe.int/digest-2018-parts-i-ii-iii-iv-en/1680939f80. Accessed 26 Oct 2021.
7. Papa A. La tutela multilivello della salute nello spazio europeo: opportunità o illusione? Federalismi.it. 2018;16(4):80–99.
8. Segretariato generale della Camera dei deputati. La Costituzione della Repubblica nei lavori preparatori dell'Assemblea costituente, I. Rome: Camera dei Deputati—Segretariato; 1970. p. 1215.
9. Perlingieri P. Il diritto alla salute quale diritto della personalità. In: Id, editor. La persona e i suoi diritti. Problemi del diritto civile. Naples: Edizioni Scientifiche Italiane; 2005. p. 101–5.
10. Perlingieri P. La personalità umana nell'ordinamento giuridico. Naples: Jovene; 1972. p. 183–90.
11. D'Aloia A. Diritto di morire? La problematica dimensione costituzionale della "fine della vita". Politica del diritto. 1998;29(4):601–36.
12. Liberali B. Vaccinazioni obbligatorie e raccomandate tra scienza, diritto e sindacato costituzionale. BioLaw Journal-Rivista di BioDiritto. 2019;6(3):115–42.
13. Perlingieri P. Il diritto civile nella legalità costituzionale, IV. 4th ed. Naples: Edizioni Scientifiche Italiane; 2020. p. 326–30.
14. Sohrabi C, Alsafi Z, O'Neill N, Khan M, Kerwan A, Al-Jabir A, et al. World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19). Int J Surg. 2020;4(76):71–6. https://doi.org/10.1016/j.ijsu.2020.02.034.
15. Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, et al. The socio-economic implications of the coronavirus pandemic (COVID-19): a review. Int J Surg. 2020;78(15):185–93. https://doi.org/10.1016/j.ijsu.2020.04.018.
16. Mittal M, Battineni G, Goyal LM, Chhetri B, Oberoi SV, Chintalapudi N, et al. Cloud-based framework to mitigate the impact of COVID-19 on seafarers' mental health. Int Marit Health. 2020;71(3):213–4.
17. Garetto R, Pascucci F. Salute della persona e organizzazione dell'attività alberghiera ai tempi del COVID-19–Person's Health and Hotel Business in Covid-19 Times. Actualidad Jurídica Iberoamericana. 2020;12bis(55):602–13.

18. Liberali B. Vaccinazioni contro il Covid-19: obbligo e nuove forme di obiezione di coscienza? Diritti comparati. 2021:1–9. https://www.diritticomparati.it/vaccinazioni-contro-il-covid-19-obbligo-e-nuove-forme-di-obiezione-di-coscienza/. Accessed 27 Oct 2021.
19. Bertolino C. "Certificato verde Covid-19" tra libertà ed eguaglianza. Federalismi.it. 2021;19(15):80–99.
20. Caravita di Toritto B. La disciplina costituzionale della salute. Diritto e società. 1984;11(3):21–60.
21. Di Federico G, Negri S. Unione Europea e Salute. Padua: Cedam; 2020. p. 32, 76.
22. Losurdo F. L'Unione europea e il declino dell'ordine neoliberale. Federalismi.it. 2018;6(1):80–99: 8.
23. Matteucci CS. Servizi sanitari, mercato e "modello sociale europeo". Mercato concorrenza e regole. 2009;11(1):181–7.
24. Williams A. Ideologie e sistemi sanitari: la scelta tra egualitarismo e liberismo, tra pubblico e privato. In: Hanau C, Muraro G, editors. Governare la spesa sanitaria: un confronto internazionale. Milan: Franco Angeli; 1987. p. 12–7.
25. Regional Committee for Europe of WHO Europe. Resolution n. EUR/RC58/R4, Stewardship/governance of health systems in the WHO European Region; 2008.
26. Wagstaff A. Social health insurance vs. tax-financed health systems. Evidence from the OECD. https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-4821. Accessed 26 Oct 2021.
27. Expert panel on effective ways of investing in health (EXPH). *Report on access to health services in* the European Union; 2016. p. 30, 44.
28. Geelhoed AG. Case C-372/04 Yvonne Watts v. Bedford primary care trust and secretary of state for health, judgment of 16 May 2006; ECLI:EU:C:2006:325.
29. Spicola M. Il Servizio Sanitario Nazionale ha una madre: Tina Anselmi. https://www.huffingtonpost.it/entry/il-servizio-sanitario-nazionale-ha-una-madre-tina-anselmi_it_5e68c51fc5b6670e730180b1. Accessed 26 Oct 2021.
30. WHO Group Consultation on Health Telematics. A Health telematics policy in support of WHO's Health for- For- All strategy for global Health development; 1997. https://apps.who.int/iris/handle/10665/63857. Accessed 1 Nov 2021.
31. European Commission. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions on telemedicine for the benefit of patients, healthcare systems and society; 2008, p. 1–14.
32. Ministero della Salute. Telemedicina linee di indirizzo nazionali; 2014, p. 1–43. https://www.salute.gov.it/imgs/C_17_pubblicazioni_2129_allegato.pdf. Accessed 1 Nov 2021.
33. European Commission. Commission Recommendation (EU) 2019/243 of 6 February 2019 on a European Electronic Health Record exchange format; 2019, p. 18–27.
34. Cerea F. Intelligenza artificiale a servizio dei pazienti per il contrasto a CoViD-19. CoVid-19 e diritto privato. 2020;16(4):45–9.
35. Marchese A. Profili civilistici dell'Information Technology in àmbito sanitario. Naples: Edizioni Scientifiche Italiane; 2021. p. 183–200.
36. Auener S, Kroon D, Wackers E, Van Dulmen S, Jeurissen P. COVID-19: a window of opportunity for positive healthcare reforms. Int J Health Policy Manag. 2020;9(10):419.
37. Occorsio V. Cartella clinica e responsabilità medica. Milan: Giuffrè Editore; 2011. p. 46–50.
38. Gambino AM, Maggio E, Occorsio V. La riforma del fascicolo sanitario elettronico. Diritto Mercato Tecnologia. 2020;29(4):4–17.
39. Irti N, Severino E. Dialogo su diritto e tecnica. Rome; Bari: Laterza; 2001. p. 63–5.
40. Nicholson Price II, W. Artificial intelligence in health care: applications and legal implications. The SciTech Lawyer. 2017;14(1):10–3.
41. De Berardinis V. L'impiego delle nuove tecnologie in medicina. In: Alpa G, editor. Diritto e intelligenza artificiale. Pisa: Pacini Giuridica; 2020. p. 489–501.
42. Glaser J, Overhage JM, Guptill J et al. What the pandemic means for health care's digital transformation. Harvard Business Review. 2020: 1–8. https://hbr.org/2020/12/what-the-pandemic-means-for-health-cares-digital-transformation. Accessed 12 Nov 2021.

43. Uohara MY, Weinstein JN, Rhew DC. The essential role of technology in the public health battle against COVID-19. Population Health Manag. 2020;23(5):361–7. https://doi.org/10.1089/pop.2020.0187.
44. Giglioni F. L'organizzazione territoriale per il presidio del diritto alla salute. Costituzionalismo.it. 2020;2(4):99–126. https://www.costituzionalismo.it/lorganizzazione-territoriale-per-il-presidio-del-diritto-alla-salute/. Accessed 12 Nov 2021.
45. Rota F, Borriello F. Organizzazione amministrativa e tutela dei diritti sociali nell'emergenza pandemica e per la ripresa "post"-pandemica, con particolare riferimento alla sanità e all'istruzione. Amministrativ@mente.com. 2021;2(5):200–227. http://www.amministrativamente.com/index.php/formez/article/view/13213. Accessed 12 Nov 2021.
46. Bassini M, Liguori L, Pollicino O. Sistemi di intelligenza artificiale, responsabilità e accountability. Verso nuovi paradigmi? In: Pizzetti F, editor. Intelligenza artificiale, protezione dei dati personali e regolazione. Turin: G. Giappichelli Editore; 2018. p. 333–72.
47. Murphy RR. Introduction to IA robotics. Cambridge: The MIT Press; 2000. p. 236.
48. Stone P, Brooks R, Brynjolfsson E et al. Artificial intelligence and life in 2030. One hundred year study on artificial intelligence. Report of the 2015–2016 Study Panel; 2016, p. 4–8.
49. European Parliament. European Parliament resolution of 20 January 2021 on artificial intelligence: questions of interpretation and application of international law in so far as the EU is affected in the areas of civil and military uses and of state authority outside the scope of criminal justice (2020/2013(INI)); 2021, p. 1–13.
50. Goodfellow I, Bengio Y, Courville A. Deep learning. Cambridge: The MIT Press; 2016. p. 8–17.
51. Warkwick K. Artificial intelligence: the basics. London: Routledge; 2012. p. 116–20.
52. Celotto A. I robot possono avere diritti? BioLaw J Rivista di BioDiritto. 2019;1(3):69–71. http://www.biodiritto.org/ojs/index.php?journal=biolaw&page=article&op=view&path%5B%5D=353. Accessed: 12 Nov 2021.
53. Santosuosso A, Boscarato C, Caroleo F. Robot e diritto: una prima ricognizione. La Nuova giurisprudenza civile commentata. 2012;(7–8)2:494–516.
54. Chi-Yong Ngu J, Bih-Shiou Tsang C, Chi-Siong KD. The DaVinci Xi: a review of its capabilities, versatility, and potential role in robotic colorectal surgery. J Robot Surg. 2017;4(12):77–85. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6193435/. Accessed 12 Nov 2021.
55. Tsai SH, Tseng PT, Sherer BA, et al. Open versus robotic partial nephrectomy: systematic review and meta-analysis of contemporary studies. Int J Med Robot Comput Assist Surg. 2019;15(1):1963–8. https://pubmed.ncbi.nlm.nih.gov/30265760/. Accessed 12 Nov 2021.
56. Amoroso D, Tamburrini G. I sistemi robotici ad autonomia crescente tra etica e diritto: quale ruolo per il controllo umano? BioLaw J Rivista di BioDiritto. 2019;1(1):1–19. http://www.biodiritto.org/ojs/index.php?journal=biolaw&page=article&op=view&path%5B%5D=350. Accessed 12 Nov 2021.
57. Guerra G. Diritto comparato e robotica: riflessioni sulla "litigation" americana in materia di chirurgia robotica. Il Diritto dell'informazione e dell'informatica. 2016;2(16):157–77.
58. Acemoglu A, Peretti G, Trimarchi M, Hysenbelli J, et al. Operating from a distance: robotic vocal cord 5G telesurgery on a cadaver. Ann Intern Med. 2020;173(11):940–1. https://www.acpjournals.org/doi/full/10.7326/M20-0418. Accessed 12 Nov 2021.
59. Chen M, Jun Y, Hao Y, Mao S, Hwang K. A 5G cognitive system for healthcare. Big Data Cogn Computing. 2017;1(2):1–15. https://doi.org/10.3390/bdcc1010002.
60. Università della Calabria. Innovativo sistema di tele-chirurgia mini-invasiva. https://www.unical.it/portale/portaltemplates/view/view.cfm?104807. Accessed 12 Nov 2021.
61. Sieg A, Friedrich K, Sieg U. Is PillCam Colon capsule endoscopy ready for colorectal cancer screening? A prospective feasibility study in a community gastroenterology practice. Am J Gastroenterol. 2009;104(4):848–54. https://doi.org/10.1038/ajg.2008.163.
62. Ministero della Salute. Telemedicina. Linee di indirizzo nazionali; 2020. https://www.salute.gov.it/imgs/C_17_pubblicazioni_2129_allegato.pdf. Accessed 12 Nov 2021.

63. European Parliament and Council. Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare; 2011.
64. Guarda P. I dati sanitari. In: Cuffaro V, D'Orazio R, Ricciuto V, editors. I dati personali nel diritto europeo. Turin: G. Giappichelli Editore; 2019. p. 591–626.
65. Miotto R, Li L, Kidd BA, Dudley JT. Deep patient: an unsupervised representation to predict the future of patients from the electronic health records. Nature. 2016:1–10. https://www.nature.com/articles/srep26094.pdf. Accessed 12 Nov 2021.
66. Simeone G. Machine learning e tutela della privacy alla luce del GDPR. In: Alpa G, editor. Diritto e intelligenza artificiale. Pisa: Pacini Giuridica; 2020. p. 275–95.
67. Cattorini PM. Narrative medicine. An ethical reappraisal. Medicina e morale. 2015;64(2):245–66.
68. Comitato Nazionale per la Bioetica (CNB) and Comitato Nazionale per la Biosicurezza, le Biotecnologie e la Scienza della Vita (CNBBSSV). *Sviluppi della robotica e della roboetica*; 2017, p. 1–36. https://bioetica.governo.it/media/1392/p129_sviluppi-della-robotica-e-della-roboetica_gruppo-misto_it-cnb.pdf. Accessed 12 Nov 2021.
69. Turano B. Robotica e roboetica: questioni e prospettive nazionali ed europee. In: Alpa G, editor. Diritto e intelligenza artificiale. Pisa: Pacini Giuridica; 2020. p. 125–60.
70. Enciclopedia Treccani. *Marche*. https://www.treccani.it/enciclopedia/marche/. Accessed 11 Nov 2021.
71. Catalino S, Federiconi L, Moroni M, Sabbatini D, Zepponi A. Il policentrismo nelle Marche un caso studio; 2007. p. 18. https://www.regione.marche.it/Portals/0/Paesaggio_Territorio_Urbanistica/Paesaggio/OsservatorioPaesaggio/PolyDev_ita.pdf. Accessed 11 Nov 2021.
72. Becattini G. Dal settore industriale al distretto industriale. Alcune considerazioni sull'unità di indagine dell'economia industriale. L'Industria. Rivista di Economia e Politica Industriale. 1979;4(1):7–21.
73. Brunelli C. Le nuove forme delle città nelle Marche. Policentrismo e nuove componenti dello spazio urbano nell'odierna idea di "abitare" il territorio. In: Compagnucci F, editor. Sguardi nel territorio Per una nuova geografia delle Marche. Ancona: Quaderni del Consiglio regionale delle Marche; 2014. p. 21–36. https://www.consiglio.marche.it/informazione_e_comunicazione/pubblicazioni/quaderni/pdf/167.pdf. Accessed 11th Nov 2021.
74. Morelli P. Urbanizzazione e territorio nelle regioni italiane. Rome: Società Geografica Italiana; 1996.
75. ISTAT. Population of the Marche region 2002–2015; 2015. http://dati.istat.it/Index.aspx?DataSetCode=DCIS_INDDEMOG1#. Accessed 11 Nov 2021.
76. Boschi E, Ferrari G, Gasperini P, Guidoboni E, Smriglio G, Valensise G. Catalogo dei forti terremoti in Italia dal 461 a.C. al 1980. Bologna: ING-SGA; 1995.
77. Guidoboni E, Valensise G. Il peso economico sociale dei disastri sismici in Italia negli ultimi 150 anni. Bologna: Bononia University Press; 2011. p. 359.
78. Piombino A. La sequenza sismica. https://www.autoritadistrettoac.it/notizie/restart/la-sequenza-sismica-del-2016-2017. Accessed 11 Nov 2021.
79. Bertelli A, Valeriani E. L'attività del Commissario Straordinario ed il futuro della ricostruzione del Centro Italia: una strategia sostenibile; 2017. https://sisma2016.gov.it/wp-content/uploads/2017/09/RAPPORTO-COMMISSARIO-STRAORDINARIO-08-09-2017.pdf. Accessed 11 Nov 2021.
80. Cipolletti S, Pierantoni I, Procaccini D, Sargolini M. Pianificazione e programmazione per la valorizzazione delle risorse naturali e culturali. In: Pierantoni I, Salvi D, Sargolini M, editors. Nuovi sentieri di sviluppo per l'appennino marchigiano dopo il sisma del 2016. Ancona: Quaderni del Consiglio Regionale delle Marche; 2014. p. 59.
81. Bazzoli N, Lello E. Tre anni dopo. Spopolamento e prospettive del cratere marchigiano. https://terreinmotomarche.blogspot.com/2019/10/tre-anni-dopo-spopolamento-e.html. Accessed 12 Nov 2021.
82. Regione Marche. Report Demografia Marche Anno 2020; 2020. http://statistica.regione.marche.it/Portals/0/Pubblicazioni/Popolazione/Report_MARCHE_POPOLAZIONE_2020.pdf. Accessed 12 Nov 2021.

83. Agenzia per la Coesione Territoriale. Strategia Nazionale Aree Interne. https://www.agenziacoesione.gov.it/strategia-nazionale-aree-interne/. Accessed 12 Nov 2021.
84. Legge 27 dicembre 2013 n. 147. Disposizioni per la formazione del bilancio annuale e pluriennale dello Stato (Legge di stabilita' 2014). https://www.gazzettaufficiale.it/eli/id/2013/12/27/13G00191/sg. Accessed 12 Nov. 2021.
85. Camera dei Deputati. *La strategia nazionale per le aree interne*; 2016. https://temi.camera.it/leg18/post/OCD25-315.html. Accessed 12 Nov 2021.
86. Consiglio Regionale delle Marche. Legge regionale 20 giugno 2003 n. 13. https://www.consiglio.marche.it/banche_dati_e_documentazione/leggirm/leggi/visualizza/vig/1403?arc=vig&idl=1403. Accessed 12 Nov 2021.
87. Consiglio Regionale delle Marche, Legge regionale 1 agosto 2011 n. 17. https://www.consiglio.marche.it/banche_dati_e_documentazione/leggi/dettaglio.php?arc=sto&idl=1690. Accessed 12 Nov 2021.
88. Azienda Sanitaria Unica Regionale Marche. https://www.asur.marche.it/. Accessed 12 Nov 2021.
89. Gardani L. La (in)soddisfazione nei servizi. In: Diamanti I, Bordignon F, Ceccarini L, editors. Dall'Italia di mezzo all'Italia media. Ancona: Quaderni del Consiglio Regionale delle Marche; 2016. p. 91–104.
90. Lippera L. Medici di base: l'emergenza Marche dice che l'Italia del futuro rischia una "Caporetto" sull'assistenza. https://www.ilmessaggero.it/marche/covid_news_salute_italia_crolla_numero_medici_base_marche_emergenza_e_assistenza_a_rischio_nel_futuro_per_tutte_malattie-6267533.html. Accessed 12 Nov 2021.
91. Ministero dell'Economia e delle Finanze. Piano Nazionale Ripresa e Resilienza. https://www.mef.gov.it/focus/Il-Piano-Nazionale-di-Ripresa-e-Resilienza-PNRR/. Accessed 12 Nov 2021.
92. Sciaudone F, Mattarella BG. Il manuale del PNRR. Milan: Class Editori; 2021. p. 169–75.
93. Izzo U. Medicina e diritto nell'era digitale: i problemi giuridici della cybermedicina. Danno e responsabilità. 2000;8(4):5–10.
94. Robeznieks A. How telemedicine is working for 3 private practice physicians. Am Med Assoc. 2020:1–5. https://www.ama-assn.org/practice-management/digital/how-telemedicine-working-3-private-practice-physicians. Accessed 17 Nov 2021.
95. Gori F, Macrì PG, Turco S, Turillazzi E. Telemedicina: da emergenza a nuova normalità. Riflessioni medico-legali. Responsabilità Civile e Previdenza. 2021;86(2):699.
96. Goodman KW. Ethics, computing and medicine informatics and the transformation of health care. New York: Cambridge University Press; 1998. p. 139–45.
97. Nardone A. Tutela della salute e nuove tecnologie. La telemedicina. Naples: Jovene Editore; 2005. p. 69.
98. Cappucci A. La configurazione giuridica delle aziende sanitarie locali e loro profili autonomistici. Sanita Pubblica. 2001;11(12):1243.
99. Presidenza del Consiglio dei Ministri. Intesa tra il Governo, le Regioni e le Province autonome di Trento e Bolzano sul documento recante "Telemedicina—Linee di indirizzo nazionali"; 2014. p. 1–43. http://www.regioni.it/cms/file/Image/upload/2014/5_SR_20022014.pdf. Accessed 17 Nov 2021.
100. Ohannessian R, Duong TA, Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. JMIR Public Health Surveill. 2020;6(2):1–18. https://doi.org/10.2196/18810.
101. Gunter RL, Chouinard S, Fernandes Taylor S. Current use of telemedicine for post-discharge surgical care: a systematic review. J Am Coll Surg. 2016;222(5):915–27. https://doi.org/10.1016/j.jamcollsurg.2016.01.062.
102. Nandra K, Koenig G, DelMastro A, Mishler EA, Hollander JE, Yeo JY. Telehealth provides a comprehensive approach to the surgical patient. J Am Coll Surg. 2019;218(3):476–9. https://doi.org/10.1016/j.amjsurg.2018.09.020.
103. Cortucci C, Cingolani M, Scendoni R, Fedeli P. Home care premium: un modello innovativo del sistema italiano di welfare. Rivista Italiana di Medicina Legale e del Diritto in campo sanitario. 2020;41(3):1409.

104. European Committee of the Regions. Opinion of the European Committee of the regions—active and healthy ageing 2020/C39/11; 2020, p. 1–5.
105. European Commission. Green paper on ageing. fostering solidarity and responsibility between generations; 2021, p. 1–24.
106. Pioggia A. Diritto sanitario e Dei servizi sociali. Turin: G. Giappichelli Editore; 2020. p. 118–20.
107. Tragni E, Sala F, Casula M. Il paziente anziano complesso: dati epidemiologici e di consumo dei farmaci. Giornale Italiano di Farmacoeconomia e Farmacoutilizzazione. 2014;(6)3:33.

Role of Internet and Communication Technologies (ICT) to Support Clinical Practice and Research in Hospitals

K. Seemanthini, N. Shoba, B. S. Sowmyalakshmi, and S. A. Karthik

1 Introduction

1.1 Overview

Nowadays, applied science and technology is transmuting the globe's terrain and driving us toward a sophisticated industrial and high-tech ecosphere. ICT's mounting situation in clinical research and healthcare has a tremendous effect. It ameliorates the quality of healthcare systems, promotes victim's safety in addition to information safety, and reduces the functioning and managerial budgets. Broadcasting appliances are easily accessible and tremendously used by a majority of the people globally, and they yield less communication gap between the people.

With the widespread use of ICT, information accessing and processing have become more convenient and easier for the people working at healthcare sectors and medical management systems.

The healthcare industries are facing numerous issues, like preserving a medical history of a patient, maintaining a common source of information about a patient's health history, conserving healthcare instruments, and dealing with prescription errors, to name a few. Clinics and hospitals are nowadays completely dependent on the information technology to redesign the entire healthcare process.

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_4

Urban-rural divides have been bridged and shortened thanks to information and communication technology. It has become easy and convenient for doctors and specialists to treat victims globally if they have an appropriate information and commination network.

The current clinical research and information technology facilitates the physician to track the medical history of patients, investigate report, and present fitness status. The physician can also talk to the victims directly and prescribe the medicine and is also able to suggest appropriate medical tests.

Due to lack of correct information, the local population lacks basic healthcare awareness. Getting the patient to the hospital on time is further hampered by transportation challenges in rural locations. This has become the main cause for the spread and effect of the infectious diseases rapidly around the world. This can be reduced and controlled by developing active communication channels such that physicians can interact and communicate with the people all around the nearby towns and save the lives of many victims.

People can easily mark the track of their own health by connecting to the healthcare information systems. Digitization of healthcare systems supports the patients to perform these actions effectively. It will also support the patients to access the second opinion from specialists all over the world. It allows patients and doctors to have an effective commination anytime, ensures that the victims have a better health condition, and supports a healthy lifestyle. This has a knock-on effect on the country's health.

There are four primary streams in which ICT is used in healthcare:

- Healthiness and clinical managing system
- Healthiness exploration
- Healthiness information managing
- Healthiness and edification

People connected to the healthcare information system can easily search, access, investigate, and communicate with all over the world whenever they need. Therefore, edification becomes easily reachable and available to all. ICT and clinical research create an awareness to the people about the spread of infectious diseases, and also the status of the health, preventive measures, and diagnosis and therapeutic procedures to be followed, which allows the people to decide and choose the best healthcare hospitals and specialists to get the best treatment and to live a happy and healthy life.

ICT also supports the healthcare management system to run and lead a successful organization. It also helps healthcare systems overpower the difficulties and problems conveniently. ICT empowers hospitals and healthcare sectors to develop victims' wellness and safety, get updated with the new technologies, have a best appreciation of population health and statistics, and keep track of administration mandates. The workplace environment may be improved.

The practice of information and communication technology (ICT) in hospitals and healthcare systems aids in identifying required illness-reducing strategies. In diagnostics, it is easier to identify places that serve patients with modern innovative techniques to save the duration and cost of treatment. By offering treatment ahead of time, many people's lives are saved. Hence, new innovative technology provides effective, good-quality treatment using ICT.

In a hospital, ICT is commonly used to store medical data electronically. This aids in the quick retrieval of data. Data can be transferred to patients or doctors for consultation using ICT. Medical records can be obtained by the patient and utilized anywhere globally.

The usage of information and communication technology (ICT) in healthcare management system has improved the life of people in many ways. Hospitals must use the technologies developed in ICT at a higher level for the growth and development of people's health all over the world.

1.2 Background

Using clinical practice and research, ICT mainly focuses on using the communication technology, which facilitates digital encapsulation, depository, computing, and exchanging of information to progress healthiness, avoid diseases, treat illness, and handle severe diseases [1, 2]. In the healthcare and hospital management system, ICT mainly focuses on providing services for people at remote places, interdisciplinary medical provision, and information exchange [3].

ICT has developed new innovative methods to treat patients globally, and it has the potential to improve the well-being of patients and also the livelihood of people all around the world. ICT supports in treating patients with low cost, shares the required information instantly, guides professionals and victims, motivates new type of communication between patients and doctors, minimizes patients' traveling time to hospitals, and also provides other benefits [1, 4, 5].

Regardless of the above well-known benefits, putting ICTs into practice is a complex process and involves adjustments at various stages, comprising patients, medical practitioners, and hospital management systems [6]. Fosters play a major role in the healthcare and hospital management system, and hence they are the main source for improving ICT technology worldwide [7, 8]. Nurses are compulsorily trained to use ICT, which improves the method of treating victims [9]. ICT removes the barrier between patients and frontline workers in the hospital management system.

Despite the fact that they have proposed numerous reviews on the special effects of ICTs on medical professionals, mainly focusing on physicians, only three evaluations explicitly targeting nurses were found in our first searches. The influence of various treatment records on foster practice and healthcare results was scrutinized in a Cochrane study [10]. Nursing record systems are defined by Urquhart et al. [10] as a top of proper care is developed and provided to the victims by the nurses and the healthcare professionals. Majority of the treatment indicates and uses communication technology by nursing records.

Nursing care planning was linked and compared with traditional systems. In terms of nurturing practices, Spranzo [11] found no meaningful results. The computerized group had a slightly more nurse diagnosis, according to Daly and collaborators [12]. The amount of documented nurturing interferences and actions was shown to have some differences. The time consumed in forecasting and documenting work with the computerized approach was longer, according to Ammenwerth et al. [13]. The usage of an intensive care information system (ICIS) by victims and patients following cardiothoracic surgery affects foster actions, according to Bosman et al. [14]. The admittance process took more time in that group, and also the use of ICIS reduced the time spent on reporting the data manually by nurses during admission.

This time has been reassigned to long-suffering treatment. Nevertheless, the special effects of modification of nurturing maintenance systems on nurturing practice and long-suffering consequences were minor, and the majority of the research focused on recording the time spent performing clinical responsibilities, which is a minor part of nursing practice.

The nurses' practice of automated healthiness records was the subject of the other two systematic evaluations. Stevenson et al. [15] used a mixed review strategy to pull together five researches (double quantifiable and thrice qualitative) that focused on nurses' experiences with electronic patient records (EPR). EPR systems have not supported the nurses' daily medical practice since they do not have a general idea about victims, have not promoted tailored attention, were not friendly to users, and were not continuously reachable on bedside, according to nurses. Similarly deemed unreliable were the workstation systems. Additional methodical training [16] looked at the influence of electronic health records (EHR) on physician and nurse phase productivity. It looked at 23 researches in total (11 of these readings calculated time effectiveness among nurses). The major discoveries revealed that employing bedside terminuses and central desktops reduced nursing time by 24.5% and 23.5%, respectively.

All these three reviews, which remained documented between 2005 and 2015, focused on precise expertise and found that they had only little effects on various parts of nursing practice. In common, these activities were not well characterized in the evaluations, and there was no theoretical outline that allowed for replication on how ICTs might impact particular areas of nursing practices and nursing care. Since only a piece of technology is utilized in an unambiguous environment and for a specific goal (e.g., certification, information collecting, nurturing analysis), the knowledge gained from these reviews is limited. As a result, each ICT application may have a different impact on different aspects of nursing care.

1.3 Objectives

We propose to perform an outline of methodical assessments to achieve the resulting intentions, assuming the deficiency of a cohesive form of information on the special effects of ICTs on nurturing carefulness:

- Methodically sum up the finest indication on the special effects of ICTs on nurturing maintenance gleaned from systematic reviews.
- Determine whether certain ICTs as well as their characteristics and their intended use have an influence on nurturing care.

1.4 Why Is It Necessary to Complete This Overview?

Summarization of methodical evaluations is a helpful method to compile the finest accessible indication into a distinct article that can be used to make broad, cumulative conclusions about the effectiveness of interventions [17]. A preliminary effort to record the possible influence of different ICT solicitations on nurturing care would be to conduct an absolute analysis of diverse ICT applications.

Systematic reviews, rendering to Moher et al. [18], can differ in excellence, difficulty, and distance and are printed in a range of magazines. One of the evaluations repossessed is a Cochrane review [10], while the others are non-Cochrane reviews [15, 16]: these dual types of appraisals may be distinct, given the procedural rigidity that underpins Cochrane reviews and their ordered apprises [19]. As a result, when assessing the reviews' findings, it is critical to consider their methodological soundness.

2 ICT Design Model-Based Healthcare Methods

We describe the key ICT-based healthcare models that have emerged in recent years as a result of ICT evolution. We examine a number of application scenarios that are gaining traction as a result of the positive influence of ICTs, guided by the scientific literature.

We live in the world of innovation, disruption, and change. As the usage of digital technology increases, more people shift from traditional manual system to digital usage of records, which improves the well-being of the healthcare and hospital management system. To obtain the tremendous outcome in healthcare and hospital management system, it is mandatory to use the supremacy of digital technology. Probably by the coming decade, the complete healthcare and the medical system will change beyond imagination, and it also demands to implement new methods and techniques to support ICT. ICT in health and hospital management system uses both hardware and software to improve the well-being of people all over the world. It also quickens the progress of sustainable development goals [1].

Healthcare in the twenty-first century is paradoxical. On the one hand, there are best hospitals and medical practitioners. On the other hand, primary and basic healthcare is still a pipe dream for many who live in poverty or in remote areas away from big cities. Equally high standard of healthcare for all is still a challenge: one that has made a cube by two factors, a massive demand for medical services and sheer numbers of those in means to a shortfall of resources both in numbers of qualified doctors and well-equipped modern hospitals and medical infrastructure.

Various methods and techniques in medical field have worked effectively with the usage of modern equipment. Some of the applications of ICT in healthcare are as follows [2, 3]:

1. Telemedicine: Using telemedicine, patients can access quality healthcare no matter how far away the doctors are located.

2. Electronic medical records: Online registration of patients and maintaining of electronic medical records have made life easier for investigation, report generation, medicine prescription, and follow-up.
3. Testing: With the advancement of technology, new healthcare equipment are invented with reduced cost and manpower and improved efficiency. There are numerous modern and new equipment which support the identification and treatment of severe diseases. Diseases can be identified and treated in the initial stage.
4. Monitoring in the operation room: Helping doctors during operations by providing visualization in computers. Modern surgical and clinical devices support clinical procedures to record the date carefully.

ICT in healthcare and medical system is widely classified into four areas: edification, investigation, referral, and managing of data.

1. Healthiness and Edification

   High-quality education can be made available by adapting ICT in medical education. We know that technology is being used in our daily lives, and constant effort is being made to incorporate that technology in the education system to enrich teaching and learning. Nurses play a vital role in providing the best possible care to patients. Access to credible evidence must be delivered to nurses in a form that is tailored to the setting, and it should be easily accessible. Authors in [4] discuss about the advantages of ICT in nursing education and also response of faculty members for adapting ICT.

   Gains of ICT in education:

   (a) Improved communication mode
   (b) Less expensive
   (c) Digitized
   (d) Modern teaching and learning methods
   (e) Improved data security
   (f) Reduced cost and time
   (g) Ease of managing
   (h) Spontaneous solution

   Learners are guided and motivated in a better way by practicing and providing classroom teaching methods.

   J. Petty [5] reviewed various devices or tools in ICT used for nursing education which include:

   (a) Obtaining and accessing resources at remote places
   (b) Cloud storage provided to store course materials and also the facility of digital library
   (c) Learning management systems
   (d) Providing the use of modern and high-tech computers and audio and visual systems with projectors

   Haman Mohammed and Mohammed Abdelmoneim [6] discussed about the effect of ICT in healthcare education system and the inventions which changed the healthcare system forever such as:

(a) Digital displays
(b) Sphygmomanometer
(c) Data handling and management
(d) Sturdy, portable IT devices
(e) Readily accessible base of information
(f) Sonogram/ultrasound
(g) Neonatal nursing advancement
(h) Many more

2. Hospital Management System

It has become a practice that workstations in the healthcare systems are not adequately governed especially in remote areas. A hospital management system can provide more efficient, effective, and adorable methods to give top-quality error-free care. It manages all aspects of the effective and efficient planning, collection, organization, implementation, analysis, and use of data to create information within the healthcare system. Certain benefits of the healthcare management system mobile app which has been introduced in hospitals throughout India as discussed [7, 8] are listed below:

(a) Supports the privacy of victims for their well-being.
(b) Makes proper arrangements to store and fetch the required information of patients in the medical system.
(c) Collects and examines the medical data to improve the quality of research and to reduce the cost of maintenance.
(d) Organizes and stores the medical documents knowledgeably.

Analisis Sistem et al. [8] conducted a study from March to June 2020 using a cross-sectional design. The major aim of this study was to identify the deployment of a healthcare and medical management system at Sabang General Hospital's outpatient department using the human organization fit model. The study's participants included hospital administrators, managers, and medical professionals. A purposive sampling technique was used to pick 106 respondents for the study. The data was analyzed using a Spearman correlation test with a P-value of =0.05 in this study, which followed a quantitative design. Quality of the system, quality of information, and quality of care were the independent factors. The system user, user satisfaction, and organizational variables were the dependent variables. The information was gathered using a questionnaire that was distributed to the participants.

The selection of crucial factors is an important job throughout the construction of a Web solicitation for a smart hospital management system, since it is based on the needs of the users and security concerns. The usable security factor preference approach [9] is an important stage in attaining the objectives of designing a Web-based application. As a result, the preference for usable security factors is a multi-criteria decision analysis (MCDA) problem. This study investigates the fundamental usable security variables and assesses their value using the Fuzzy-Delphi analytical hierarchy process (Fuzzy-Delphi AHP). In this study, six of the most important usable security variables were used to assess their value. During the creation of a Web-based smart hospital management system, the combined method of Fuzzy-Delphi and AHP would assist practitioners in selecting the most familiar usable security factors in a consistent manner (WSHMS). This work would also be valuable during the creation of a Web application for a smart hospital management system.

3. Health Research

   Medical research is an important part of improving medical care and finding better treatments. Health research helps us to find new ways to treat and cure diseases. Authors in [20] convey the scope of health research methods as a practical guide.

   Artificial intelligence (AI) in healthcare is inevitable. A deep learning algorithm designed and trained for a huge set of datasets detects the majority of abnormalities on chest X-ray machines effectively, according to a research. In 2018, many deep learning algorithms were developed, and they identified more than 7000 scans of active TB from 50,000 chest images. The procedure showed good presentation and correctness.

4. Health and Management of Data

   In healthcare arena, all the information about patient is data, irrespective of their sources like electronic medical records (EMR), consultant nodes, labs, or radiology. EMR is a basic approach for using ICT in healthcare systems.

   Blockchain technology is the new advance in ICT for healthcare data management [21]. The goal of this pilot research was to give an overview of blockchain technology's potential in the healthcare system. From keeping medical information in blockchains to maintaining personal data ownership and smartphones to reach patients, the review covers a wide range of technological concerns.

   The HealthBlock system is a decentralized healthcare management system built on the blockchain by Zaabar et al. [22]. To create an effective and secure RPM and EHR administration system, the suggested solution integrates blockchain technology with healthcare IoT devices. The suggested system's architecture is based on utilizing the decentralized storage idea as well as a permissioned blockchain network as an access control mechanism for monitoring the patient's vital sign data. The proposed system solves security concerns with its resistant architecture against a variety of recognized cyber threats, including spoofing via fabric certificates, manipulation via cryptographic measures, and repudiation via fabric digital signatures.

   Leila Ismail et al. [22] recommended a lightweight blockchain for healthcare by separating the network users into clusters and maintaining one copy of the ledger per cluster, which decreases the computational and communication overhead compared to the Bitcoin network. The design makes use of canal, which enables secure and private transactions among a group of network members. They also proposed a way to avoid the forking that is so common in the Bitcoin network. By assessing various risks and assaults, they proved how effective our suggested architecture is at ensuring security and privacy when compared to the Bitcoin network. As the number of blocks increases, experimental results showed that suggested architecture generates 11 times less network traffic than the Bitcoin network and ledger update of 1.13 times faster than the industry standard.

5. Potential of Electronic Personal Health Records

   A new method to assist patients by accessing and supervising personal electronic health records in the UK was surveyed by Claudia Pagliari et al. The electronic version of medical history of a patient is maintained in electronic health record (EHR). Medical data like patient's problems, medications, past medical history, laboratory reports, and patient's progress diary are stored in the database. Patients can access health record through the Internet. EHR also helps to maintain a good relationship between doctors and patients. It provides assurance to improve the quality and efficiency through better maintenance and availability of patient data. NHS HealthSpace is the world's first fully national system and information portal, which is also recognized as a secure online personal health organizer, and helps a person to manage his or her own health data. NHS stores the important health information securely, and this portal helps to find out about locally available NHS services.

   In the USA, patients can manage and access their health-related information through Health Connect Online, which provides records of diseases, problems, future appointments, diagnoses, past medical history, and laboratory results. It also allows patients to book appointments, and they can communicate with the particular doctors for medical prescriptions through email.

   In Europe, they use a complex online personal record to maintain the patient's information.

   In Germany, Switzerland, Austria, and Bulgaria, they use the Life Sensor product, which allows patients to store and manage information about their current health status, past medical history, laboratory results, X-ray images, and health-related documents. Here, the patient can give the authorized access for trustworthy healthcare team members to view, add, or update their information, but the system is not directly linked to provider records.

   Online personal health system called "HealthSpace" maintains secured health record of each patient in England. The system started in the year 2003, and it preserves health indexes such as sugar level, blood pressure, weight of a patient, and database contact and also stores the data related to hospital consultation. HealthSpace system allows patients to access their health reports and book doctor's appointments and provides link to online health details.

   NHS HealthSpace system is working to provide consciousness among US and European citizens to access and manage their personal health records. The system allows patients to access personal health-related reports and clinical results. The system identifies diagnostic inaccuracy or drug error, by documenting non-recommended medicines or treatments, increasing test results, and suggesting drug alerts. EHR maintains centralized chart management; this allows patients to retrieve information from any place and shows that the proposed system is more efficient than paper records.

6. Telemedic Sensor Networks and Informatics for Healthcare Services

   Shaftab Ahmed et al. have explained about the current development in the medical field and about the healthcare systems. Healthcare systems and medical field are using network-enabled sensors, where it is also known as wireless sensor networks. These wireless sensor networks are being used for the purpose of monitoring patients from nursing stations and emergency mobile units. The healthcare model can be designed for developing and developed countries using various sensor networks and ICT methods. Patients, doctors, nurses, and necessity-handling units are connected through wide area networks and metropolitan area networks for remote investigation, consultation, and fast feedback. Doctors can give instructions, opinion to patients, and suggestions to their family members through workflow and decision support system. Patients can get advice for surgical operations and postsurgical healthcare through a new emerging method called "medical tourism." Recent advancement in optical networking improves ICT infrastructure and removes communication limitations.

   Electronic patient journal (EPJ) allows physicians and doctors to observe emergency cases and give instructions to paramedical staff and also allows doctors to use audio/video to consult their colleagues for second opinion, etc. Same way, patients can see the suggestions given by the physician and submit feedback. EMERGE (Emergency Monitoring and Prevention) project was initiated by Germany to enhance emergency support through early detection and prevention. Finally, telemedic services provide healthcare information and suggestions, patient monitoring through wireless sensor networks, maintaining of secure patient health record, and emergency treatment during heart attacks and myocardial infarction. Intelligent agent-based system monitors patient records and also gives alerts during emergency period. Teleconferencing provides training to physicians and paramedical staff and assists in remote consultation. New methods encourage patients to make use of advanced technologies and to involve in treatment procedures to achieve better results.

7. Healthcare Services Through Early Warning Systems Using Service-Oriented Technology and Mobile

   Silvester Namuye et al. have studied EWS to reduce the risk of epidemic diseases in Kenya. Data was gathered from five rural areas of different countries, where there is low ICT framework. EWARS Spatial Fuzzy Logic demo was built to visualize results on questions about basic health information, and it is accessible from different locations to all citizens using mobile and communication technologies. It is concluded that early warning system (EWS) model addressed health-related issues and treatment to prevent epidemic diseases such as HIV, AIDS, and malaria.

   Surveillance systems are early warning systems, which are used to collect information about infectious diseases to alert public. To provide good-quality health to Kenyan citizens, the government maintains health centers which provide subsidized medicine for diseases such as Ebola.

   A wide range of health issues are handled by information and communication technology (ICT) in developing countries. To reduce the health risk before it occurs has created more research interest. The United Nations Millennium Declaration comprises the advancement of vulnerability mapping, early warning systems, and technological transfer and training. The main focus of EWS implementation is that they are reachable to suitable healthcare. The system mainly focuses on diseases such as HIV/AIDS, malaria, and other disorders. The Government of Kenya has a vision to provide "preventive healthcare" services to all Kenyan citizens by the year 2030.

ICT allows information access via messages to prevent serious diseases; for example, health services and health control text messages were sent through mobile phones to control malaria in Africa. ICT also supports "cloud computing" services via the Internet using SaaS4, IaaS3, and Paas2 cloud computing models. SaaS offers lower maintenance cost, less capital investment, and rapid distribution results with lower IT burden and quick return investments.

8. Chronic Disease Management

   Edward et al. have explained about the chronic disease management system. To fulfill the complex requirements of chronic disease is the main challenge for the medical field. Patients are not receiving proper therapy, have low disease maintenance, and are not happy with their test results. Active health programs attain better results.

   Chronic disease management system demonstrates that results will improve only when the system can address the problems of chronically ill patients. Researchers recommended that a model should be built to provide appropriate suggestion to the patients, building confidence among patients that in turn reduces illness. The problems will be addressed by personal physicians and integrated practice team. To reduce the cost of illness is the main goal of the system.

3 Research on E-Health

Nowadays, maintaining good health is one of the challenging tasks due to a lot of commutable and deadly infections. Health monitoring is not only a responsibility of an individual but also one of the main responsibilities of the government. Due to the significant rise of deadly diseases in the twenty-first century, maintaining good health is extremely challenging. At almost the same time, we are on the cusp of a technological revolution that includes the use of advanced technologies for communication like cellular phones and Wi-Fi. These technologies have paved the way to explore new dimensions in the healthcare system, the so-called e-Health. Healthcare call center staff and toll-free services are utilized in all parts of the world to achieve e-Health. All area of the medical field is moving forward into digitization, which includes a range of health services such as consultations, surveillance, health education, and a variety of other services in the online platform. Skills to conduct studies on the efficacy of such e-Health solutions on patient care are very poor in developing countries. Health-related e-records, which are broadly employed in industrialized nations, will undoubtedly aid in the proper assessment of a patient's health. If it is integrated with the traditional medical system, it will be beneficial to a person's health.

The spread of Internet backbone data analysis and developments in digitalization generated a new paradigm of widespread accessibility and globalization of interactions, inventiveness, and services. Several innovative ICTs are being deployed in the healthcare domain to progress the effectiveness of whole stages of healthcare. e-Health, often referred to as digital well-being, is the usage of information and communication technology (ICT) to increase the capacity to cure individuals, encourage behavior change, and maintain good health.

Many advantages of e-Health were provided, including a reduction in price and suitability for customers [1, 2], reduction of overall health provider fees and enhancement of health carrier satisfaction [3, 4], achieving remote or defamed collections, timeliness of getting right of entry to the Internet [5], growing person and dealer manipulate of the e-Health intermediation [6], and transforming political policy. e-Health is making healthcare more green while allowing sufferers and specialists to get admission to and manipulate facts in ways that had been previously not possible [7]. Thus, e-Health does no longer, in particular, refer to a positive problem. It is a utility area where many subjects are related such as medical informatics, fitness informatics, digital fitness document, purchaser health informatics, and diverse Internet-based technology and service area [8].

The examination of e-fitness has appealed research interest after it was used by the World Health Organization (WHO) [20]. First, a few scholars enhance the theory that e-Health verbal exchange may additionally have a big capacity to promote conduct adjustments via particular features. As a result, healthcare can be more enjoyable and less expensive. Printed apprenticeships in related fields are on the rise, and many countries have also increased programmes. Printed apprenticeships in related fields are at the upward thrust, and many nations have additionally raised packages. It enlightens us that combining fitness paintings with ICT is the trend of medicine improvement due to the fact that medicinal drugs and health are the ideas of solid development for a rustic system. The academic literature has normally centered on troubles in the adoption and diffusion of particular e-Health technology, and just a few papers are concerned with the improvement of e-fitness situation.

This takes a look at pursuits to give an analytical evaluation on the country of e-Health studies. An assessment framework composed of multiple research methods is advanced and carried out to yield a broad coverage of e-fitness studies.

L. Zhang et al. [1] describe a dynamic personal privacy technique that provides fingerprint scanners at the server level while keeping the actual amount of the biometric trait hidden from the server. Furthermore, since the data conveyed using the present framework are irreversible, user privacy may be entirely retained during the key exchange protocol renegotiation process. Furthermore, the suggested approach is shown to be semantically secure. The presented method fits the e-Health environment comprised of quality and energy consumption, according to the evaluation of the performance. The authors present three-factor authenticated key agreement approach for e-Health platforms in this work, which uses a vibrant security mechanism to secure the interest of the consumers. The addition of identity verification on the web server compensates for the flaws in two-factor methods. A vibrant identification matrix replaces the standard identity password set to offer deals with the interaction and ensure privacy protection. In comparison to other relevant efforts, the proposed technique only uses lightweight hash and biohash operations, which decreases operational and transmission expenses. The author further shows that the suggested technique is semantically secure when applied to the real-or-random model. As a result, the suggested solution may effectively reduce the energy consumption and safety requirements of e-Health services.

Aldawood et al. [2] provide a critical review that goes through the IT/ICT tools that are used to raise health consciousness in great detail. Through the system implementation, Individuals can use the services provided by the system to help them maintain their health. Health professionals can use the devices to facilitate therapeutic control too. ICT specifically aims at enhancing the dissemination of healthcare information and developing methods to empower individuals to control their level of consciousness with a smartphone, telemedicine, and different Web-based tools. The comprehensive examination points out that contemporary ICT projects enable customers and sufferers to become actively engaged in the overall health administration and to make much better judgments about their sickness. In addition, ICT provides an adequate method for criticism via social media and messaging and controls consumer awareness of treatment.

Azeez and Vyver [3] recommend that content is clear and tidy using the proposed strategy, but that can be probably cleared and recovered in a matter of minutes. Despite the immense advantages associated with this endeavor, e-Health continues to face many difficulties. The e-Health architecture has several difficulties, including protection, manageability, and compatibility. The focus of this research is to address the e-Health security concern. To do so, researchers offer a data secrecy protecting system that ensures complete control over information dissemination to third parties. Researchers believe that widespread adoption of this paradigm will go a long way toward achieving global trustworthiness, consistency, and sustainable e-Health deployment.

Bhattacharyya et al. describe the idea of research to make it possible for distant patients and a physician to communicate real-time information over a low-bandwidth connection. Sometimes, it might be a game-changer, as the incapacity to interchange graphics has long been a major roadblock to extending the advantages to underserved areas which are the true beneficiaries of the notion. e-Health can be made more realistic using the suggested technologies. Nevertheless, unlike other off-the-shelf video messaging services, researchers have not focused on audiovisual synchronization difficulties such as lip-synching. Empirical anecdotal evidence suggests that the practitioner in the relevant circumstance focuses primarily on the sickness and artifacts. When the audio can be consistently heard, the app fulfills its primary function.

Biswas et al. [5] provide a unified approach for converting disparate traditional e-Health services to a cohesive blockchain-based environment in this paper. They focus on the differences in data formats between traditional database systems and blockchain file databases. The answer explains how to convert data and synchronize it in a single system for huge e-Health analytics. Substantial progress in information storage, password protection, and smooth transfer can be made, according to the operation and assessment. The current proposal initially linked traditional e-Health providers to one another via a BC backbone, allowing for frictionless medical data interchange with a rigorous authentication mechanism. After that, it established an integrated data structure for information storage in various storage devices. Finally, it allowed data to be stored off-chain. This could be part of the network for huge data. Not only was the efficiency within reasonable standards after deployment and assessment, but it was also below reasonable parameters after analysis.

Naghshvarianjahromi et al. [6] propose a technology that is built on a CDS for the effectiveness of the control and that can generate various judgment call trees. The presented system is appropriate for practical system simplicity and moderate computational architecture. The classification approaches attained 95.4% accuracy. Moreover, these approaches can decide in less than 80 ms, which incorporates time for training for one user. As a consequence, the presented CDS strategies can serve as a model for creating the parasympathetic processing layer of a best feature home platform's first phase.

Idoga et al. [7] started their research to figure out what elements influence people's attitudes toward Web health centers. The path coefficient model was determined using the descriptive and inferential statistics (20.0), factor analysis, and LISREL (9.30). The findings demonstrate that before implementing a Web health center, healthcare administrators must think carefully. Consequently, assimilation will remain difficult.

Feng et al. [8] present an optimal paradigm for tactile interactions via nanonetworks in this research, where in-body nanodevices communicate sensory information via the terahertz frequency to a controller. Researchers use Brownian motion to understand the characteristics of the terahertz band. In addition, designers build a randomized model based on the modulation scheme previously built. As a better time-varying particle and a probabilistic problem, a swarm-based approach is provided that can deal with a large number of variables. By efficiently decreasing the problem's limitations, a considerable reduction in the number of iterations is achieved. Results of simulation can be used to verify the suggested system's mathematical model.

Gupta et al. [9] recommend an IoT-enabled e-Health system from quantum attacks, a LAAC protocol. The difficulty in the hypothesis of the nonhomogeneous small integer solution issue is shown to be insensitive to LAAC. Designers also present a security study of LAAC that is backed up by evidence. Furthermore, performance testing reveals that implementing LAAC in an IoT device is feasible.

Hatzivasilis et al. [20] present that the state of the parts is captured by ultralight surveillance modules, which feed data to the CyberSure cloud server, which makes critical decisions. As a result, a protected system is actively certified, with reinsurance viewpoints being reviewed in real time as the system operates. Safety management and asset strategies are modified and perfectly alright when new data becomes available. When an accident happens, the insurance provider has enough evidence to quickly evaluate the situation, precisely determine the size of expected risk, and shorten the time it takes to compensate the affected customer. The methodology is used to examine the systems of medium-sized enterprises in the ICT and healthcare industries.

4 Discussion

The findings suggest that ICT strategies in the studied environment should take into account the college's research skills as well as available learning tools for developing proposals and tracking progress. Collaboration on research and grant writing should be considered as well. Students placed a high value on publishing their research efforts via the intranet, which was also supported to a lesser extent by faculty and staff and should be considered. Learning how to make online sites and YouTube videos and use Skype was ranked last. These findings could be due to a lack of understanding of the tools' potential applications in academic and research settings. Participants in the older age groups, on the other hand, gave Skype training a higher priority, possibly due to a generational divide in familiarity with the technology.

Participants placed a high value on interacting with the blackboard system, which could indicate that more training on how to use the system is required before users feel comfortable with it. Graphic design and digital audio and video tools were not accorded as much weight as other technologies, suggesting that they are currently underutilized. This discovery could indicate a missed opportunity because such tools can be used to effectively promote public health messages, construct social marketing efforts, or develop behavioral change theories and models, to name a few examples. The findings may indicate that when constructing the COPH website, ICT employees should collaborate closely with academics and staff in order to reduce the website's complexity and inconsistency in terms of website use and user needs.

Personal computer speed, Internet connectivity, printer troubles, and computer backup methods were all cited as high-priority ICT issues. Maintenance and support of technology in classrooms and conference rooms are critical for participants and should be prioritized by ICT workers. In the academic setting, personal portable devices such as iPads and iPhones have been identified as critical hardware, demonstrating the need to include them in the creation of ICT strategies and solutions. Social media is increasingly being used in academia and research, with the majority of participants placing a moderate to high value on its use. There are a few flaws in this research. The overall response rate for the survey was low, which could restrict the results' generalizability. Email surveys, unfortunately, have low response rates.

In higher education institutions, the typical response rate for online surveys is 30% or less than 21%. Because it is impossible to determine how those who participated in the study differ from those who did not, nonresponse bias may have been introduced into the study. However, it is likely that the poll respondents are more interested in ICT concerns at the COPH, which could explain why they gave the questions a higher overall priority. Another drawback of the study was the self-reported assessment of the participants' perceptions of ICT use, which could lead to under- or overestimation of the findings.

However, there has been an effort to look into many elements of how ICT might be used effectively in academic and research settings for a variety of audiences. The current survey did not allow for an evaluation of the influence of ICT on COPH community engagement initiatives. A study of community views should be used in future studies to capture the community's perspectives.

References

1. Haluza D, Jungwirth D. ICT and the future of healthcare: aspects of pervasive health monitoring. Inform Health Soc Care. 2018;43(1):1–11.
2. Ariani A, Koesoema AP, Soegijoko S. Innovative healthcare applications of ICT for developing countries. In: Innovative healthcare systems for the 21st century. Cham: Springer; 2017. p. 15–70.
3. Harerimana A, Mtshali NG. Types of ICT applications used and the skills' level of nursing students in higher education: a cross-sectional survey. Int J Afr Nurs Sci. 2019;11:100163.
4. Nsouli R, Vlachopoulos D. Attitudes of nursing faculty members toward technology and e-learning in Lebanon. BMC Nurs. 2021;20(1):1–15.
5. Petty J. Interactive, technology-enhanced self-regulated learning tools in healthcare education: a literature review. Nurse Educ Today. 2013;33(1):53–9.
6. Mohammed HM. New technology in nursing education and practice. Zagazig Nurs J. 2018;14(1):233–9.
7. Jacob B, Kamath R. Introduction of a universal EMR integrated online healthcare management system mobile app in hospitals throughout India and its benefits to patients, hospitals and governments. Indian J Publ Health Res Dev. 2019;10:2.
8. Arora L, Ikbal F. Experiences of implementing hospital management information system (HMIS) at a tertiary care hospital, India. Vilakshan-XIMB J Manag. 2021;
9. Alharbe N. A fuzzy-Delphi based decision-making process for measuring usable-security of web based smart hospital management system. ICIC Express Lett. 2020;14(1):15–21.
10. N. A. Azeez and C. V. d. Vyver, Towards a dependable access framework for E-health, 2017 international conference on computational science and computational intelligence (CSCI); 2017, pp. 1695–1701, https://doi.org/10.1109/CSCI.2017.295.
11. Naghshvarianjahromi M, Kumar S, Deen MJ. Brain-inspired intelligence for real-time health situation understanding in smart e-health home applications. IEEE Access. 2019;7:180,106–26. https://doi.org/10.1109/ACCESS.2019.2958827.
12. Biswas S, Sharif K, Li F, Latif Z, Kanhere SS, Mohanty SP. Interoperability and synchronization management of blockchain-based decentralized e-health systems. IEEE Trans Eng Manag. 2020;67(4):1363–76. https://doi.org/10.1109/TEM.2020.2989779.
13. Bhattacharyya A, Agrawal S, Rath HK, Pal A. Towards democratizing E-health under constrained ICT infrastructure through 'A-REaLiST' solution, 2019 European Conference on Networks and Communications (EuCNC); 2019, pp. 533–538. https://doi.org/10.1109/EuCNC.2019.8802034.
14. Idoga PE, Toycan M, Nadiri H, Çelebi E. Factors affecting the successful adoption of e-health cloud based health system from healthcare consumers' perspective. IEEE Access. 2018;6:71,216–28. https://doi.org/10.1109/ACCESS.2018.2881489.
15. Feng L, Ali A, Iqbal M, Bashir AK, Hussain SA, Pack S. Optimal haptic communications over nanonetworks for E-health systems. IEEE Trans Indus Inform. 2019;15(5):3016–27. https://doi.org/10.1109/TII.2019.2902604.
16. Gupta DS, Islam SH, Obaidat MS, Karati A, Sadoun B. LAAC: lightweight lattice-based authentication and access control protocol for E-health systems in IoT environments. IEEE Syst J. 2021;15(3):3620–7. https://doi.org/10.1109/JSYST.2020.3016065.
17. Mittal M, Battineni G, Singh D, Nagarwal T, Yadav P. Web-based chatbot for frequently asked queries (FAQ) in hospitals. J Taibah Univ Med Sci. 2021;16(5):740–6. https://doi.org/10.1016/j.jtumed.2021.06.002.

18. Eide AH, Josephsson S, Vik K. Participation in health and welfare services. New York: Routledge; 2017.
19. United Nations. The standard rules on the equalization of opportunities for persons with disabilities. New York: United Nations; 1994.
20. Jacobsen KH. Introduction to health research methods: a practical guide. Jones & Bartlett Publishers; 2020.
21. Dimitrov DV. Blockchain applications for healthcare data management. Healthcare Inform Res. 2019;25(1):51–6.
22. Zaabar B, et al. HealthBlock: a secure blockchain-based healthcare data management system. Comput Netw. 2021;200:108500.

Proactive Digital Mental Healthcare Using ICT-Based Psychiatry Services to Prevent Cognitive Diseases During COVID Environment

Mariappan Ramasamy and Gopi Battineni

1 Introduction

In the recent years, the entire globe was experiencing a genuine well-being emergency related with the COVID-19 pandemic, a life-critical disease caused by extreme intense respiratory disorder due to a variant of SARS [1]. With the fast spread of this pandemic, the worldwide medical care framework has been encountering a severe shortage of important hardware, accessories, equipment, and clinical assistants. Subsequently, clinics ought to make efforts to decide the most ideal method for giving opportune and top-notch patient consideration and simultaneously protect suppliers who are now at the most elevated danger for getting this infection, deeply and basic clinical help. Nonetheless, with regard to the current situation, the underlying response of medical care offices in an extraordinary number of nations is to decrease or even stop numerous clinical administrations, like conclusion of centers and delay of elective medical procedures.

Due to the control and restrictions during the current pandemic, for instance, social distancing, quarantine, and sanitizing, whenever demonstrated, clinical experts are faced with amazing difficulties in passing on clinical services. For such a situation, telemedicine [2, 3] has at present been shot into the fundamental administrations for the affected people to assist with decreasing the severity of COVID-19 and save a few critical stuff. Albeit hardly such telemedicine organizations were open during the scourge of SARS in 2003, from that time forward, they have opened up after the headway of Internet services, advancement of digital technologies,

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_5

evolution of mobile phones, and fifth-generation communication technologies [4], making it suitable for tending to a few challenging troubles introduced by this COVID-19. For example, executing telemedicine stages can ease pressing in the emergency divisions, giving the bearing that patients are searching for a while tending to illness receptiveness stresses of low astuteness. Moreover, telemedicine can assist with consistent clinical services needed for ongoing ailments of patients while diminishing personal and face-to-face visits. Additionally, telemedicine can pass on its remote services to patients at faraway regions where sparse intensivists are accessible, guaranteeing that first-class clinical services are put aside for the individuals who are in a tight spot while diminishing human contacts during this exceptionally infectious COVID-19 pandemic.

The year 2020 should be the beginning of a thrilling 10 years for telemedicine, especially during the period with a turn of advancement of a couple of emerging technologies such as Internet of Things (IoT), 5G communication networks, artificial intelligence (AI) and machine learning (ML), robotics, and blockchain technology, which can be applied to deal with explicit major clinical issues or challenges. The improved variant of SARS resulted in a large outbreak than its earlier SARS models, progressing into an emergency well-being crisis. Fortunately, tele-healthcare centers have at present been set up in numerous nations, intertwined into the existing clinical methods during this episode, and have showed to be conceivable, convincing, and enabling direct relationship with medical care providers, restricting the danger of COVID-19 and further developing a good acceptance among patients. Though a couple of reviews have investigated the chronicled use and effects of telemedicine, the tele-healthcare methods reliant upon the recent developments such as COVID-19 pandemic have not been reviewed at this point of time. Developing telemedicine for mindfulness during the COVID-19 flare-up will be ideal to present a precise survey on telemedicine related with COVID-19 and its effect on cognitive health for medical care workers and staff, which incorporates a general cognitive tele-healthcare framework and associated advanced developments in mental health. Developing such telemedicine strategy, to fathom different avenues of this new technology development and to speed up its utilization in this health crisis, in the long run working on the idea of patient mental health while at the same time ensuring the singular sufficiency of clinical staff and resources.

1.1 Information and Communication Technology (ICT) Tools

Figure 1 shows the information and communication technology (ICT) tools [5] and advanced communication devices such as telephone, mobile, workstations, e-learning accessories, and videoconferencing devices. Recently, the computerized development has been changing the global view and triggering towards a refined world. The emerging position of ICT gigantically influences healthcare and its applications. It improves the type of healthcare, creates confidence among the patients, and reduces the cost of medical treatment. The media transmission contraptions are all the more simple to utilize and used by an enormous people all

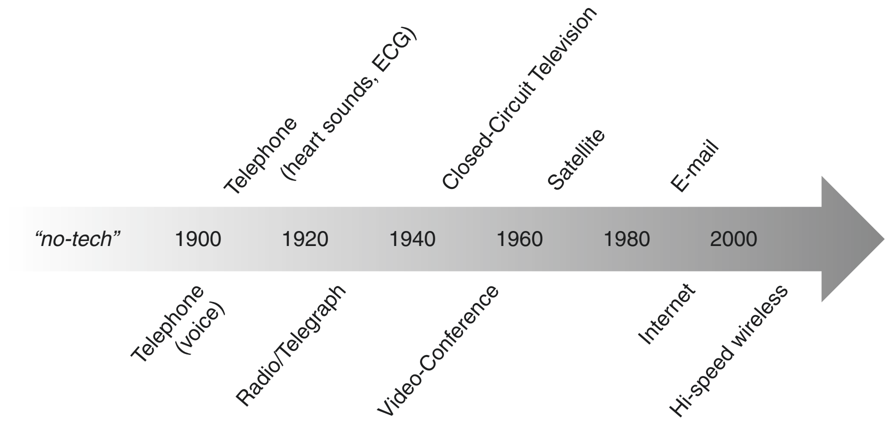


Fig. 1 Evolution of ICT tools

around the planet, which has waived off the correspondence cost. In this way, free open-source software gets popular in utilizing ICT and profiting the healthcare industry. There are different difficulties faced by the medical application areas, for example, putting away the medical record of the patient, storing up with electronic health record system, support of medical gear, medicine blunder, and many more. Presently, hospitals rely upon ICT to patch up the entire course of the medical service area. Through ICT, the metropolitan-provincial inconsistencies have been broken and abbreviated. In the event that a specialist knows the suitable communication media, it is not difficult to convey medical facilities and medicare for the patient who is found in anyplace around the globe. The framework assists the clinician in persistently observing the experience of the patient and analytic history and monitoring the improvement status. The clinician can also collaborate to take clinical assessment and recommend appropriate treatment and medicines.

The village populace needs legitimate medical care mindfulness because of the shortfall of precise data. The transportation troubles in provincial regions are likewise a drawback for taking the patient to the clinic on schedule. This is a significant justification for the expanded number of irresistible sicknesses and passing rates in towns. This can be tended to by introducing legitimate correspondence channel, so doctors in towns can speak with those in the close-by towns, and along these lines the existence of many individuals can be saved.

By digitalizing the reports, one can have a track on his/her own ailment. It likewise by implication further develops the well-being status of the country. In this digital era, individuals can without much of a stretch look for “ease to access, learn, and speak with others inside a fast range of time.” Healthcare schooling improves mindfulness and mental health, transmittable diseases, healthcare preventive measures, and various demonstrative helpful techniques. This gives an opportunity to individuals to choose the appropriate and best clinic and specialists for treatment and to have a good life.

ICT helps the healthcare sector in terms of providing various modern diagnostic tools for detailed analysis and prognosis of diseases. It assists the association with chipping away at the prosperity of patient and fulfillment, to get animated to the most recent turn of developments, to have information on individuals flourishing and assessments, and to know the information about public power orders on target. In a general sense, the workspace can be invigorated. ICT along with machine intelligence in clinical research helps in noticing the intelligent prediction methods to obliterate and decrease the impact of chronic diseases. Moreover, the recent developments in medical diagnostics diminish the recovery time and cost for the patients incurred by early treatment. The ICT tools replace the existing and old diagnostic methods with the modern technologies and diagnostic devices. The key usage of ICT in hospitals is for electronic health record for maintaining healthcare data, which helps in maintaining healthcare information without any issues. With the help of ICT-based electronic data, the patient can utilize electronic health records wherever and whenever needed. In summary, the ICT tools offer various ways for improving the healthcare framework. The healthcare sector needs to utilize ICT all the more astutely to get more advances and hoist the healthcare services to furthermore significance for the nation's turn of events.

1.2 Telemedicine

Telemedicine [6] can be extensively characterized as "the utilization of information and communication technologies to give medical care administrations without barriers of existence." As an ICT tool, tele-healthcare devises a perfect model for the creation, communication, and administration of clinical data. What is more, telemedicine has at this point involved an authoritative development, reliably changing the sort of diagnostic cycle, conference, oversight, and tutoring. The usage of telemedicine was followed at the very early stage of the year 1877, when the chief telephone exchange framework was associated with the local medical store. From that point onward, albeit different undertakings were made to push ICT developments to expand clinical benefits transport, the quantity of medical and healthcare application practice was still generally little and bound, as opposed to sent across country for a surprisingly long time, basically due to the clinical, money-related, or specialized obstructions. These days, tele-healthcare is used across various clinical forte including cognitive diseases, psychiatry, ophthalmology, and nervous system science and can possibly induce a notable change in medical services. When this advancement has passed the versatility stage, it would be difficult to get back to the primary strategy for healthcare, confining to some indulgent in-person visits. Developments in present-day technologies such as IoT, AI, and blockchain have changed the medication practice to its current status. Especially, 5G communication networks could offer all the more consistent and faster tele-data transfers while reducing the torpidity to 1 ms, empowering them to rapidly and constantly scatter remarkable measures of instinctive data, from or to wherever in the world. Using these continuous developments for telemedicine can give an outstanding experience to those medical service suppliers all around the globe and simultaneously kill the view of distance for in-person clinical visits.

1.3 ICT Tools in Telemedicine

As shown in Fig. 2, the ICT tools for telemedicine include the following:

- ICT healthcare, Kiosk health, mHealth, tele-doctor
- ICT tools for dementia and dependent people
- Smart health, internetworking Web applications
- Social networking applications
- Robotics applications
- AI or machine learning-based healthcare applications, etc.

mHealth [7] includes the utilization of cell phone and handheld gadgets outfitted with Web admittance to oversee clinical consideration tasks in overseeing clinical information, investigating medical related information, and working on generally quiet insight. Mobile phones introduce the product application to get to their clinical data and can be utilized by doctors to help spread the data to other clinical specialists progressively. The Mobile assisted tele-medical services with more significant level well-being support given carefully directed by doctors to increase care supplier to individual who call by means of crisis channels, hence diminishing the requirement for travel to the crisis spot. This treatment gives virtual crisis discussions and assigns work among subspecialty clinical experts.

Automated robotics innovations are being embraced to give furthermore synchronous immediate help to crippled patients and give security of clinical specialists and volunteers taking care of patients impacted with COVID-19. A few automated advances utilized for clinical consideration offer help for analysis, understanding consideration. With headway in AI, robots now work quicker and serve patients in disconnection office or quarantine focus as utilized in nations, for example China,

Medical application such as Primary Care, K-Health,Teladoc, and Doctor on Demand	Telemedicine	Mobile Integrated health care programs or community paramedicine
Artificial Intelligence (AI) and machine learning decision making applications	Mobile health (mHealth) applications	Health and fitness applications
Robotic technologies	Social networking applications	Contact tracing applications

Fig. 2 ICT tools in telemedicine

for COVID-19 treatment. Besides, these robots are furnished with in-assembled mind-set translators to comprehend patients' looks, furthermore get inputs, evaluate voice acknowledgment, and give drug organization.

Social system administration applications (Facebook, Skype, WhatsApp, FaceTime, and so forth): Long-range informal communication applications are being utilized in self-quarantine and friendly confinement. Despite the fact that eHealth stages cannot supplant eye-to-eye communication, they give ease for the people who feel forlorn and discouraged because of the stay-at-home request/ lockdown.

Contact tracing is a significant technique for clinical specialists and district organization to deal with the spread of coronavirus. As of now, contact tracing tools are being utilized around the globe. Examples include the following: the Singapore Government delivered a versatile tool named "Trace Together" created to help well-being authorities in finding contaminated individuals and those who might have been in their contacts. In Israel, an enactment was implemented which allows the public authority to follow the cell phone information of people with suspected disease. In Taiwan, well-being foundations are given admittance to follow telephone area information for people under isolation. Clinical applications include programs that give both simultaneous and non-concurrent medical care administrations to patients. eHealth stages offer clinical aide and assets particularly to patients living in lacking regions where clinical admittance to mind is restricted. Plus, eHealth stages associate patients to distant doctors during cataclysmic event or crisis when there is expanded interest for clinical benefits.

1.4 Internet of Things (IOT)

The word Internet of Things (IoT) [8] can be characterized as organization of the interconnected devices (things), which are particularly identifiable by communication standard conventions, in that all the physical devices, such as shrewd apparatuses, independent transportation systems, and individual well-being screens, are inserted in the computerized advancements and can be arranged to associate with one another through the IoT platform. In this pandemic, the significance of IoT could be reached in giving an information, which could allow general prosperity associations admittance to ceaselessly screen what is happening with the health crisis.

1.5 Internet of Medical Things (IoMT)

The Internet of Medical Things (IoMT) is the association of Internet-related clinical devices, hardware systems, and software tools utilized to communicate clinical devices and healthcare information management. In the IoMT, the IoT is coordinated with clinical gadgets, empowering worked on quiet solace, financially savvy clinical arrangements, fast emergency clinic therapies, and surprisingly more customized medical care as shown in Fig. 3. Some IoMT gadgets are MRI machines,

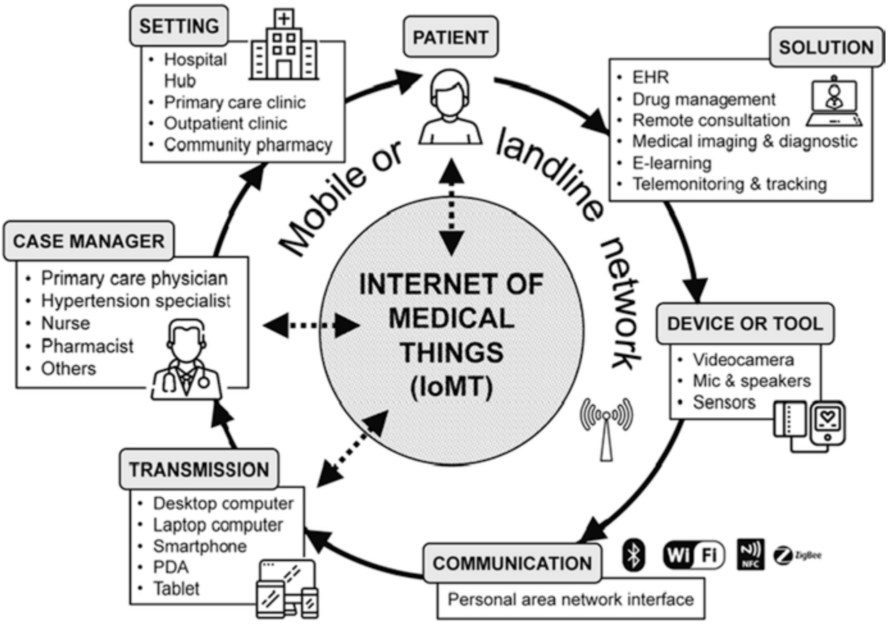


Fig. 3 Internet of Medical Things (IoMT)

IV pumps, patient screens, ventilators, restorative lasers, savvy beds, and far-off emergency unit. IoMT diminishes pointless emergency clinic visits and a general weight on medical service frameworks by straightforwardly interfacing patients to their doctors and consequently permitting the exchange of clinical information through a protected organization. The IoMT, integrated with mobile apps and Web applications, provides licenses to patients to send their prosperity information to specialists and all the more likely to keep an eye on sicknesses and follow and forestall persistent ailments. The IoMT involves a few arising innovations like physically unclonable functions (PUF), blockchain, artificial intelligence (AI), and software-defined networking (SDN), which are imagined as significant advances to beat a few tests.

1.6 Artificial Intelligence (AI) and Machine Learning-Based Telemedicine

Artificial intelligence (AI) is a subject of programming, which reflects the human insight cooperation to act and make decisions autonomously and decipher complex datasets. In spite of the way that it was once acknowledged that programmatic autonomous heading could outperform the precision of manual decisions, AI was pardoned in 1987 by the New England Journal of Medicine due to the reason that "medication was completely wide and critical" to the point that it was inconvenient, on the off chance that certainly feasible, to get the appropriate information in rules.

Later, over the past one decade, it has undergone revitalization generally in light of the redesigns, advancement of intelligent algorithms, and growing size and nature of datasets. These days, AI is essentially revolutionizing the structure of our lives, starting from biometric-based recognition to self-driven vehicles and natural language processing. AI and machine learning algorithm are quickly developing and moreover accept a huge part in this pandemic to work on the recognizable proof and finish of COVID-19. For instance, in light of the gigantic datasets of COVID-19 from China, a few AI computations have been created and used as a fundamental mechanical assembly for screening presumed cases, and hence patients at high risk could be confined for advanced tests or treatment. Moreover, an AI-based crisis system, tele-healthcare like "talk bot," has been carried out in the setting of this episode to assist patients with perceiving early aftereffects and the meaning of hand tidiness, possibly lightening the obligation of doctors.

As shown in Fig. 4, AI is used in telemedicine [9–13] to help with convincing demeanor of surveyed patients through far-off examination. Accordingly, AI chatbot is sent to give the most recent data on COVID-19 remembering the idea of anticipation and conceivable manual for the general public. It additionally gives continuous circumstance reports to clinical professionals. Using initial screening by online AI, dubious cases could be alluded to clinical staff for additional examination. The AI calculation has the computational ability to meet and even surpass the exhibition of a human specialist in diagnostics; however, it lacks instinct and delicate abilities, which are alluring in clinical administration, patient direction, and backing. In like manner, Kaminski contended that AI bots can be conveyed to

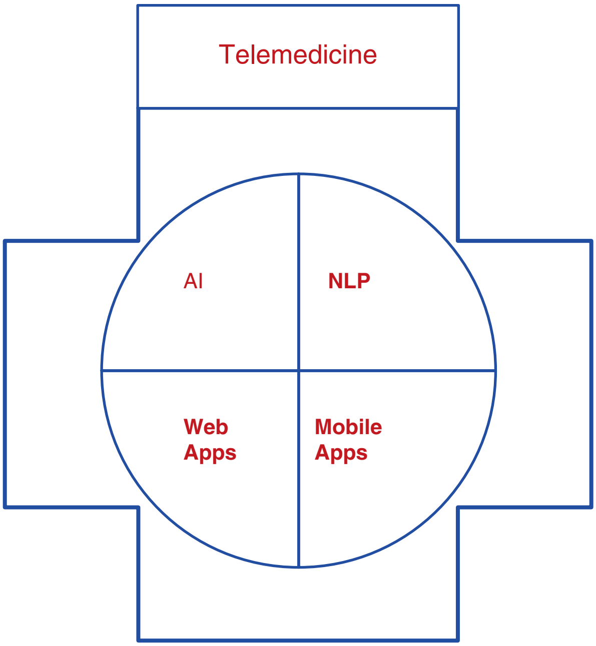


Fig. 4 Artificial intelligence (AI) and natural language processing (NLP) in telemedicine

diminish a large amount of patient data brought about by high calls to healthcare hot spots in this pandemic. Similarly, AI models and their applications are utilized to foresee the most risky areas where COVID-19 may be high and to fasten the cycles associated with findings and observing of the disease.

1.7 Big Data in Telemedicine

Digital health records [14, 15] yield tremendous datasets, which are manageable to the data analytics. Big data is a term characterized by Google, which alludes to amazingly enormous datasets, which can be analyzed using computational algorithms to extract the features. In medical industry and related services, the very large datasets can be confined principally to analyze and extract relevant biomarkers and required medical data. In this pandemic, big data gives extraordinary freedom for executing and displaying investigations of the important movement and developing clinical strategy association to improve the groundwork for this flare-up.

The heterogeneous blend of mind-boggling information has become universal in each industry today. The way that looking at such information is basic for settling on rewarding and informed business choices has brought forth big data analytics. Discussing ventures, medical service is by all accounts an area that has benefited in excess of a couple of ways with the big data analytics. The clinical history of every understanding is exceptional and can be found on different variables like the financial foundation, hereditary qualities, natural openness, and food propensities. The availability of such different and huge measures of data has been conceivable through the execution of big data analytics in medical services as shown in Fig. 5.

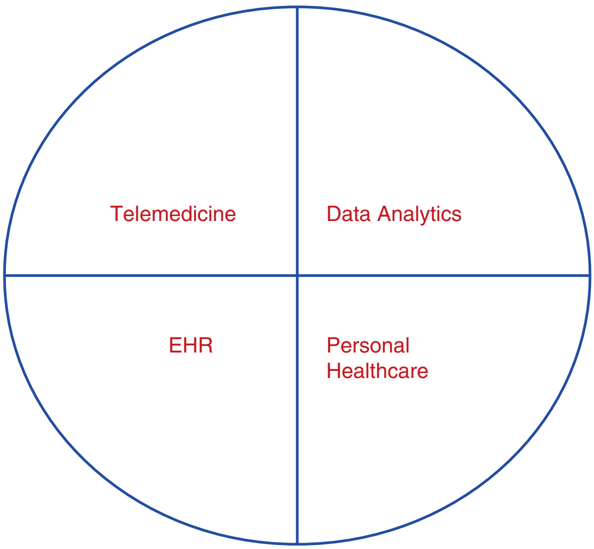


Fig. 5 Big data in telemedicine

1.8 Blockchain

Blockchain was first introduced and procured acknowledgment in 2009, due to Bitcoin, the essential progress to cryptographic cash [16, 17]. Indeed, even in the event that it was at first seen as a public, decentralized assortment of a couple of advancements to think about taking care of data forever while being protected from deception without the need of a central or trustworthy power like a bank, this idea is right presently not bound to the exchanging of installments. In the emergency healthcare system, blockchain is one of the advanced transaction methodologies for electronic health records (EHR) in the state-of-the-art clinical biological systems as shown in Fig. 6.

1.9 ICT Tools for COVID-19 Pandemic

In the current pandemic, tele-healthcare [18] is utilized as a tele-healthcare observation tool to all the more likely comprehend the progression of COVID-19 infection, similarly as the status of high-risk patient masses. Apart from the previously

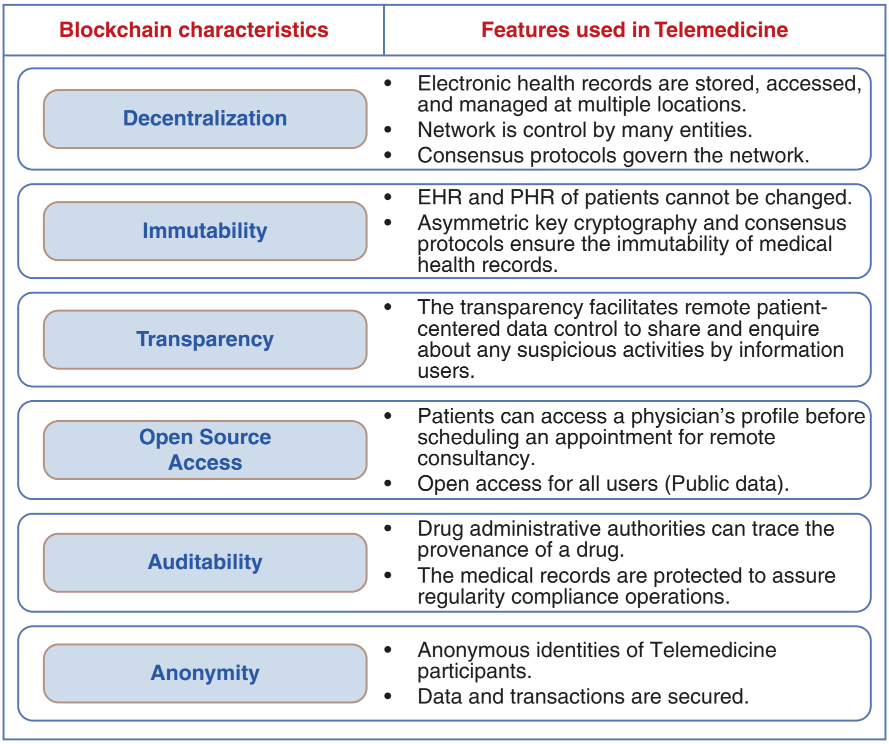


Fig. 6 Blockchain technology in telemedicine

mentioned self-revealed tele-healthcare systems, robotic automation furnished with gadgets like thermometer, cameras, and healthcare accessories, which can move around the COVID quarantine areas while following social distancing by clinicians by means of versatile mobile applications, has been currently utilized in the hospitals of Wuhan, China, to assist with shielding clinical staff members from contamination and save defensive assets.

1.10 ICT Tools in Cognitive Assessment and Tele-Psychiatry

Restricted resources of psychosocial administrations [19] in numerous nations globally have been delineated, which ought to be additionally extended by increasing request in the worldwide pandemic. In this chapter, extensive methodologies dependent on tele-psychiatry are proposed to adapt to the absence of admittance to emotional well-being administrations, which include AI, just as a variety of trend-setting innovations, like Internet-based mental apparatuses and administrations. For example, online mental guiding administrations at present have been generally evolved by cognitive experts from clinical organizations or academic societies through all territories in the central area of China. Also, online psychological wellness self-improvement intercession frameworks, such as online intellectual conduct treatments for tension, depression, and a sleeping disorder, have been set up. Several AI programs have as of now been placed into utilization as medications for certain mental health emergence. Di Carlo et al. summed up an innovation, tele-psychiatry, which provides a promising way for tele-emotional health services. The recent advancements are AI, machine learning, deep learning algorithms, promotion of 5G portable framework, smartphones, and medical robots [20] enabling people to gain tele-psychiatry administrations during this COVID-19 flare-up. The impact of ICT tools on the cognitive assessment and tele-psychiatry is shown in Figs. 7 and 8.

2 Related Work

Worldwide, neurological disorders (ND) [21] are the essential driver of lifelong inability. Additionally, neurological illnesses are the second driving reason for death all around the world. Individuals experiencing neurodegeneration go through neuronal design and practical misfortunes. These unusual underlying changes in the mind give a deterrent to ordinary cerebrum work. The neurons begin to lose their associations with different neurons in the mind [22]. This results in the weakening of the ordinary mind and human body capacities [23]. In this way, individuals that experience the ill effects of neurodegenerative infections, for example Alzheimer's, gradually begin to lose their intellectual and engine capacities. This ultimately makes them reliant upon others for conveying out their exercises of day-to-day existence (ADLs). Until this point in time, no standard fix has been tried for these conditions, despite the fact that there have been broad endeavors in such manner. Other than hereditary qualities and legacy, age is one of the most important factors for

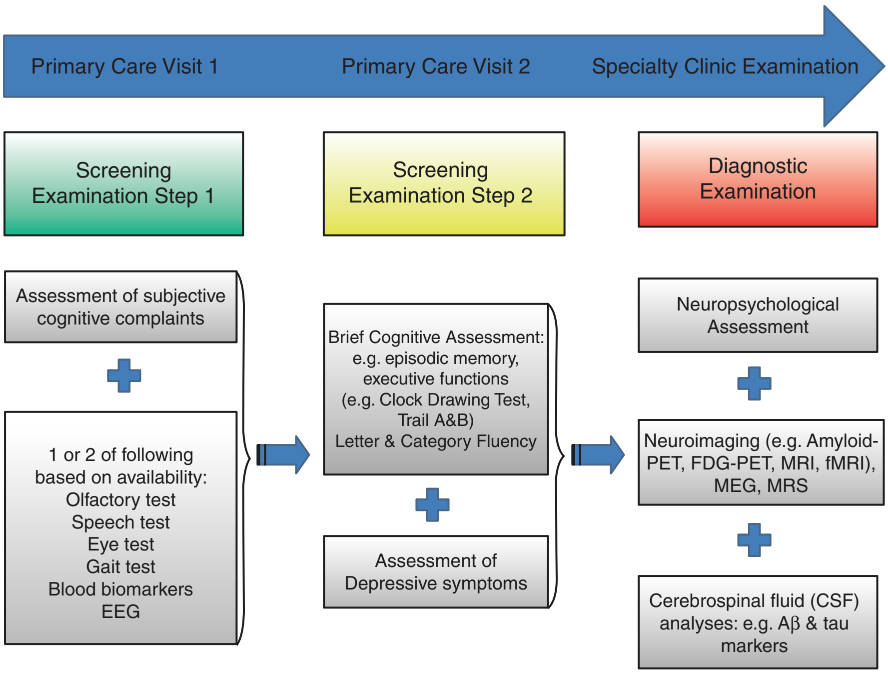
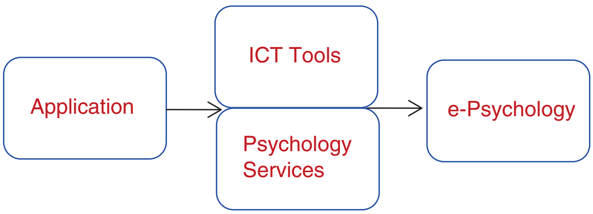


Fig. 7 ICT tools in cognitive disease monitoring

Fig. 8 ICT-based e-psychiatry



Alzheimer's disease (AD). As indicated by the 2020 yearly report by the Alzheimer's Association, 3% of individuals between the age of 65 and 74 years are right now experiencing Alzheimer's infection. This is clear from the insights that show that 17% of individuals matured from 75 to 84 years, and 32% of the complete individuals matured at 85 years or more are presently experiencing AD [24]. Neurodegeneration is somewhat a sluggish interaction. Nonetheless, once begun, it cannot be returned. As of now, the finding of Alzheimer's illness vigorously relies upon neuroimaging strategies. These tests incorporate mind sweeps like MRI, PET, and CT scan. These sweeps, despite the fact that being powerful, end up being quite difficult for individuals with neurological conditions. These techniques are cumbersome, costly, and surprisingly obtrusive on account of PET sweep. Committed lab prerequisites bring about arbitrary roundabout observing of the AD patient. This builds the opportunity for late recognition of additional neuronal harm. In view of the current surveys, the accompanying gaps in the literature review are distinguished.

The current literature does not concern with the total movement of Alzheimer's infection, consequently giving a far-reaching image of the role of these detecting advances for Alzheimer's sickness. Accordingly, there is a requirement for a new exceptional survey that features the current clever and savvy advances that are fit for helping and dealing with Alzheimer's illness. This audit expects to give a modern condition of the information for the clever assistive mechanical answers for Alzheimer's infection via looking at the writing over the recent 5 years. Additionally, as indicated by [25], the quantity of assistive advances is multiplying like clockwork. It gives a definite outline of the as of late investigated astute innovations referenced in the writing, zeroing in just on Alzheimer's sickness.

Gonzalez et al. planned a framework that assesses the memory of a person, using a hardware design, which incorporates a three-entryway cabinet introduced with wireless sensors, a Raspberry-Pi microcontroller, and accessories. A self-announced memory test [26] was utilized as an assessment tool for measuring the performance parameter. The calculation on the Raspberry-Pi recorded data of the quantity of endeavors of tracking down an article in the cabinet was really tracking down the item. The review completed by Suzumura et al. [27] likewise will in general analyze the decrease in intellectual capacity utilizing finger smoothness. They had the option to do as such utilizing a savvy terminal gadget "JustTouch," which was utilized to evaluate the different finger tapping designs. These tests included musical and sounded cadence designs. The reaction time was additionally determined with accuracy. The framework is equipped for diagnosing discernment issues too as giving treatment to them. The determination is done by ascertaining the response rate as a reaction to the game. The comprehension treatment is done by giving rehashed discernment incitements and dealing with the hand, vision, and hearing coordination. Minimal expense haptic criticism automated interface was created by Bartoli et al. [28]. The review demonstrates that the relationship between intellectual capacities furthermore memory to that of visio-engine execution. The test bunch was fundamentally more slow according to time. Additionally, the attentive matrix test and MMSE were adversely related with response time. There are various technologies and tools developed to assist dementia patients, such as mHealth, VR tools, intelligent tools, assistive technology tools, and autonomous robots [29–35].

Fardoun et al. fabricated a model framework comprising a smart watch and versatile tool, which helps Alzheimer's patients in perceiving individuals using an inherent camera and cloud interfacing. The Alzheimer's patient snaps the photo of the individual before him/her utilizing the smart watch. The image is then shipped off the portable, which is then, at that point, contrasted with a prior modified information base on the cloud information. The robot is tele-operated, and when a guardian is required or interceded, the robot is not generally utilized for help with that specific errand or time. McGoldrick et al. and three more experts analyzed the "mild cognitive incline (MCI)" stage as per ICD-10 models and answered to encounter memory issues. Lyu et al. fostered a framework comprising a shrewd automated canine alongside a versatile fluffy rationale induction module and cloud innovation, a comparing Web application alongside a couple of sensors, for example pulse oximeter, electroencephalogram (EEG), and smart watch.

3 Proposed Work

As shown in Fig. 8, this section proposes an ICT-enabled digital mental healthcare, which incorporates electronic medications, tele-psychiatry, videoconferencing frameworks, or virtual reality frameworks, that might be utilized corresponding to eye-to-eye administrations or as the sole method for admittance to mental intercessions. The utilization of the ICT tools is made to observe the progressive stage of dementia and proactively control or instruct the patient to act accordingly, with the aid of machine learning-based prediction tool.

The ICT tools identified for the tele-health monitoring of psychiatry are as follows:

i. Internet-based Web application
ii. Mobile application
iii. Videoconferencing
iv. Teleconferencing
v. IoT-based smart health
vi. IoMT-based smart health
vii. AI/machine learning-based smart health
viii. Assistive technology-based tools
ix. Intelligent virtual reality tools
x. Haptic technology tools

As shown in Fig. 9, the ICT-based tele-psychiatry can be accessed on a personal computer with videoconferencing software having picture-in-picture capability. The remote systems are connected over fiber-optic Internet link through geosynchronous satellites. Each PC is equipped with an inbuilt microphone and speaker and additional speakers with microphones for flexible access to dementia patients. The patients can access this tele-psychiatry framework to get proactive or precautionary access to the psychiatric services or consultations from the psychiatrists.

4 Methodology for Proactive Tele-Psychiatry

The implementation methodology for the proactive tele-psychiatry is shown in Fig. 10. This method involves the following steps:

1. Preclinic assessment
   (a) The CVT caregiver measures and records in computerized patient record system (CPRS).

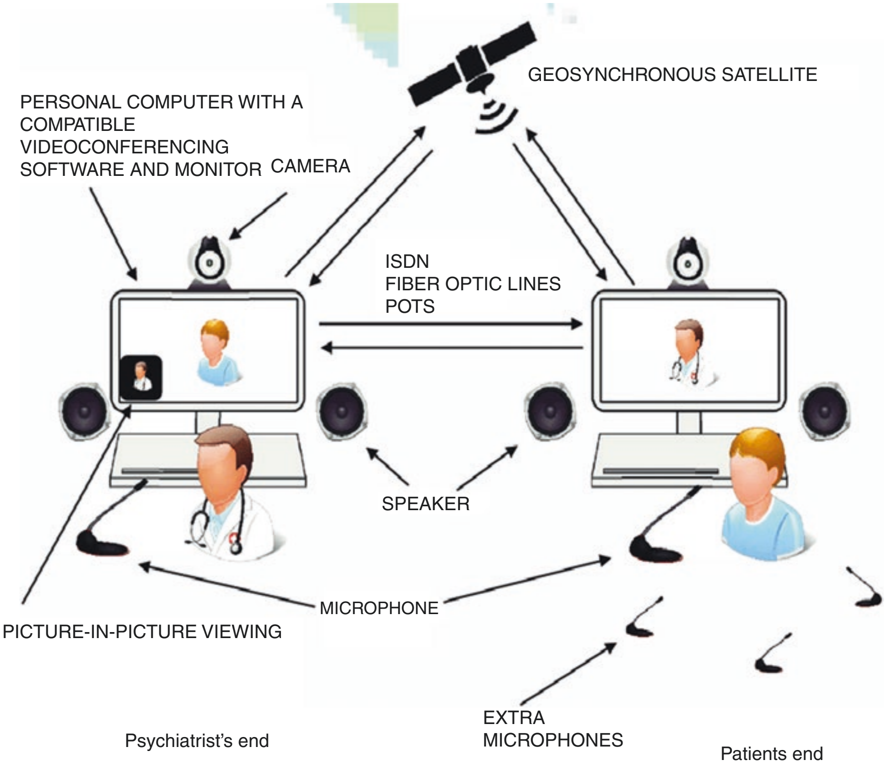


Fig. 9 ICT-based tele-psychiatry

2. Clinic assessment
   (a) Tele-healthcare technician (TCT) initiates pre-visit tests and mini-mental state exam (MSME).
3. Review of patients' health record
   (a) Reviews health records—CPRS and MSME result data.
4. Clinical video tele-health call
   (a) Initiating the tele-health call from TCT.
   (b) The tele-psychiatric service provider answers the call using CISCO tele-health software.
5. Tele-psychiatric consultation
   (a) The service provider makes comprehensive psychiatric assessments and updates in CPRS records.
6. Completes computerized patient record system and does follow-up.
7. Post-CVT clinic assessment.

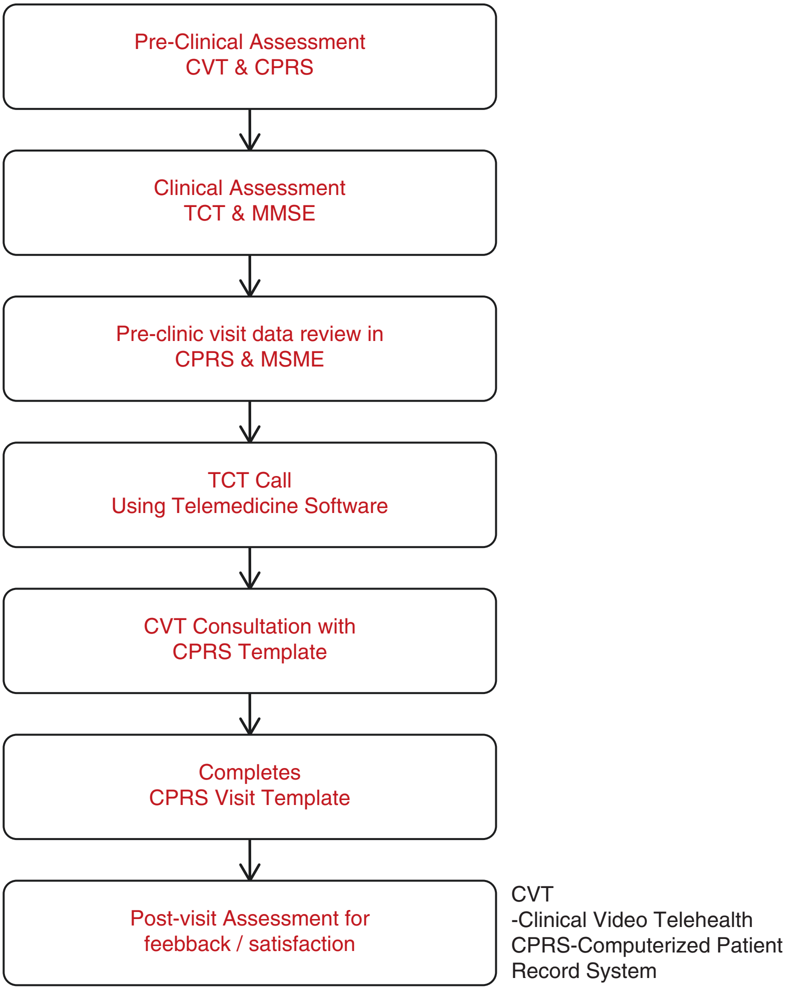


Fig. 10 Methodology for CVT-based tele-psychiatry

5 Conclusion

Information and communication technology (ICT) finds numerous applications including agriculture, education, medicine, and industrial sector. One such ever-growing field is medicine with ICT tools, in particular telemedicine. Exceptional research has begun in the fields of telemedicine (e-well-being) and tele-psychiatry (e-psychological well-being), with the goal that we can become familiar with the new methods of recuperating, its advantages, and negative outcomes just as changes in the connection between specialists and their understanding. Because of the improvement of the new information and communication technology (ICT), these devices offer a special freedom to work on intellectual disabilities and old consideration. ICT tools diminish the recurrence of crisis care, emergency clinic confirmations, and emergency clinic stay.

This book chapter has explored various ICT tools such as IoT, Internet of Medical Things (IoMT), AI, and machine learning tools for telemedicine applications. Nowadays, various ICT tools are accessible to identify psychological health or cognitive diseases like dementia and Alzheimer's dementia. This chapter proposes a proactive strategy for digital mental healthcare utilizing ICT-based tele-psychiatry services to forestall cognitive diseases during COVID environment. These ICT-based tele-psychiatry services such as monitoring, digital mental healthcare, and prevention of cognitive diseases would improve accessibility and adaptability, self-monitoring, and treatment during COVID environment.

References

1. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA. 2020;323:1061–9. https://doi.org/10.1001/jama.2020.1585.
2. Battineni G, Pallotta G, Nittari G, Amenta F. Telemedicine framework to mitigate the impact of the COVID-19 pandemic. J Taibah Univ Med Sci. 2021;16(2):300–2. https://doi.org/10.1016/j.jtumed.2020.12.010.
3. Bokolo AJ. Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic. Ir J Med Sci. 2021;190:1–10. https://doi.org/10.1007/s11845-020-02299-z.
4. Stefano GB, Kream RM. The micro-hospital: 5G telemedicine-based care. Med Sci Monit Basic Res. 2018;24:103–4. https://doi.org/10.12659/msmbr.911436.
5. Whitelaw S, Mamas MA, Topol E, Van Spall HGC. Applications of digital technology in COVID-19 pandemic planning and response. Lancet Digit Health. 2020;2:e435–40. https://doi.org/10.1016/S2589-7500(20)30142-4.
6. Battineni G, Nittari G, Sirignano A, Amenta F. Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic? J Taibah Univ Med Sci. 2021;16(3):305–6. https://doi.org/10.1016/j.jtumed.2021.02.009.
7. Sim I. Mobile devices and health. N Engl J Med. 2019;381:956–68. https://doi.org/10.1056/NEJMra1806949.
8. Hittinger E, Jaramillo P. Internet of things: energy boon or bane? Science. 2019;364:326–8. https://doi.org/10.1126/science.aau8825.
9. Janan A, Benke Kurt K. Artificial intelligence and telehealth may provide early warning of epidemics. Front Artif Intell. 2021;4:7.
10. Ting DSW, Lin H, Ruamviboonsuk P, Wong TY, Sim DA. Artificial intelligence, the internet of things, and virtual clinics: ophthalmology at the digital translation forefront. Lancet Digit Health. 2020;2:e8–9.
11. Wong ZSY, Zhou J, Zhang Q. Artificial intelligence for infectious disease big data analytics. Infect Dis Health. 2019;24:44–8. https://doi.org/10.1016/j.idh.2018.10.002.
12. Chintalapudi N, Battineni G, Amenta F. Sentimental analysis of COVID-19 tweets using deep learning models. Infect Dis Rep. 2021;13(2):329–39. https://doi.org/10.3390/idr13020032.
13. Angermueller C, Parnamaa T, Parts L, Stegle O. Deep learning for computational biology. Mol Syst Biol. 2016;12:878. https://doi.org/10.15252/msb.20156651.
14. Hsieh J-C, Li A-H, Yang C-C. Mobile, cloud, and big data computing: contributions, challenges, and new directions in telecardiology. Int J Environ Res Public Health. 2013;10:6131–53. https://doi.org/10.3390/ijerph10116131.

15. Shilo S, Rossman H, Segal E. Axes of a revolution: challenges and promises of big data in healthcare. Nat Med. 2020;26:29–38. https://doi.org/10.1038/s41591-019-0727-5.
16. Mettler M. Blockchain technology in healthcare the revolution starts here [conference presentation]. In: 2016 IEEE 18th International conference on e-health networking, applications and services (Healthcom). Munich: IEEE; 2016.
17. Heaven D. Bitcoin for the biological literature. Nature. 2019;566:141–2. https://doi.org/10.1038/d41586-019-00447-9.
18. Matusitz J, Breen G-M. Telemedicine: its effects on health communication. Health Commun. 2007;21:73–83. https://doi.org/10.1080/10410230701283439.
19. Grossman SN, Han SC, Balcer LJ, Kurzweil A, Weinberg H, Galetta SL, et al. Rapid implementation of virtual neurology in response to the COVID-19 pandemic. Neurology. 2020;94:1077–87. https://doi.org/10.1212/wnl.0000000000009677.
20. Robots help to make drive-through virus testing safer; 2020. https://drivesncontrols.com/news/fullstory.php/aid/6334/Robots_help_to_make_drive-through_virus_testing_safer.html. Accessed 10 May 2020.
21. GBD 2016 Neurology Collaborators. Global, regional, and national burden of neurological disorders, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019;18:459–80. [CrossRef].
22. Lussier M, Lavoie M, Giroux S, Consel C, Guay M, Macoir J, Hudon C, Lorrain D, Talbot L, Langlois F, et al. Early detection of mild cognitive impairment with in-home monitoring sensor technologies using functional measures: a systematic review. IEEE J Biomed Health Inform. 2018;23:838–47. [CrossRef].
23. Sánchez SM, Mora-Simon S, Herrera-Santos J, Roncero AO, Corchado JM. Intelligent dolls and robots for the treatment of elderly people with dementia. ADCAIJ Adv Distrib Comput Artif Intell J. 2020;9:99–112. [CrossRef].
24. Battineni G, Chintalapudi N, Amenta F, Traini E. A comprehensive machine-learning model applied to magnetic resonance imaging (MRI) to predict Alzheimer's disease (AD) in older subjects. J Clin Med. 2020;9(7):2146. https://doi.org/10.3390/jcm9072146.
25. Ienca M, Fabrice J, Elger BS, Caon M, Pappagallo AS, Kressig RW, Wangmo T. Intelligent assistive technology for Alzheimer's disease and other dementias: a systematic review. J Alzheimer's Dis. 2017;56:1301–40. [CrossRef].
26. Costanzo MC, Arcidiacono C, Rodolico A, Panebianco M, Aguglia E, Signorelli MS. Diagnostic and interventional implications of telemedicine in Alzheimer's disease and mild cognitive impairment: a literature review. Int J Geriatr Psychiatry. 2020;35:12–28. [CrossRef] [PubMed].
27. Battineni G, Hossain MA, Chintalapudi N, Traini E, Dhulipalla VR, Ramasamy M, Amenta F. Improved Alzheimer's disease detection by MRI using multimodal machine learning algorithms. Diagnostics. 2021;11:2103. https://doi.org/10.3390/diagnostics11112103.
28. Bartoli E, Caso F, Magnani G, Baud-Bovy G. Low-cost robotic assessment of Visuo-motor deficits in Alzheimer's disease. IEEE Trans Neural Syst Rehabil Eng. 2017;25:852–60. [CrossRef] [PubMed].
29. Elfaki AO, Alotaibi M. The role of M-health applications in the fight against Alzheimer's: current and future directions. mHealth. 2018;4:32. [CrossRef] [PubMed].
30. Ginnavaram SRR, Myneni MB, Padmaja B. An intelligent assistive VR tool for elderly people with mild cognitive impairment: Vr components and applications. Int J Adv Sci Technol. 2020;29:796–803.
31. Carotenuto A, Traini E, Fasanaro AM, Battineni G, Amenta F. Tele-neuropsychological assessment of Alzheimer's disease. J Personal Med. 2021;11(8):688. https://doi.org/10.3390/jpm11080688.
32. Kaur PD, Sharma P. IC-SMART: IoT cloud enabled seamless monitoring for Alzheimer diagnosis and rehabilitation system. J Ambient Intell Humaniz Comput. 2019;11:3387–403. [CrossRef].

33. Alberdi A, Weakley A, Schmitter-Edgecombe M, Cook DJ, Aztiria A, Basarab A, Barrenechea M. Smart home-based prediction of multidomain symptoms related to Alzheimer's disease. IEEE J Biomed Health Inform. 2018;22:1720–31. [CrossRef].
34. Radziszewski R, Ngankam HK, Grégoire V, Lorrain D, Pigot H, Giroux S. Designing calm and non-intrusive ambient assisted living system for monitoring nighttime wanderings. Int J Pervasive Comput Commun. 2017;13:114–29. [CrossRef].
35. Lazarou I, Stavropoulos TG, Meditskos G, Andreadis S, Kompatsiaris I(Y), Tsolaki M. Long-term impact of intelligent monitoring technology on people with cognitive impairment: an observational study. J Alzheimers Dis. 2019;70:757–92. [CrossRef] [PubMed].

Role, Impact, and Scope of ICT Tools and Knowledge During Pandemic Emergencies and Beyond

Manjari Joshi and B. P. Pande

1 Introduction

Pandemics bring destruction to human civilization, and sometimes they are mighty enough to abolish the whole civilization. Infectious diseases had been in existence since ancient times, but with the development of mankind and the inception of the internal and external trade system, such diseases wore the robe of epidemics and pandemics eventually. In today's era of globalization, infectious diseases proliferate very fast, and the evolution of modern society has become the indirect genesis of pandemics. The sudden outbreak of the COVID-19 pandemic supports the above rationale. Without knowing the existence of pandemics from prehistoric times to the postmodern era, we cannot properly analyze the role and impact of digital advancements for pandemic emergencies. Table 1 presents ever-known pandemics/epidemics chronologically [1].

Human civilization evolved from hunter-gatherer to agriculture and from agriculture to industrial life, and the industrial revolution brought revolutionary changes in human society. The term information and communication technology (ICT) refers to the amalgamation of a multitude of communication constituents like computers, telephones, smartphones and smart TVs, digital devices, networks and Internet, software and middleware, video/audioconferencing, social media, and other platforms that enable humans (and devices) to store, access, retrieve, manipulate, and transmit data in digital format. The importance and impact of ICT are well known in the present era of the fourth industrial revolution. In the course of human civilization, many earlier pandemics disfigured human life and development badly,

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_6

Table 1 The pandemics/epidemics from history

S. No.	Label	Active span	Dispersion	Death toll	Knowledge/usage of ICT tools
1.	Prehistoric epidemic	Circa 3000 B.C.	Prehistoric villages of China	No record	No
2.	Plague of Athens	430 B.C.	Athens	100,000	No
3.	Antonine Plague	A.D. 165–180	Roman Empire	5–10 million	No
4.	Plague of Cyprian	A.D. 250–271	Rome, Syria, Egypt	5000 people per day in Rome	No
5.	The Black Death	1346–1353	Asia and Europe	75–200 million	No
6.	Flu pandemic	1889–1890	Global	1 million	No
7.	Spanish flu	1918–1920	Global	17–100 million	Only telephone facility
8.	Asian flu	1957–1958	China	1.1 million	Yes, limited
9.	AIDS	1981–present day	Global	36.3 million	Yes, limited
10.	H1N1 swine flu	2009–2010	Global	151,700–575,400	Yes, moderate
11.	West African Ebola	2014–2016	Africa	12,000	Yes, satisfactory
12.	Coronavirus disease 2019 (COVID-19)	2020–present day	Global	5.1–20 million (till November 2021)	Yes, vast scale. Three billion cell phone users have been active

and the ICT knowledge and tools had not been so developed during these epidemics and pandemics. The access to ICT techniques had been limited to a small class of people initially, but gradually ICT paved its way to the easy reach of a common man, and it affected every sphere of human life eminently. Amidst the outbreak of pandemics, ICT tools cannot save lives directly, but they may play a significant role in supporting preventive ramparts and alternative means to continue human activities, operations, and functions. For instance, maintaining quarantines, lockdowns, stay-at-home orders, curfews, and social distancing globally could be the only and obvious means to mitigate the coronavirus infection. And in such a grave emergency, the ICT knowledge and tools proved to be the only panacea to perdure social, economic, education, administrative, and government businesses. On the contrary, for instance, regular business activities and gatherings could not be banned during the Spanish flu pandemic since mankind had not progressed so much in technology then. During the outbreak of the COVID-19 pandemic, governments all around the globe exploited the ICT platform to the fullest to broadcast information, updates, and awareness of safety measures to avoid infections, and we have been witnessing some peculiar applications of it, like coronavirus-specific caller tunes, mandate of installing contact tracing apps, registering and acquiring e-passes to travel, implementation of massive vaccination drives, and mandate to keep vaccination certificates in travelling. ICT tools helped people to endure the hard and stressed quarantine and lockdown tenures and provided them with a multifaceted platform for enhancing knowledge, skill development, innovation, and creativity. Beneath the compulsions of consequences of the COVID-19 pandemic, people with a traditional and conservative mindset and perception have also started embracing digital technologies. The Internet has been proved as the lifeline in the present pandemic times: it has been the only way for millions of people across the globe to work from home, get medical services, and stay connected. The outbreak of the COVID-19 pandemic has exposed our dependence on the Internet, and it has also accelerated the campaign to perceive the Internet as a fundamental human right [2]. The current pandemic emergency opened a window of genuine opportunity for ICTs for its global acceptance, usage, implementation, and development, and undoubtedly, every inch of this chance has been exploited by them. In the present era of the most hazardous pandemic in the history of mankind, the ICT advancements have been playing a key role in sustaining modern human activities, precautions, necessities, and endurance, and it is becoming the chief protagonist in the play of the *post-COVID* world.

The rest of the chapter is organized as follows: Sect. 2 presents a brief literature review; Sect. 3 discusses the need, role, and impact of ICT-driven tools during pandemic emergencies; Sect. 4 compares the preventive and operational practices in the COVID-19 pandemic and earlier pandemics; Sect. 5 discusses limitations of ICT tools during such emergencies; Sect. 6 portrays the place of ICTs in the post-pandemic world; and the final section concludes this work.

2 A Brief Literature Survey

Christopoulos et al. [3] studied the hurdles educators confronted while embracing the ICT techniques amidst the global COVID-19 pandemic. The authors studied the integration of digital technologies in remote education and realized the immediate need for prompt decisions, potential analysis of ICT tools, and their trials. In their detailed literature review, Pokhrel and Chhetri [4] mentioned that pedagogical requirements amidst the COVID-19 pandemic essentially include knowledge and expertise of ICT-driven tools of both the instructors and learners. The authors mentioned that a few digital platforms had been exploited before the outbreak of the coronavirus, and they felt the need for flipped classroom practices. Pozo et al. [5] analyzed the teaching activities through digital ICT tools during the COVID-19 pandemic in Spain. The authors studied the type of learning promoted and its outcomes. They investigated that the reproductive teaching activities through ICT usage were more frequent than the constructive activities. They also noticed the lack of procedural learning during this period. Sharma [6] mentioned that the COVID-19 pandemic shifted the education system to blended, remote, and virtual mode, and ICT had been the only remedy with which this sector survived. The author discussed various ICT initiatives that were taken in India to sustain the education system digitally and concluded that the blended teaching-learning practices will fill the digital gaps in the post-COVID era. Valverde-Berrocoso et al. [7] tested the integration of ICT and remote education situations aroused as a consequence of the COVID-19 pandemic. The authors studied the applications of digital technologies in teaching before lockdown and identified the most common ICT-enabled teaching practices and spaces. Zalat et al. [8] mentioned that e-learning through ICT platforms had been underrated before the COVID-19 pandemic, and it forced the entire world to rely on these platforms. The authors conducted a study to assess the perceptions of university medical staff and found that the majority of participants accepted that online courses enhanced the educational experience. Bajpai et al. [9] highlighted the role and impact of ICT in various domains related to public health issues during the COVID-19 pandemic. The authors discussed the usage of ICT in testing, diagnosis, patient record keeping, contact tracing, telemedicine, social distancing, etc. and summarized the ICT practices carried out in the current pandemic. De et al. [10] highlighted the causes and consequences of the digital divide resulting from digitalization in the era of the COVID-19 pandemic. The authors predicted that *blockchain* technology may become crucial and provoke research over digital regulations. Iivari et al. [11] mentioned that the digital divide does exist in our society and the digital future of the young pupils is being affected. The authors investigated digital transformations in education brought by the COVID-19 pandemic, dimensions of the digital divide, and barriers on the path. Lorente et al. [12] compared responses of institutes to continue teaching-learning processes during the hard pandemic times. This international study was carried out over various parameters like basic and digital infrastructure, perception, skills and teaching means of teachers, and implementation strategies. The authors realized the development of remote or virtual educational policies, especially for the low-income group. Mohite [13] discussed the role, scope, and applications of ICT during the COVID-19 pandemic. The author presented how the teaching-learning process was affected and the ICT tools proved to be a savior. Schildkamp et al. [14] mentioned that the application of ICT tools helped in the professional development (PD) of teachers in tough pandemic times. Their study summarized salient points of effective PD during the COVID-19 pandemic through the creative usage of ICT. Vargo et al. [15] presented a rapid review of the literature on the usage of digital technology amidst the COVID-19 pandemic. The authors studied 281 empirical articles and investigated specific knowledge on four points: particular technology, people, activities, and effects. They modelled the current knowledge on how ICT had been employed during the current pandemic. Yang et al. [16] raised and answered three questions related to the role and implications of ICT amidst global crises. The authors discussed applications of ICT knowledge and tools by nonprofit organizations, governments, individuals, health workers, etc. They also highlighted the negative aspects of it like the dissemination of fake news and misinformation. Zaman et al. [17] performed the *strengths, weaknesses, threats, and opportunities (SWOT)* analysis of ICT tools and techniques in combating hard pandemic situations. They investigated the impact of ICT on various services, solutions, and health affairs that emerged during the COVID-19 pandemic and its scope in future pandemics.

Table 2 compacts the above discussion.

Table 2 A glance at the literature review

S. No.	Author(s) and year	Key observations
1.	Christopoulos et al. (2021)	The integration of ICT tools in education must take care of the pedagogical goals, and it should not be affected by technological pressures.
2.	Pokhrel and Chhetri (2021)	The global education system should invest and exercise in the digital and technical enhancement of instructors.
3.	Pozo et al. (2021)	Analysis of ICT teaching activities to assess learning paradigms and outcomes in Spain, with less frequent ICT usage among young students; general teachers apply ICT techniques more frequently than specialists.
4.	Sharma (2021)	Elaboration of individual, state, and national level ICT initiatives to support the teaching-learning process during the pandemic.
5.	Valverde-Berrocoso et al. (2021)	Integration of ICT with remote education; lack of digital interest or competence among faculties; requirement of ICT training.
6.	Zalat et al. (2021)	Scope of e-learning as an ICT tool for teaching within higher education.
7.	Bajpai et al. (2020)	Role of ICT in medical activities, contact tracing, enforcing social distancing, prevention, and resilience.
8.	De et al. (2020)	Need for secure technologies, like blockchain; need of developing policies to regulate digital infrastructure; the role of the Internet
9.	Iivari et al. (2020)	The education of young children has been affected by the digital divide; the need for research that addresses information management goals especially for children.
10.	Lorente et al. (2020)	Comparison of international regional groups over several basic, digital, and operational parameters; students of low-income regions suffered significant loss of learning.
11.	Mohite (2020)	Impact of ICT on the teaching-learning process; ICT tools and their scope.
12.	Schildkamp et al. (2020)	Comparison of two national PD initiatives (*Vraagbaak* and *DDguide*) of the Netherlands developed to support higher education system through ICT techniques during the pandemic.
13.	Vargo et al. (2020)	28 types of technologies employed; medical professionals used ICT tools extensively among the 8 groups of people who employed digital technologies; 32 types of activities were performed including health services; 35 types of effects were identified including the mitigated impact of the pandemic.
14.	Yang et al. (2020)	Role and practical implications of ICTs in global health crisis; effects of ICTs towards social order.
15.	Zaman et al. (2020)	SWOT analysis of ICT inventions during the pandemic.

3 Need, Role, and Impact of ICTs During Pandemic Emergencies

In this section, the requirements, influence, and scope of ICTs in various realms of modern human society have been thoroughly investigated and discussed.

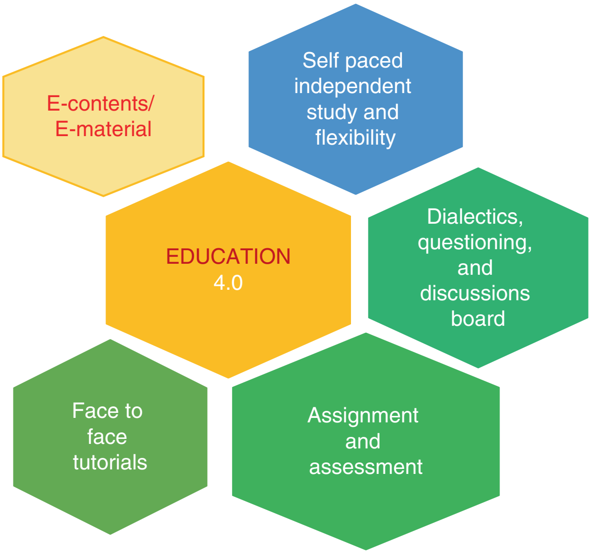
3.1 Education

The academic world is the most affected sector due to the COVID-19 pandemic. According to the UNESCO, studies of 1.38 billion students have been affected by the pandemic [18]. Approximately 165 countries closed their schools, and the pandemic posed numerous challenges to both the instructors and students. There has been no option other than resuming the teaching-learning processes through virtual media and ICT tools like *Zoom App*, *Google Meet*, *Webex*, *Microsoft Teams*, and *Google Classroom*. Before the outbreak of the COVID-19 pandemic, almost every educational institution had been practicing the traditional classroom teaching methods and a very few of them had been applying the methods of blended learning and flipped classrooms. The consequences of the COVID-19 pandemic forced the institutions to adopt the virtual or remote teaching-learning pedagogy and posed the challenges of digital and ICT skill development for instructors and for learners as well. The inception of ICT-driven teaching-learning practices all around the globe brought new vistas and opportunities for the academic world. Initially, there had been a state of confusion and dilemma among teachers and students due to the lack of ICT knowledge and proficiency; non-availability of laptops, smartphones, tablets, and gadgets; poor Internet reach and connectivity, etc. Gradually, the adaptation, familiarity, and implementation of ICTs started to creep into academia. Apart from the virtual interactions through the ICT tools, the instructors and learners started to encash the potential of *Open Educational Resources (OER)* and other digital repositories of knowledge and endeavored to enhance their digital skills. However, almost in the whole academia, the practical classes could not be conducted through ICT tools. The attendance, assessment, and evaluation of students' learning had also been possible through online forms, automatic quizzes, presentations, assignments, etc. Therefore, both teachers and students realized more learning opportunities through digital channels as compared to the traditional paper-based education and assessment. The term *webinar* perhaps had never been so popular earlier. ICTs supported medical education as well; in a literature survey, it was found that medical educators employed ICT tools more effectively than instructors from other disciplines [19]. Clinical skill lessons were also delivered from online platforms. Some online resources also explained the techniques of surgery [19]. The education department of China released 1291 online courses to the learners including 401 virtual practical courses executed from 22 digital platforms [20] (Fig. 1).

3.2 Medical

The two primary usages of ICTs had already been practiced in the medical sector before the COVID-19 outburst: telemedicine and online trading of medicines. But these practices were confined to a limited population. As a consequence of the current pandemic, getting online consultation through mobile apps (like

Fig. 1 ICT-supported education 4.0



MDLIVE, *LiveHealth*, *PlushCare*) and purchasing medicines over digital platforms (like *1mg*, *PharmEasy*) became the necessity of the time. Soon, a larger public had adopted these practices, and they eventually became popular. Oxygen meters, masks, sanitizers, PPE kits, etc. were purchased heavily over online platforms. Another ICT application was seen in contact tracing. Governments made it mandatory for the public to install and activate contact tracing mobile apps (like *Aarogya Setu*, *NHS COVID-19*, *COVIDSafe*). These apps also provided information on the proximity of the potentially infected people and were used to send alerts. The reports of COVID-19 tests were used to release in soft form through online platforms. Through the digital platforms, official authorities released authentic and trustworthy information, pieces of advice, and protocols regarding the COVID-19 situations. Out of the 193 United Nations member states, 167 countries provided information, statistics, travel guidelines, practices, etc. through Web and app channels. Many governments across the globe introduced automated chatbot services on WhatsApp that allowed the public to get answers to the most common queries about the COVID-19 pandemic. ICT tools have also been playing the primary role in implementing the world's most giant vaccination drive. People find information and book their vaccination slots through mobile apps and receive e-certificates on the same. A mobile app named "*DocDot*" was developed by Italy-based SDG Group which was used in the hospitals of India, Japan, and the USA after clinical trials. This app helped in monitoring and detecting the virus [21]. Lockdowns, quarantines, curfews, etc. affected mental and emotional health adversely. ICT tools supported people to mitigate fears, doubts, and dilemmas and helped them to align themselves in positive healthy activities like joining online yoga classes and seeking Ayurvedic treatments to boost immunity (Fig. 2).

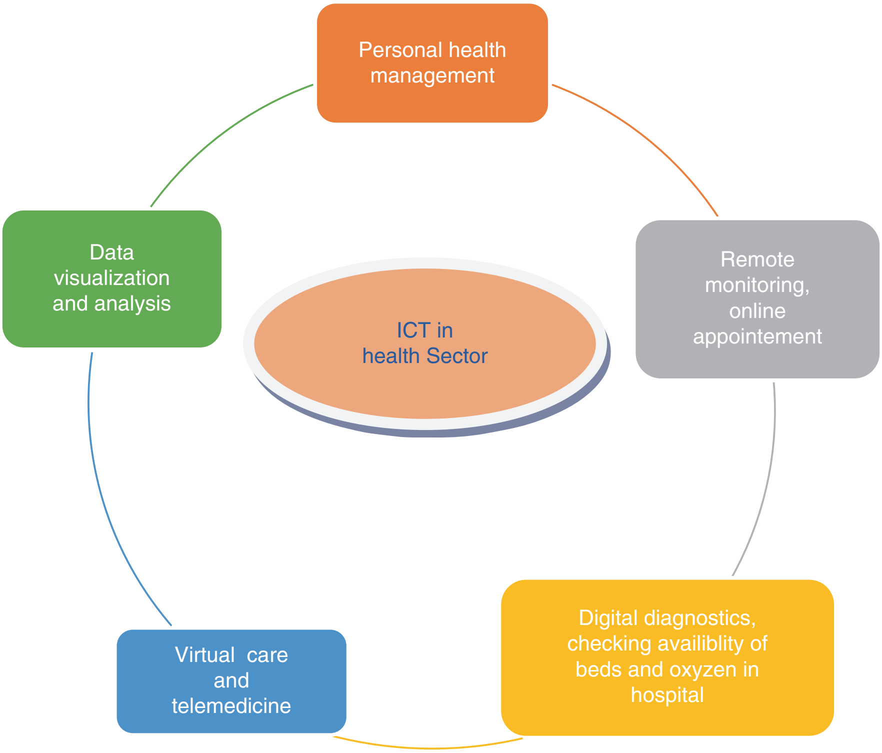


Fig. 2 Applications of ICT in medical sector during the COVID-19 pandemic

3.3 Social

Humans are social animals that have a basic need to interact with others. Being unable to do so can have a negative impact if it goes on for a long time. Staying home for weeks or months can trigger feelings of loneliness, especially if you live alone. This can increase the risk of many mental, emotional, and physical health issues. The quarantines, isolation, and stay-at-home experiences amidst the COVID-19 pandemic forced humans to embrace ICT knowledge and platforms completely in their daily routine. ICT tools have been the only way out to sustain social lives. People were connected virtually through cellular calls, video calls, teleconferences, real-time messengers, social media platforms, etc. Social activities like marriage gatherings, funerals, religious rituals, and social gatherings had been restricted to a few participants with proper care and precautions. Family members, relatives, and friends witnessed such activities virtually and remotely through ICT tools and techniques. Broadcasting of the classical Indian epics, Ramayana and Mahabharat, brought family members together. ICT-driven social media platforms proved to be beneficial to mitigate boredom, anxiety, psychological impact, and long-term distress caused by being kept in isolation or quarantine.

3.4 Governance

The COVID-19 pandemic posed critical challenges in many dimensions for governments across the globe to be operational. Provincial and central governments carried meetings and discussions virtually through ICT tools. SAARC countries had a virtual meeting. As a consequence of the current pandemic, the themes of *e-governance* and *e-administration* have been promoted, hyped, endorsed, adopted, and accepted hugely. Digitization and internalization of central and provincial government institutions and offices enabled citizens to carry out related activities remotely. During such emergencies and crises, it is the responsibility of the government to protect the rights of citizens and to provide accurate and reliable information. ICT knowledge and access to its tool made this quest possible, and thus a new concept emerged: *digital government* [22]. Decisions related to public safety, pandemic updates, protocols, safety, and preventive measures were released over e-channels by the governments. Public representatives interacted with citizens virtually during the emergency from time to time. Many international clusters organized virtual meetings, for instance *SAARC* [23] and *G20* [24]. In India, when the process of *unlocking* started, mandatory registrations for travelling from one district/state to another were imposed by the governments. These registrations and dissemination of e-passes were possible only through ICT platforms. The Indian Government digitally transferred money to help the poor combat the COVID-19 pandemic through direct benefit transfer (DBT) [25].

3.5 Cultural

Various bodies organized cultural activities, programs, and competitions virtually through ICT tools. The *New Town Development Authority* of Kolkata organized an online music, drawing, and writing competition [26]. The participants registered online through a website of *NKDA* [26]. Its main purpose was to develop the creativity of children locked in the house. Annual festivals in schools were organized with the help of digital tools. A cultural program named *CREED* was conducted online completely [27]. Amidst the COVID-19 emergency, writers, poets, storytellers, artists, etc. had been continuously active in the social and digital world and created cultural and intellectual content over social media platforms, blogs, forums, websites, mobile apps, etc. Religious and heritage institutions offered their vistas through digital channels. Cinema and theatrics shifted to *over-the-top (OTT)* platforms.

3.6 Commercial

The society in which we live is based on economic developments. If there is work, there will be a job; if there is a job, there will be income; and if there is income, then life will continue at its pace. The massive lockdowns caused by the COVID-19 pandemic disturbed this structure. Currently, economists are endeavoring to resume the normal flow of the economy. Amidst the pandemic conditions and lockdowns, digital marketing and selling of edibles, groceries, household items, etc. gained pace. The digital economy and consequences of the COVID-19 pandemic exhibited a positive correlation [28]. People intended to prefer cashless transactions through UPI, net banking, IMPS, NEFT, wallet, card payments, RTGS, etc. along with COVID cases. The development of the digital transaction environment through easy mobile applications boosted the digital economy. Thanks to the high-scale implementation of ICT tools, the Internet, *Industry 4.0* technologies, economic entities, and institutions have more easily and efficiently adapted to the new challenging economic conditions posed by the COVID-19 pandemic. Through the *Industry 4.0* information technologies, businesses have developed online platforms for communication with contractors and customers, increased the efficiency of production processes, reduced certain categories of operating costs, improved the quality of products and services, and also improved the supply and production logistics and their distribution. Villagers were also benefitted through the concepts of e-Panchayat, e-Mandi, etc.

3.7 Judicial

During the COVID-19 pandemic, the courts continued legal hearings through videoconferencing. According to a report, the Indian authorities have been contemplating introducing *e-courts* to ensure speedy disposal and resolution of legal cases [29]. Amidst the lockdowns and unlocks, citizens accessed judicial services and continued allied processes like e-filing and e-hearings through ICT tools and platforms. In exercise of its powers under Article 142 of the Constitution, the Indian Supreme Court ordered the operations of the machinery of the court through videoconferencing during the COVID-19 pandemic [30]. Five *e-court vans*, equipped with Wi-Fi and computers for exercising videoconferencing, were set up by the provincial High Court to implement virtual courts in remote and hilly areas of an Indian province, Uttarakhand [31].

The above discussions can be summarized in the following figure (Fig. 3).

4 Practices During the COVID-19 Pandemic vs. Practices in Earlier Pandemics

The Spanish flu, which was a terrible pandemic, existed from 1918 to 1919. In 2020, the coronavirus brought human activities to a standstill. Travelling through airways was limited during the time of Spanish flu; this twenty-first-century infection spread very rapidly from one country to another. The death rate from the Spanish flu was more than that from the COVID-19 pandemic. Lack of knowledge and awareness about the preventive measures might be one of the reasons for this. The fast and efficient information and communication technologies and their reach to the common man were limited or almost void. Many

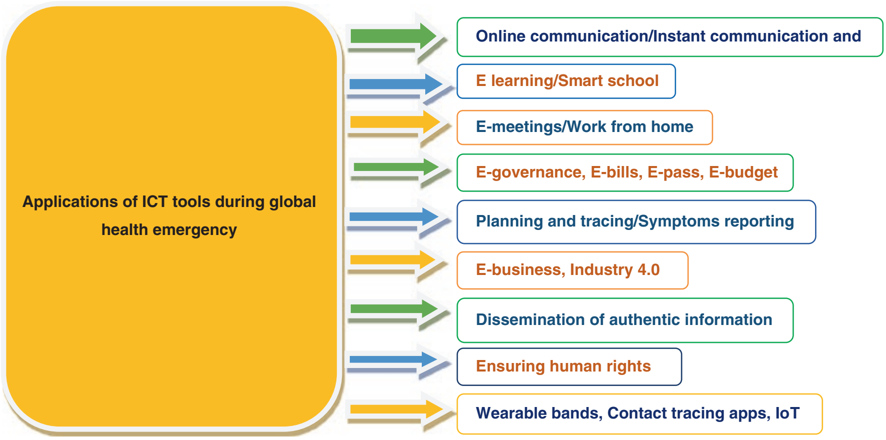


Fig. 3 Applications and impact of ICT amidst the emergency

Table 3 Spanish flu vs. COVID-19

Points	Spanish flu	COVID-19
Disease	Respiratory	Respiratory
Measures	Measures did not have much impact on the flu spread. A significant peak was achieved	Strict lockdown imposed in approx. 160 countries
Medical infrastructure	Lack of medical infrastructure	Lack of medical infrastructure but telemedicine and videoconferencing were available
Control efforts	Isolation, quarantine, school closures, suspending public gathering	Isolation, quarantine, school closures, suspending public gathering
Effectiveness of lockdown	The government could not stop the public gatherings; some schools remained open	Lockdown remained effective. Education, commercial, and other sectors survived because of advanced ICT tools
The usefulness of ICT tools	Radio and telephone were used by the public and officials to share information. Telephones were also employed in the teaching-learning processes, though their usage was limited	Society has been practicing work-from-home culture, virtual meetings, remote education, digital payments, e-governance, e-courts, etc. on a huge scale

countries adopted the techniques of closing schools and educational institutions to mitigate the Spanish flu. But due to the nonavailability of ICT tools, the education sector suffered badly. Telephones were available but they were limited. People used to communicate in their quarantine times to order household items through the telephone, the "*Bell Telephone*" [32]. In the Spanish flu epidemic, the social gatherings at religious places were not banned and all the business activities continued physically due to the limitations of communication technology. The two most devastating pandemics in the history of mankind are compared in Table 3.

5 Limitations of ICT During Pandemic Emergencies

The poor and handicapped children, who had already been facing a shortage of teachers and institutions, were completely deprived of teaching activities during the COVID-19 pandemic. These children neither have smart mobile for smart studies nor trained teachers to teach. A very few possess a single smartphone in the family, but they cannot afford the monthly data packs. Most children are living in interior areas where connectivity problems are very common. The digital divide put a strain on the poorest, and they are pushed further away from the nuclei where information, culture, and education circulate. Despite the advanced ICT tools, board examinations could not be conducted in India and students of all levels were promoted. Many students were dissatisfied with this decision. A teenage girl in Kerala allegedly committed suicide due to the nonavailability of ICT tools for attending online classes [33]. Such incidents highlighted that not everyone is digitally empowered. Fake information was also spread rapidly through ICT platforms. Misinformation and rumors about the increasing number of patients; lack of treatment, medicines, beds, and oxygen; and deceptive policies made the public worried and increased their dilemma and panic. Due to the increased digitization of day-to-day activities during the pandemic times, the graph of cybercrimes also escalated. Usage of contact tracing applications posed serious questions against data privacy. Experts alleged that these apps store Bluetooth and GPS information of users and pass them to the servers. Overindulgence in digital devices and increased screen time resulted in serious physical and mental health issues.

6 ICT in the Post-pandemic World

Looking to the future, almost every educational institution will introduce a new paradigm for the teaching-learning process, which would be based on ICT tools and remote education. After the current pandemic, the *work-from-home* culture may change the office operations. Commercial transactions would tend to be cashless in the majority through the gigantic applications of e-payment culture. This will boost the digital economy. In the academic world, the trend of organizing seminars, conferences, symposia, etc. virtually may become popular and somewhat necessary. The practices of *Industry 4.0* technology may flourish in various dimensions for digitally smooth production and development of goods and services. Institutions and their operations have been upgraded digitally in the way they deliver services to society. The current pandemic will divide modern history into pre- and post-COVID-19 eras. This pandemic boosted digitization, and no one would want to go in the pre-COVID times. Following the protocol of COVID, people changed themselves very fast. The severe pollution conditions in Delhi forced the government to impose lockdown-like restrictions. This has become possible since the COVID-19 pandemic has made us technologically sound and confident. ICT tools have shown us a way to remain operationally alive in tough emergency times. History has witnessed that when there is any crisis or disaster in the world, significant changes take place. During the current pandemic, many educational, economic, social, religious, and political changes were realized, which will change the future of all of us. The epidemic has taught us that remote education, virtual medical consultation, digital economic operations, production with virtual human involvement, etc. are possible under the aegis of advanced ICT tools. The world has entered into the era of quantum computing, 5G technology, and superfast Internet; all these are future advancements that would put wings on the development and implementation of ICTs. The world would soon experience the era of the hybrid education system, remote diagnostics of diseases, a large share of digital transactions and operations in the economy, ICT-driven production and business houses, e-courts, absolute e-governance, and complete or partial work-from-home culture (Fig. 4).

Fig. 4 Challenges in the post-pandemic world

7 Conclusions

From time to time, many pandemics destroyed mankind and affected societies badly. The COVID-19 pandemic has also affected various dimensions of human civilization and posed many challenges before mankind. Governments across the globe declared a health emergency. Science and digital technology played a significant role during this pandemic, and the consequences of the COVID-19 pandemic created many opportunities for ICT. And undoubtedly, humans encashed and exploited ICT knowledge to the fullest. A digitally empowered society emerged from the dark tunnel of the COVID-19 pandemic. In this hardest emergency, ICT knowledge and tools have become the medium of social communication, supporting platform for domestic and commercial operations, a boon for the health sector, panacea for remote education, lifeline for the digital economy, emerging hope for Industry 4.0, and so on. Amidst the devastating pandemics that roughly come in every 100 years, the ICT tools have been proved to be a savior. Necessity is the mother of invention. COVID-19 pandemic created the necessity for incorporating positive changes and developments that were otherwise progressing at a different pace. However, the serious existence of the digital divide has also been realized. We have to find a solution to fill the gap, ensure digital equality, and increase the faith and trust of the people over ICT platforms. Dissemination of ICT knowledge and tools and training of the officials, employees, teachers, students, and the common man are the earnest need of the present time. The governments and scientists should also work to ensure the digital privacy of the citizens and to strengthen cybersecurity. Man is the most intelligent creature on Earth; with the ICTs created by the human brain, unprecedented endeavors have been witnessed to combat the COVID-19 pandemic.

References

1. Jarus O. 20 of the worst epidemics and pandemics in history. All about history; 2021. https://www.livescience.com/worst-epidemics-and-pandemics-in-history.html
2. Sarpong E. Covid-19 shows why internet access is a basic right, We must get everyone connected. Web Foundation; 2020. https://webfoundation.org/2020/04/covid-19-shows-why-internet-access-is-a-basic-right-we-must-get-everyone-connected/.
3. Chhetri B, Goyal LM, Mittal M, Battineni G. Estimating the prevalence of stress among Indian students during the COVID-19 pandemic: A cross-sectional study from India. J Taibah Univ Med Sci. 2021;16(2):260–7. https://doi.org/10.1016/j.jtumed.2020.12.012.
4. Pokhrel S, Chhetri R. A literature review on impact of COVID-19 pandemic on teaching and learning. Higher Educ Future. 2021;8(1):133–41. https://doi.org/10.1177/2347631120983481.
5. Pozo J, Echeverría MP, Cabellos B, Sánchez DL. Teaching and learning in times of COVID-19: uses of digital technologies during school lockdowns. Front Psychol. 2021;12:1511. https://www.frontiersin.org/article/10.3389/fpsyg.2021.656776.
6. Sharma A. Education through ICT initiatives during the pandemic in India. Center for sustainable development working paper series: towards a new Indian model of information and communications technology-led growth and development; 2021. https://csd.columbia.edu/sites/default/files/content/docs/ICT%20India/Papers/ICT_India_Working_Paper_30_0.pdf

7. Valverde-Berrocoso J, Fernández-Sánchez MR, Dominguez FIR, Sosa-Díaz MJ. The educational integration of digital technologies preCovid-19: lessons for teacher education. PLoS One. 2021; https://doi.org/10.1371/journal.pone.0256283.
8. Battineni G, Pallotta G, Nittari G, Amenta F. Telemedicine framework to mitigate the impact of the COVID-19 pandemic. J Taibah Univ Med Sci. 2021;16(2):300–2. https://doi.org/10.1016/j.jtumed.2020.12.010.
9. Bajpai N, Biberman J, Ye Y. ICTs and public health in the context of COVID-19. Center for sustainable development working paper series: towards a new Indian model of information and communications technology-led growth and development; 2020. https://csd.columbia.edu/sites/default/files/content/docs/ICT%20India/Papers/ICT_India_Working_Paper_30_0.pdf
10. De R, Pandey N, Pal A. Impact of digital surge during Covid-19 pandemic: a viewpoint on research and practice. Int J Inf Manag. 2020;55:102171. https://doi.org/10.1016/j.ijinfomgt.2020.102171.
11. Battineni G, Nittari G, Sirignano A, Amenta F. Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic? J Taibah Univ Med Sci. 2021 Jun;16(3):305–6. https://doi.org/10.1016/j.jtumed.2021.02.009.
12. Lorente LML, Arrabal AA, Pulido-Montes C. The right to education and ICT during COVID-19: an international perspective. Sustainability. 2020;12(21):9091. https://doi.org/10.3390/su12219091.
13. Mohite M. Covid 19 and use of ICT in education. Educ Resurgence J. 2020;2(4):17–23.
14. Schildkamp K, Wopereis I, Jong MK, PeetA., HoetjesI. Building blocks of instructor professional development for innovative ICT use during a pandemic. J Prof Capital Commun. 2020;5(3/4):281–93. https://doi.org/10.1108/JPCC-06-2020-0034.
15. Vargo D, Zhu L, Benwell B, Yan Z. Digital technology use during COVID-19 pandemic: a rapid review. Human Behav Emerg Technol. 2020;2021(3):13–24.
16. Yang S, Fichman P, Zhu X, Sanfilippo M, Li S, Fleischmann KR. The use of ICT during COVID-19. Proc Assoc Inform Sci Technol. 2020;57(1):e297, 1-5. https://doi.org/10.1002/pra2.297.
17. Zaman A, Islam MN, Zaki T, Hossain M. ICT intervention in the containment of the pandemic spread of COVID-19: an exploratory study arXiv. arXiv:2004.09888; 2020. https://arxiv.org/abs/2004.09888
18. McCarthy N. COVID-19's staggering impact on global education. Statista; 2020. https://www.weforum.org/agenda/2020/03/infographic-covid19-coronavirus-impact-global-education-health-schools/
19. Chatterjee I, Chakraborty P. Use of information communication technology by medical educators amid COVID-19 pandemic and beyond. J Educ Technol Syst. 2020;49(3):310–24. https://doi.org/10.1177/0047239520966996.
20. Sun L, Tang Y, Zuo W. Coronavirus pushes education online. Nat Mater. 2020;19:687. https://doi.org/10.1038/s41563-020-0678-8.
21. Jones R. Ten innovations in the fight against COVID-19. RACONTEUR; 2020. https://www.raconteur.net/healthcare/healthcare-innovation-covid/
22. United Nations Department of Economic and Social Affairs. COVID-19: embracing digital government during the pandemic and beyond; 2020.
23. ANI. SAARC virtual meet: India invites Pakistan to coronavirus workshop; 2021. https://www.business-standard.com/article/current-affairs/saarc-virtual-meet-india-invites-pak-to-covid-19-workshop-121021700473_1.html
24. Karl KA, Peluchette JV, Aghakhani N. Virtual work meetings during the COVID-19 pandemic: the good, bad, and ugly. Small Group Res. 2021;1-23 https://doi.org/10.1177/10464964211015286.
25. Nandi S. Covid-19: digital payments aids cash transfer under garib kalyan scheme. Mint; 2020. https://www.livemint.com/news/india/covid-19-digital-payments-aids-cash-transfer-under-garib-kalyan-scheme-11586701007067.html
26. Press Trust of India. Many organisations in Kolkata holding online events amid lockdown. Hindustan Times; 2020. https://www.hindustantimes.com/

kolkata/many-organisations-in-kolkata-holding-online-events-amid-lockdown/story-GxNkiQochuWLMBjtixhxrL_amp.html#aoh=16374955727872&referrer=https%3A%2F%2Fwww.google.com&amp_tf=From%20%251%24s
27. Staff Reporter. School students host cultural events online. The Hindu; 2020. https://www.thehindu.com/news/cities/chennai/school-students-host-cultural-events-online/article32207720.ece
28. Digital Economy Report. Cross-border data flows and development: for whom the data flow. United Nations Conference on Trade and Development; 2021.
29. De-Souza SP, Aithala V, John S. The supreme court of India's vision for e-courts: the need to retain justice as a public service. The Hindu Centre; 2021. https://www.thehinducentre.com/publications/policy-watch/article35229520.ece
30. Subramanian K. The epidemic and ensuring safety in courts. The Hindu; 2020. https://www.thehindu.com/opinion/lead/the-epidemic-and-ensuring-safety-in-courts/article31552305.ece
31. Jha P. Wheels of justice: 'E-court' vans to reach remote Uttarakhand. The Times of India; 2021. https://timesofindia.indiatimes.com/city/dehradun/courts-on-wheels-for-remote-uttarakhand-areas/articleshow/85228784.cms
32. Hand B. Spanish flu vs the telephone. Sun J; 2020. https://www.newbernsj.com/story/special/2020/04/27/spanish-flu-vs-telephone/1285839007/
33. Agencies. Kerala: this 14-year-old girl allegedly commits suicide as she could not attend online classes. The Free Press J; 2020. https://www.freepressjournal.in/india/kerala-this-14-year-old-girl-allegedly-commits-suicide-as-she-could-not-attend-online-classes

Telemedicine Services and Frameworks During COVID 19: A Case Study of Seafarers

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1 Introduction

COVID-19 is an individual disease from an enormous group of infections causing a few pathologies influencing the pneumonic framework going from the normal cold to extreme respiratory conditions like the severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS). The virus called SARS-CoV-2 causes the COVID-19 disease.

It is undeniably seriously a testing time and hard to treat the coronavirus of patients on-board a ship compared with onshore patients. Ships Ships are at sea for days or weeks before they can reach a port and in general do not carry doctor or qualified paramedics. The transportation area conveys 90% of worldwide exchange and is the fundamental conduit of worldwide stockpile chains [1].

The COVID-19 pandemic addresses a significant issue for sailors. According to an association's perspective, seafarers need to deal with extensive issues joining and leaving their deliveries in ports (every month, around 100,000 sailors are associated with group changes). The restriction or if nothing else delays in being permitted to get back, augmentation of voyages through obligation with the subsequent weakness brought about by an expanded responsibility, disconnection, and prevalent difficulties for sailors due to constrained detachment from their families all build mental pressure among sailors. The pandemic likewise has a direct impact on the medical issue of sailors. There are quarantine limitations for global sailors on being

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_7

ready to go aground for clinical treatment or access port-based government assistance benefits just as limitations on the conveyance to boats of fundamental clinical supplies, in situations where ships are declined passage into ports.

The circumstance on the cruise ship called Diamond Princess is an ideal example of the troubles in giving clinical help on-board a boat during the outbreak caused by COVID-19 disease. The Diamond Princess is a British-enrolled voyage transport that showed up seaward of Yokohama port on the evening of February 3 (Monday), 2020, and on that day the quarantine started [2]. There were 2666 travellers and 1045 group individuals on-board the boat (a sum of more than 3700), and surprisingly however the boat had clinical offices locally available and was helped by Japanese health specialists; the quarantine went on until February 20, and 619 of 3700 travellers and team individuals (17%) were tested positive [3]. Despite the conversations about the viability of general health countermeasures taken on that event, the circumstance exhibits that it is so hazardous to oversee epidemic issue on-board ships.

On other hand, the COVID-19 crisis has required proceeding with alternate courses of action, making it important to re-examine the current way to deal with medical services just as the most effective method to adjust to the arising needs of medical services in the specific circumstance of a pandemic. Through the implementation of telemedical systems, it was figured out how to relieve the spread of infection by carrying out social distancing and avoiding patient-doctor interactions. The spread of infection among communities should be forestalled to limit the dangers of disease for health experts. In this regard, fundamental telemedicine administrations might assist with protecting public health in emergencies.

One of the benefits of telemedicine can be the everyday observing of certain health parameters and side effects like monitoring via mobile apps, which can also be measured or reported by patients. Telemedicine additionally permits admittance to patient visits who, for different reasons, face difficulty going to the hospital or the specialist's centres or who live in regions ineffectively associated with therapy habitats. Moreover, remote patients' consultants (and a few tests) have proved to be fundamental in this time of health emergency, to have the option to complete clinical preliminaries that in any case would have needed to stop.

A movement of frameworks has been proposed for infection prevention and control (IPC) that might control the COVID-19 danger. Telemedicine together with live videoconference and an essential valuable call license could contribute to identify the clinical situation which allows assistance of adequate treatement. It can likewise be applied for patient symptom recordings like respiratory, heartbeat, and oxygen level rates needed at home.

Moreover, telemedicine can give mental Web-based support to organizations in the setting of patient protection by diminishing the emotional health inconvenience from COVID-19 and sharing information about the symptoms of stress, demoralization, and anxiety. It is suggested that telehealth has a couple of advantages in giving comprehension of immunology behaviours, for instance confining the introduction of clinical specialists to possibly stained patients and induction to the quick evaluation for COVID-19 tainting.

It is reported that the exercises for the security of medical services, clinic staff, and patients should have to embrace the virtual frameworks to make staff timetables and do charging for clinical consideration organizations. There are some easy-to-set-up potential outcomes to monitor COVID-19 in live videoconferencing. Live videoconferencing helps to avoide the direct physical contact, likewise, diminish the risk of the show to respiratory deliveries and anticipating the normal transmission of tainting to specialists and other clinical benefits providers. Moreover, live video could be useful for patients who search for a gathering on coronavirus, and likewise for ship workers with high tension, rather than in-person visits in circumstances of persistent sickness reviews (for instance, diabetes and danger), some remedy checks, and emergency when telephone services are not available.

The need for telemedicine administrations for COVID-19 (i.e., Rather than anticipating that all outpatient practices should remain mindful of a rapidly developing proposition concerning COVID-19, medical frameworks made chatbots that imply moderate- to high-risk patients to sustain crisis lines). These facilities permit patients to design video visits with setting up or on-demand providers to avoid the travel to personal care centres.

In this chapter, we provide a discussion on recent telemedical technologies used for seafarers' health. In addition, this chapter also provides the telemedical frameworks used in controlling measures during the outbreak of COVID-19 for seafarers.

2 Attention to On-Board Psychiatric Issues During COVID-19 Pandemic

At present, the global pandemic caused by COVID-19 disease has changed all human lives because of its sheer magnanimity. Its rate of infection and death is unprecedented and is manifold as compared with other existing epidemics. This dangerous disease has affected people worldwide irrespective of nation, gender, and racism. Especially people from remote areas like seafarers are getting more attention due to their psychological issues, and their mental health will also be not in a good position.

When seafarers get mild symptoms, a greater risk of fear and stress would make them more vulnerable. This vulnerability causes various psychological problems like distress, depression, anxiety, insomnia, and even suicidal death. During COVID-19, social and economic factors (i.e. education, job status, and employment) were responsible for half of the overall individual well-being, and the remaining half was determined by individual behaviours (i.e. smoking, alcohol consumption, diet) and access to health [4]. Figure 1 presents the conceptual tree model of social determinants in the mental health competency of seafarers.

To lessen the psychological vulnerabilities, it is time to understand the science behind the disease rather than fearing it. Psychiatrists, psychiatric nurses, clinical psychologists, and other mental health workers should bridge the gap between fear and reality. The false news spreads are to be curbed; instead, solidarity towards frontline workers with kindness gestures would certainly motivate them to stay

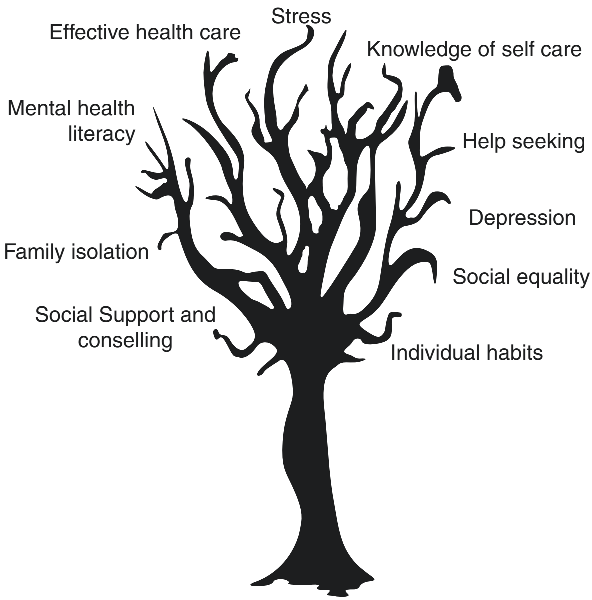

Fig. 1 Conceptual tree model of communal psychiatric issues among seafarers

energized with their mental status high. Online assessment to understand emotions and behaviour and fear assessment can be made available to ease out stress, depression, and fear [5]. Various computational and learning algorithms need to be put in place to pre-empt the psychological imbalance like the risk of suicide, lessen human manoeuvrability within the affected area, predict viral relapse, and classify and contain the disease, which would amend the calibre of effectiveness during emergency interventions.

Research initiatives have been taken to develop efficient and cost-effective medical devices for analysis of virus strains, etc. In closed environments like ships, testing facilities are needed to have access to each and every employee of the ship. There is also a sufficient amount of personal protection gear and equipment along with an insurance scheme for health and police personnel serving across the maritime industry. Yoga, meditation, and training sessions should be conducted on-board to overcome mental pressure. However, after all these commendable efforts, the sailor population is still scarred by the stigma of fear and distress about the contagion leading to psychological health.

Despite this, there is an instance of psychological imbalance among marginalized people and low-level workers. At this rate of infection and death worldwide, challenges are emerging to keep everyone psychologically well. On-board, psychiatrist intervention is much required today [6]. When a seafarer loses his/her job, it amalgamates financial burden, social stigma, and family disobedience leading to disorderly behaviour, disrupting mental health in such a stressful and chaotic environment.

As per the International Labour Organization report, 305 million full-time jobs are at risk of being lost due to this pandemic. This number is about 1.5 times the previous estimation of around 195 million jobs being lost in the first quarter of 2020 [7], thus creating panic in the life of global seafarers and predominantly leading to various psychological disorders. Thus, this epidemic can be regarded as a mental health catastrophe [8]. It is quite evident that there is an inherent characteristic of epidemics including COVID-19 to have comorbidity with psychological disorders related to either fear or financial distress. Every other loss like economic slowdown or job loss can be recovered except the psychological disorders, which are more catastrophic to human life. Thus, timely intervention and medical management are the call of the hour in the current scenario.

To forestall psychological wellness issues among seafarers, all attributes of associations at sea, at the port, and in different sorts of vessels have to be remembered for prevention programmes, and more examination needs to be led on factors of weariness and stress among sailors and fishing workers. We worried about long-haul mental and social impacts on seafarers during the COVID-19 pandemic. In the initial segment, psychological disorders like despondency, uneasiness, and an expanded rate of suicide will show up. In a subsequent part, with uneasiness, social pressure from family, and financial challenges, we could estimate that various seafarers will not return on-board vessels and will leave the sea transport.

Increasing access and health information and in-person meetings with psychologists or by videoconference are imperative. Capacities of team changing, help from well-being administrations, and foreign workplaces are likewise required. Conversations between worldwide associations, transportation sectors, and labourer's institutions to assemble present-moment and long-haul counteraction activities could surely be beneficial for seafarers.

3 Reliability of Telemedical Services During COVID-19 Outbreak

Since the beginning of the national emergency from COVID-19, the Italian National Centre for Telemedicine and New Assistive Technologies of the Higher Institute of Health (Istituto Superiore di Sanità) has been collaborating with the operational realities on the Italian territory by providing its support to the realization of concrete, rapid solutions to be applied. It follows current regulations to offer the best guarantee of health safety for both patients and professionals. There are numerous needs for care and assistance both in hospitals and even more in the territories that are also rigorous in terms of medical practice and protection of safety, covering real needs, including non-local ones, with solutions that can be scaled according to needs and using the network to cancel the distance between people and create impassable barriers for the virus [9, 10].

In the COVID-19 health emergency, the National Health Service (NHS) was called upon to provide services to persons obliged to quarantine or in fiduciary isolation with unprecedented significant numbers. These services have the dual purpose of helping to combat the spread of COVID-19 and of ensuring as far as possible the continuity of care and assistance, to which people are entitled. Moreover, even those who find themselves isolated at home as a result of the necessary rules of social distancing may still have needs for continuity of care and assistance [11–13].

Although it is a priority to increase the possibilities of home care for people affected by COVID-19, for the reasons just mentioned, at the same time the care and home care for those people who present it cannot be neglected because of their pathological conditions or frailty. Furthermore, all these needs must be addressed in conditions of a health emergency, with a relative lack of material and human resources and taking care to observe the anti-contagion rules for the greatest possible protection also of health personnel.

It should be noted in terms of the personalized surveillance of the clinical picture in these people, that the choice of signs and symptoms to be monitored can be organized in pre-established digitized files, suitably according to the pathologies taken care of and taking care to leave it to the doctor, with always the possibility to modify them. These operational aspects will be addressed in further specific insight documents, considering that even in the course of an emergency from COVID-19, the creation of a telemedicine service includes the assumption of responsibility to define when it can be indicated in the individual case and which ones are the methods of alternative service provision when contraindicated.

The use of remote services is therefore fully justified. They should be provided to people, where possible, primarily through modern digital and telecommunication technologies, which offer the best operational opportunities compared to the use of previous technologies. The possible services with telemedicine are manifold, where they were in operational conditions even before COVID-19 [14]. Instead, where telemedicine is not yet structured in a system of national significance, being in a situation of health emergency, it is, first of all, necessary to create and make available those solutions that can be activated quickly: in less time, which can be used by people at home with the technological equipment available to them immediately and that can be activated for periods corresponding with the needs posed by the situation of emergency.

Based on the Chinese experience of the evolution of the epidemic, as a first approximation, in creating remote services, the relational needs of users with the health system must be taken into account. The isolation inside one's home makes it particularly desirable to be able to count on a service that can be easily used remotely, being able to quickly access the interview with the healthcare professionals, as needed. Due to the limitation of travel, the person expects to receive already through the electronic contact the solution of his/her problem or the clear indication of how to solve it or at least to perceive the concrete possibility of being assisted effectively and safely. In the absence of the aforementioned feedback, the person will tend not to trust the proposed system and not to use it, especially when faced with urgent needs in reality.

Patients suffering from chronic diseases or requiring long-term treatments are usually managed in part or entirely by local services or residential structures (just think for example diabetes, chronic cardiovascular diseases, COPD, pain therapies, chemotherapy, psychiatric pathologies, disabilities), also including people suffering from rare diseases and frail conditions that require constant contact with healthcare facilities and healthcare professionals of reference, or people who need particular assistance and/or support not in the hospital, but not deferrable (for example pregnant women, mothers, people with psychological problems).

The target of a home assistance service in telemedicine consists of bringing healthcare services to people in isolation who are isolated following the rules of social distancing, to proactively monitor their health conditions, in relation to both the prevention and treatment of COVID-19 and the continuity of assistance that may be necessary for other pathologies and/or conditions that require it.

This general objective is useful for directing organizational actions within the framework of a scientifically valid methodology that facilitates its implementation. However, this alone is not sufficient to provide individual services appropriate to the care of the individual. In building these telemedicine services, it is also necessary that the doctor identifies which diagnostic, therapeutic, and assistance activities can be carried out remotely, with the technologies available and usable by the person concerned. The physician responsible for the treatment must be able to choose from time to time the combination of organization and technology that proves best, in terms of efficacy and safety, for the person to be assisted. Equipping the patient with technology, however advanced, does not automatically lead to recovery. The patient can be cured if the technology is appropriately used within clinical reasoning that has as its purpose the care of the individual and not the use of technology.

Within healthcare facilities, the connectivity of the workstations is usually ensured optimally. However, it is recommended to perform connection speed tests and verify the real possibilities of the local network to support data traffic compared to the average volume of simultaneous download and upload requests, which will be useful both as guarantee of good functioning at the time of implementation and to document its quality in future analyses on the work carried out during the emergency period. This will not be an additional effort since the applications to perform such tests are very common and easy to use.

A particular case concerns the position of the doctor who works in telemedicine from the place where he/she is domiciled for quarantine. In this case, beyond the opportunity assessments, it is recommended to assess the same procedures described above in the paragraph relating to the recipient of the service, requiring the doctor to perform the above connection speed tests.

4 The Types of Telemedical Services

This section proposes the structuring of four different types of telemedicine services to respond as best as possible to health needs in different situations. Each of these services can be created and provided individually. With appropriate technical measures, the four services can be associated with each other in various combinations, or even implemented all within a single telemedicine system.

For the sake of simplicity, we considered the implementation option in which all four types of services are present. The four services can be applied on a single territory but can be extended in modular form in further areas, even if not contiguous to the first, or be replicated separately, but in the latter case, it is necessary to duplicate all the parts that compose it, including the related health coordination centres.

It is useful to underline, before going into the details of the different types of services, that they are not aimed at a specific category of doctors but can work with the collaboration of any doctor. This is consistent with the health emergency and in particular should the relative shortage of doctors increase. However, the organization of remote work envisaged in these services is especially adequate for collaboration with general practitioners, who can contribute better than others to the more precise assessment of the situation and evolution. For their knowledge of patients, they can insert into the system the baggage of their specific knowledge of the patients entrusted to them, with anamnestic details and considerations.

The four types of telemedical services during COVD-19 that are in need are mentioned below.

4.1 Type 1: Active Remote Control of the Health Status of People to Detect the Possible Appearance of Signs and Symptoms of COVID-19 Infection

This type of service is aimed at people affected by diseases before the time when quarantine or isolation was required, asymptomatic and falling within the definition of close contact or confirmed case. This type of service is proposed to immediately identify in such people the appearance of symptoms and/or signs attributable to the beginning of the symptomatic phase of COVID-19. This service finds its direct utility in the remote control of the spread of the contagion, with a clear utility in the overall management of the emergency by the authorities, but it also has an individual utility as it allows to make the treatment of support to the individual, increasing the chances of recovery.

Furthermore, it facilitates the correct adoption of home hygiene and prevention measures by the person himself/herself and any cohabitants. Healthcare personnel must operate in a coordinated manner concerning the public health services of the relevant territory, to optimize the use of resources, and must also act according to national provisions and guidelines, to ensure uniformity of procedures and services. The remote control activities can be performed by adequately trained healthcare personnel; they are based on repetitive and standardized procedures of anamnestic update and detection of some simple objective signs (e.g. body temperature), together with regular interviews in a video call in which the collected data and information on the state of health are verified. At the same time, during the video call, the person is provided with useful information and advice. These contacts, regularly, also contribute to improving individual adherence to indications, prescriptions, and treatments.

For this type 1 service, the objective data that must be collected are all those that are indicated by official sources as necessary and sufficient to make a clinical diagnosis of COVID-19 or at least to suspect it [15]. The clinical symptoms most commonly encountered in laboratory-confirmed COVID-19 cases were fever, dry cough, fatigue, sputum production, dyspnoea, sore throat, headache, etc. [16]. It is advisable to include all these symptoms in the computerized procedures for the detection of anamnestic and control information, asking the person in isolation to indicate only if one or more of them are present. This can also be done via a questionnaire in the app or during video-call interviews and is used exclusively to identify people in quarantine or isolation who become symptomatic or paucisymptomatic.

The video-call system, by its nature and always in consideration of the health emergency, does not require the high characteristics that are normally required to ensure health safety when making decisions in the differential diagnosis (e.g. precision image) and for which high- or maximum-level certifications are required. This allows us to be flexible in using various video-call systems to adapt to the technological possibilities available at the person's home.

4.2 Type 2: Tele-Surveillance of the Clinical Picture of People in a Situation for the Necessary Treatment Against COVID-19 and to Arrange for Any Hospitalization When Appropriate

This type of service is aimed at people related to a situation already illustrated ("people not affected by diseases before the time when isolation was required, who have mild to moderate symptoms compatible with COVID-19 infection, and who fall within one of the definitions of the suspected, probable, or confirmed case"). These are numerous patients who develop symptomatic forms of COVID-19, or symptomatologic pictures compatible with COVID-19 in suspected cases, with mild or moderate symptoms and signs, whose condition is manageable at home and in the absence of further pathologies.

The typical medical image of reference for inclusion in this service consists of fever between 37.5 and 38.6 °C, dry cough, cold symptoms (and/or other symptoms indicative of COVID-19 referenced in type 1), and without dyspnoea. The objective of this type 2 service is to treat the aforementioned patients remotely with suitable treatments, maintaining medical control at home, with greater proactivity than would be possible without telemedicine systems, providing an effective and easy-to-use tool for optimizing primary care in the current emergency and to safeguard the safety of healthcare professionals. The insertion of the patient in this type 2 service is associated with the reporting of the case to the public health services for the execution of the COVID-19 test, where required. The patient can be entered directly into type 2 service or addressed to it by type 1.

The changeover manoeuvre from type 1 to type 2 service allows the doctor to be placed in the best conditions to recognize as quickly as possible at the moment the symptoms that tend to increase in number and intensity, increasing control in telemedicine. Severe forms of the disease, with more intense symptoms, occur in 13.8%

of cases, and 6.1% of patients present a critical form of COVID-19 with respiratory failure, septic shock, and/or multi-organ dysfunction/failure, with further related symptoms [17–19]. Using telemedicine systems in this way means treating people at home instead of hospitalizing them, when this is possible and useful for the person, while it does not mean using telemedicine to delay hospitalization that is deemed necessary.

In type 2 service, the appropriate combination of measuring equipment can have a high level of standardization, but it cannot be established first rigidly for all people. The doctor based on the interviews with the patient, decides from time to time which measurement scheme is suitable, choosing from a basic set of measurements that he/she can modify in part. In case of need the same patient can transmit the measurements online or can report them during the follow-up video call with the doctor.

The control video calls, always associated with the detection of the symptoms and signs indicated above, have the meaning of allowing the patient's clinical and risk conditions to be assessed remotely, directly by the connected doctor, to complete the framing of the case, to decide on the treatment against COVID-19, and above all to react promptly in case of worsening towards serious forms of the disease. The video call allows to partially overcome the limits of simple telephone contact, also transmitting images and colours.

In this way, it allows the doctor to perform at least part of the normal medical examination including the collection of the anamnesis and partially the physical examination (inspection).

4.3 Type 3: Active Tele-Surveillance of the Overall Clinical Picture of People to Provide the Best Possible Continuity of Care and Assistance at Home, About the Underlying Condition and Any COVID-19 Infection

This type of service is aimed at people suffering from chronic diseases or rare diseases and people in fragile conditions, or who require long-term treatment or particular assistance and/or support not in the hospital, and who need to maintain the continuity of services during quarantine or isolation or in the period of application of the social distancing rules.

The objective of this type 3 service is to continue home care and assistance in favour of the aforementioned patients concerning their basic condition, placing them under the maximum protection obtainable against COVID-19. For these people, the damage produced by the interruption of care and assistance following forced isolation or social distancing has the same importance as that deriving from the contagion. The development of COVID-19 in people already suffering from other demanding pathologies, with reduced functional reserve, can more easily induce extreme consequences in a short time, but the interruption of the necessary treatments will cause damage that is difficult to recover, which will manifest itself in a long time but equally with serious consequences.

For these people, it is necessary to use telemedicine systems to keep the services dedicated to them actively, modifying, if necessary, the procedures to obtain the widest possible accessibility and usability even at a distance while maintaining medical control for both primary care and specialist services and also in these cases to safeguard the safety of health professionals. The patient can be inserted directly into type 3 service or addressed to it by type 2 in the manner described above. The changeover manoeuvre from type 2 to type 3 service allows the doctor to be in best conditions to keep the underlying pathological picture under control and at the same time monitor any appearance/evolution of symptoms and signs from COVID-19. The operational procedures relating to COVID-19 in this type 3 service are identical to those reported in types 1 and 2. However, in the activities in telemedicine for the contrast to COVID-19 aimed at these patients, measures of greater protection are applied based on the cases.

Upon the appearance of symptoms, the telemedicine system, using checks on the data detected by the devices and together with the daily verification of the doctor via video call, must allow the doctor to prescribe the appropriate and personalized treatment at home, as well as to immediately identify situations of worsening of conditions that require more care in a hospital setting. About the points in the list above, it should be borne in mind that, even in the health emergency due to COVID-19, the task of the telemedicine services offered at home for these patients essentially consists of limiting the frequency of episodes of exacerbation of chronic pathologies and/or preventing complications, reducing as much as possible the need for services for which it is essential to go to health facilities. This task, as already extensively studied and applied in telemedicine, can be carried out, in part or whole, by detecting and transmitting the necessary and personalized set of clinical parameters to the referring physician. However, in an emergency, it is possible to be forced by circumstances to organize home services in telemedicine having to accept the limits of the availability of hardware and software at the patient's home.

In cases where it is not possible to deliver the necessary instruments to the patient and either he/she or caregivers are not able to use them acceptably, it is necessary to organize an adequate sequence of alternative actions, until the material resources available are such as to guarantee safety and efficacy. It is recommended already in the organizational phase to define in which situations the assisted patient must be directed to face-to-face services, which in turn may be both at home and in health facilities.

4.4 Type 4: Psychological Tele-Support Regarding the Discomforts and Limitations of Isolation (at the Request of the People)

This type of service is aimed at any person who is in isolation or quarantine, or de facto isolated following the rules of social distancing, in the course of COVID-19. The service aims to put the person in isolation in audio-video contact with a psychologist [20]. The video call is activated on individual request, with a procedure that allows the service to be provided in the shortest possible time, based on the available resources, directly at the person's home.

It is particularly indicated and recommended for this type 4 service that the coordination of the activities is assumed by the competent authorities. By definition, this type of activity cannot be standardized, and therefore coordination serves exclusively to optimize the provision of the service to guarantee its uniformity, especially concerning the application of scientifically correct intervention methods in safe conditions.

The interviews will in any case be subject to the code of ethics of the order of psychologists and will not be recorded. The service does not consist of medical assistance activities but consists exclusively of carrying out interviews with a psychologist, which have the purpose of giving support to people in isolation against the discomforts, limitations to relationship life, and fears caused by the specific situation. The psychologist, registered in the register, interacts via video call with the people who request it and can, once the first contact has been established and where he/she deems it necessary, arrange further interviews via video call with the person.

Before starting the interview, it is recommended that the psychologist identify the person to whom he/she is addressing, using the most appropriate methodology. The video-call system for psychological interviews, by their nature of individual interviews without the use of instruments and always in consideration of the health emergency, only requires good connectivity that allows the psychologist to adequately grasp the non-verbal language as well during his/her speech.

5 Telemedical Frameworks for Seafarers' Health

This section presents the two major telemedical frameworks that are helpful to mitigate the problems of on-board seafarers due to COVID-19. For example, cloud-based technologies have been intended to help patients from home by proactively overseeing mental worries like melancholy, tension, and different conditions with the work of prescient investigation controlled by artificial intelligence (AI) models.

5.1 Cloud-Based Technology

The fundamental commitment of this work is to introduce a theoretical system for the observing of psychological circumstances of COVID-19-contaminated patients. This system has been introduced in Fig. 2 to help the clinical consideration, mental issue appraisal, instructing of healthcare staff, and online self-evaluation of people just as depressed patients as seafarers. It can likewise assist with controlling mental issues using individual interchanges with different patients through basic chat sessions.

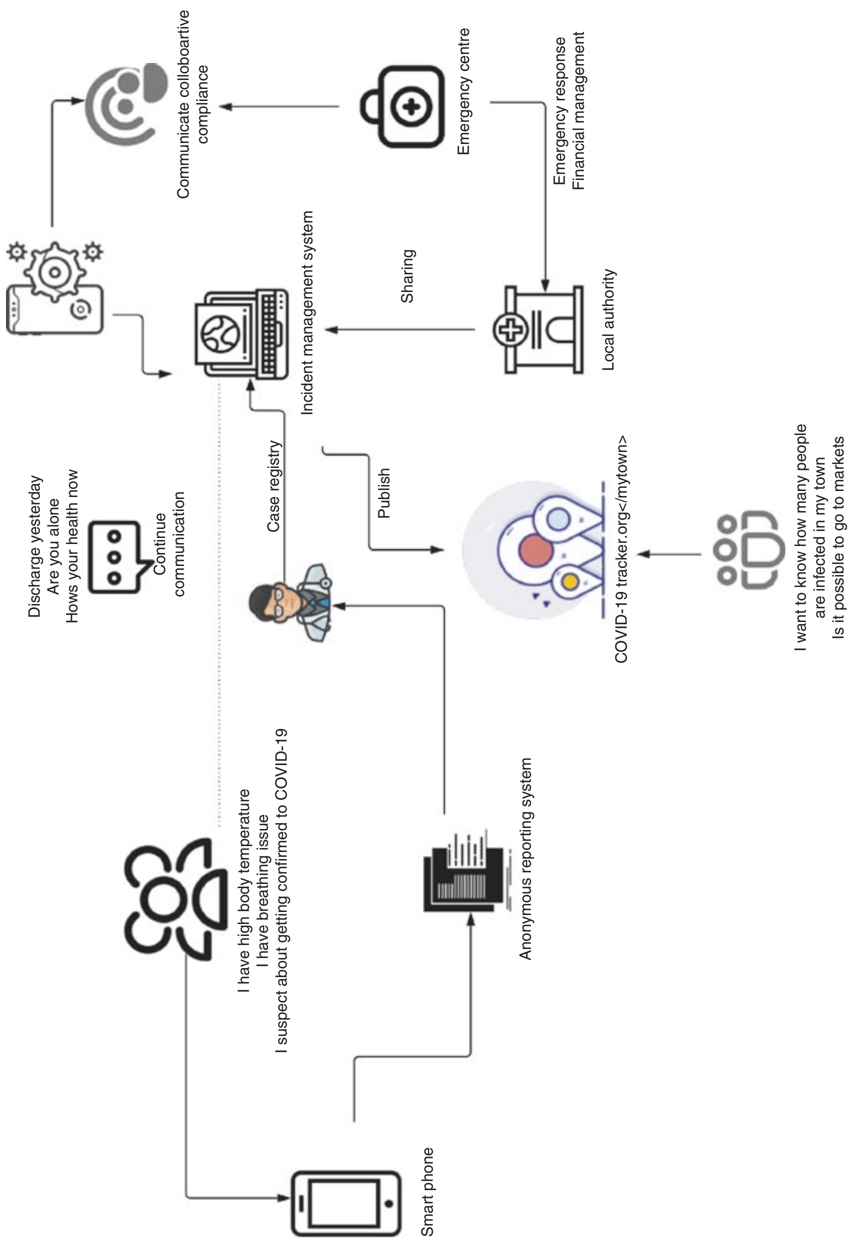

Fig. 2 Cloud-based telemedical framework

The presented model has been planned with the incorporation of both AI and cloud knowledge. The data set of occurrence of the executive's framework gathers the nearby information of mental and actual conditions of quarantined (or isolated) seafarers with COVID-19. The seafarer can be enrolled into the given application and record the health parameters (i.e. heartbeat, body temperature, body mass index (BMI), pulse) to screen normal health situations.

When a seafarer gets sick or feels that he/she has got an abrupt climb in internal temperature, or faces breathing issues, this application cautions the patient and makes a prompt arrangement to reach the emergency department. This incident is recorded in the management systems and records the number of on-board infections and offers the day-by-day successful implementation of COVID measures in the shipping environments. Distributing or sharing of recovered patient's experiences empowers infected persons to feel much improved and more certain to battle against COVID-19. Along these lines, the proposed system can open new ways to utilize public health technologies to save lives during this new pandemic by giving a far-reaching method of track and dealing with a person's COVID-19 reactions.

5.2 ICT Framework

Telemedicine has as of now been proved as an effective solution during SARS-CoV (severe acute respiratory syndrome coronavirus), MERS-CoV (Middle East respiratory syndrome coronavirus), Ebola, and Zika [21]. Another proposed system to mitigate the virus risk on-board is based on information and communications technology (ICT). The major aim of proposing this framework is to introduce a conceptual model for seafarers observing both COVID-19-suspected and -infected patients. This incorporated framework might ensure controlled supervision not just of positive patients but also of asymptomatic and constantly sick patients during novel coronavirus.

The proposed model is outlined with SIoT (Social web of things) and AI methods (i.e. deep learning, text mining, genetic algorithms) The SIoT is utilized to gather the suggestive data of COVID-19-contaminated patients (Fig. 3). The utilization of computerized gadgets, biosensors, and thermometers can assist with giving everyday data, for example pulse, body temperature, circulatory strain, and galvanic skin reaction. After having the required data, the model system with AI knowledge will be utilized to case extensive arrangement model to check the patient situation in three possible ways mentioned below:

- Assuming that the patient is asymptomatic, telemedicine checking will proceed till the finishing of the incubation period.
- If the patient is possessing mild to moderate symptoms, continuous support will be expected till the patient is recovered.

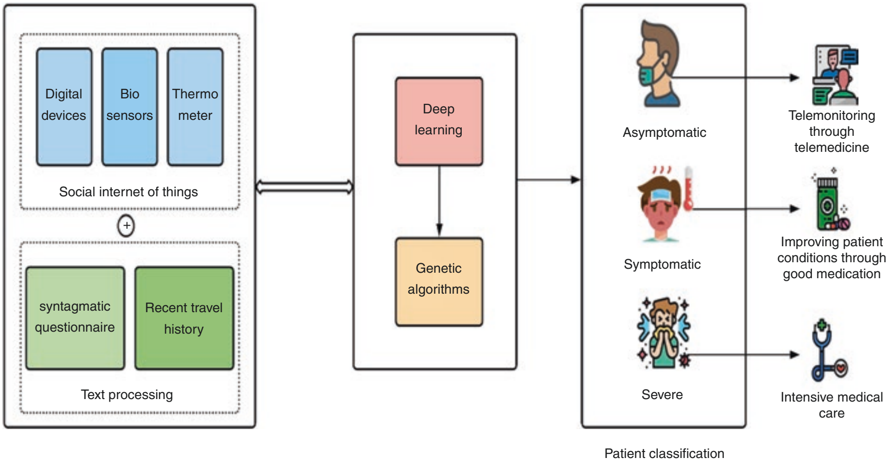

Fig. 3 ICT-based telemedical framework

- Assuming that the patient is in extreme conditions, immediate data can move to emergency clinical support to the extreme arrangement of concentrated medical care.

6 Conclusions

Telemedicine and telemonitoring technologies can treat patients with emergency conditions despite a physical appearance at the healthcare centre. These types of systems are largely helpful for remote-area patients (i.e. seafarers). With videoconferencing, telemedicine frameworks empower direct correspondence with patients by computers or mobile phones. The whole framework has to be overseen by uniquely planned programming to ensure stable associations, data stream, and information security. These frameworks are a combination of medical objects, which will autonomously record the patient biomedical data and review the seriousness of medical problems. Several efforts are needed by all global nations to guarantee that pandemics like the COVID-19 can be effectively managed. According to this viewpoint, assuming that telemedicine is completely incorporated into a public health framework, it could demonstrate a legitimate instrument all alone to ensure continuous care and reduce virus severity, particularly among well-being experts.

Conflicts of Interest No author produced any conflicts of interest.

Acknowledgements The support from ITF Seafarer's Trust No. 1624/2021 and Italian Ministry of Health No. J59J21011210001/2021, for the development of an Observatory on the Pathologies of Seafarers are greatly acknowledged.

References

1. Sagaro GG, Battineni G, Chintalapudi N, Di Canio M, Amenta F. Telemedical assistance at sea in the time of COVID-19 pandemic. Int Marit Health. 2020;71(4):229–36. https://doi.org/10.5603/IMH.2020.0041.
2. Takeuchi I. COVID-19 first stage in Japan—how we treat 'Diamond Princess Cruise Ship' with 3700 passengers? Acute Med Surg. 2020;7(1):e506. https://doi.org/10.1002/AMS2.506.
3. J. Rocklöv, H. Sjödin, and A. Wilder-Smith, "COVID-19 outbreak on the Diamond Princess cruise ship: estimating the epidemic potential and effectiveness of public health countermeasures," J Travel Med, vol. 27, no. 3, pp. 1–7, May 2020, https://doi.org/10.1093/JTM/TAAA030.
4. Takian A, Kiani MM, Khanjankhani K. COVID-19 and the need to prioritize health equity and social determinants of health. Int J Public Health. 2020;0123456789 https://doi.org/10.1007/s00038-020-01398-z.
5. Battineni G, Kumar S, Mittal M, Amenta F. COVID-19 vaccine on board ships: current and future implications of seafarers. Int Marit Health. 2021;72(1):76–7. https://doi.org/10.5603/IMH.2021.0010.
6. Banerjee D. The COVID-19 outbreak: crucial role the psychiatrists can play. Asian J Psychiatr. 2020; https://doi.org/10.1016/j.ajp.2020.102014.
7. Coronavirus: nearly half the global workforce at risk of losing income. https://www.cnbc.com/2020/04/29/coronavirus-nearly-half-the-global-workforce-at-risk-of-losing-income.html. Accessed 29 June 2020.
8. World Health Organization. Mental health and psychosocial considerations during COVID-19 outbreak. World Health Organization; 2020.
9. Battineni G, Nittari G, Sirignano A, Amenta F. Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic? J Taibah Univ Med Sci. 2021;16(3):305–6. https://doi.org/10.1016/j.jtumed.2021.02.009.
10. Siddiqui J, et al. Infectious Diseases Society of America position statement on telehealth and telemedicine as applied to the practice of infectious diseases. Clin Infect Dis. 2017;64(3):237–42. https://doi.org/10.1093/CID/CIW773.
11. American Geriatrics Society policy brief: COVID-19 and nursing homes. J Am Geriatr Soc 2020;68(5):908–911. https://doi.org/10.1111/JGS.16477.
12. Tseng TG, Wu HL, Ku HC, Tai CJ. The impact of the COVID-19 pandemic on disabled and hospice home care patients. J Gerontol A Biol Sci Med Sci. 2020;75(9):e128–9. https://doi.org/10.1093/GERONA/GLAA081.
13. Dosa D, Jump RLP, LaPlante K, Gravenstein S. Long-term care facilities and the coronavirus epidemic: practical guidelines for a population at highest risk. J Am Med Dir Assoc. 2020;21(5):569–71. https://doi.org/10.1016/J.JAMDA.2020.03.004.
14. Keesara S, Jonas A, Schulman K. Covid-19 and health care's digital revolution. N Engl J Med. 2020;382(23):e82. https://doi.org/10.1056/NEJMP2005835.
15. Huang C, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet (London, England). 2020;395(10223):497–506. https://doi.org/10.1016/S0140-6736(20)30183-5.
16. Chen N, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet (London, England). 2020;395(10223):507–13. https://doi.org/10.1016/S0140-6736(20)30211-7.
17. Eurosurveillance Editorial Team. Updated rapid risk assessment from ECDC on the novel coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK. Euro Surveill. 2020;25(10) https://doi.org/10.2807/1560-7917.ES.2020.25.10.2003121.
18. Zhou F, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet (London, England). 2020;395(10229):1054–62. https://doi.org/10.1016/S0140-6736(20)30566-3.

19. Yang X, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med. 2020;8(5):475–81. https://doi.org/10.1016/S2213-2600(20)30079-5.
20. Wright JH, Caudill R. Remote treatment delivery in response to the COVID-19 pandemic. Psychother Psychosom. 2020;89(3):130–2. https://doi.org/10.1159/000507376.
21. Ohannessian R, Duong TA, Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. JMIR Public Heal Surveill. 2020; https://doi.org/10.2196/18810.

Health-Related Quality of Life (HRQOL) Analysis Based on Physical Activity and Sleeping Pattern Among Seafarers Using Smartphones

Smartphone Applications for Monitoring Physical Activities Onboard

U. K. Sridevi, S. Sophia, and S. R. Boselin Prabhu

1 Introduction

Smartphones are growing more common by each day, drawing people closer to them, allowing them to carry them in their pockets, and allowing them to become more embedded into people's daily lives. This closeness of the smartphone to the user's daily life brings up a plethora of possibilities for exploiting smartphone use to help make sense of the context of everyday habits and behaviours.

Seafaring has a distinct set of characteristics that distinguish it from other professions. This includes physically hard work environments, possibly dangerous duties, lengthy work hours, and high levels of stress and weariness. Seafaring has sometimes been referred to as a "lonely life". Seafarers are not only separated from their relatives and friends over longer periods of time, but many also often live alone on ship.

Smaller crews have resulted from rising levels of automation onboard ships, and crew members may come from a variety of cultural and ethnic backgrounds. The worker may be considered particularly sensitive to mental illness in this situation. The subject of behavioural disorder is a wide one, and ship operators are recommended to dedicate more time in learning about it. As a preliminary step, it is

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_8

critical to recognise that mariners face the same problems, emotions, and goals as everyone else. Furthermore, they have the problem of being confined to a ship for long durations and also being separated from family members and friends.

In this chapter, we intend to improve the computation precision in order to obtain more accurate figures about an individual's sleep behaviour (beyond sleep duration), depending on, for instance, patterns in the person's perceptions that might help us better understand which sleep occurrences exist, and to decide whether and to what large extent there is a strong association between users' sleep habits and their interactions with smartphones with respect to the time duration they were used, what application was they used for, and so on.

Additionally, few particular attempts were made to estimate the actual waking time, since health experts identify a regular actual waking time to be the significant provider of an individual's long-term well-being and general health.

2 Literature Study

Kim and Jang [1] investigated the factors impacting sailors' quality of life with the use of culture-work-health model. The investigation found that the aspects impacting self-efficacy possess larger impacts over sailors' QoL. Self-efficacy and organisational support possess beneficial impact on work-life quality, according to the statistics. The importance of a health improvement training programme for sailors deems to be critical. Seafarers' emotional and physical health shall be greatly improved through health promotion programmes.

Using linear regression analysis, Xiao et al. [2] investigated the support from society and wellness quality concerning the seafarers. The influence of support from society has greater significance on wellness and quality of life. In comparison to the general population, Chinese seafarers have a higher well-being and standard of living, and emotional benefits have a beneficial impact on life.

Smartphones are becoming much more ingrained in our daily lives, serving as the final one that is used before sleeping, and also checking of it will be done once wakened. Significant link was noticed in identifying the sleep duration sensors to better understand people's lifestyles and sleep patterns (Ciman & Wac) [3].

As sleep is such an important element of people's well-being, assessing sleep is a significant indicator of their health. Conventional sleep diagnostic methods require a lot of time and resources, and they can have self-reporting biases. Researchers have recently begun to use cell phones to passively monitor sleep in people's daily lives. However, this research is still in its early phases, as it has only looked at tiny, homogeneous groups in well-controlled environments. As a result, how well mobile device-based sleep monitoring generalises to broader populations in typical use scenarios remains an unanswered subject.

Using a data set that contains 698 male workers in Malaysia, Rusli et al. [4] assessed the relationships between working environment and health conditions affecting the quality of life of workers. Seafarers frequently labour in insecure and constrained living circumstances for several extended periods of time, according to Youn and Lee [5]. Because seafarers must exert greater number of health efforts to maintain regular physical parameters (e.g. mobility, posture, and stability) due to their unique living situations at sea, considerable lifestyle modifications and health hazards have been identified in the seafaring group.

According to Hjarnoe and Leppin [6], sailing is a riskier occupation when linked to ground businesses since incidence and mortality rates are greater. This tendency can be attributed to an increase in the frequency of incidents, as well as an increase in the incidence of lifestyle disorders such as heart disease and lung cancer. When compared to general communities, the number of smokers, as well as severely obese people, is greater among sailors. This risk factor implies that this part may provide an increasing threat in sea concerning protection and health issues, and there arises a necessity for teaching more regarding the advancement of health in their workplaces.

The COVID-19 pandemic created lots of challenges in health and stress as reported in many industries. The study helps in identifying the causes of stress, nervousness, and despair amid seafarers. The impact analysis of COVID-19 and health risk for seafarers was discussed by Birgit Pauksztat et al. [7]. The factors related to mental health problem and work-related issues were taken to investigate the impact of the pandemic.

3 Proposed Methodology

Many variables may be considered to be detrimental to the health and well-being of sailors. Some of these variables are common to all occupations, while others are specific to ship types/trades, shipboard jobs, and business policies. The research discovered that the characteristics that are thought to be fundamental to the nautical profession affect sleeping habits and physical activities. This study adds to our understanding of promoting health in a unique work environment that is critical to many deals in the emerging markets, i.e. seafaring. One of the significant results obtained was that adopting health improvement programmes in the seafarer's workplace is difficult due to the "changing nature" of the marine work, which affects execution, and especially a great participation range becomes problematic.

3.1 Structural Equation Model of Health-Related Quality of Life (HRQoL)

Structural equation modelling (SEM) corresponds to a set of arithmetical methods, which had long been used in the domains of behavioural science; however, it was just recently being used in the biomedical science (Gardiner et al.) [8]. The ability of SEM to study complicated interactions in a single, effective system can be used to better understand chronic disease progression and to construct a statistical model to monitor disease symptoms in patients. Faller et al. [9] investigated whether the level of chronic disease impacts largely concerning physiological and psychological health categories of HRQoL in individuals with chronic heart failure. The SEM explains causal links between latent variables, explains their indirect impacts, and assigns explained and unexplained variance for analysis to be carried out.

Evaluating the best fit of the suggested model is one of the significant concerns while employing SEM over HRQoL investigation. This was achieved by analysing the null hypothesis, which corresponds to this suggested model to fit the sample data. The basic idea is in considering the association of two non-nested opposing models M_1 and M_2 while relating to the hypothesis testing. M_1 and M_2 signify two propositions H_1 and H_2 correspondingly. Considering the perceived data set to be Z which shall or shall not contain partial data, the corresponding Bayesian information criterion (BIC) can be expressed mathematically as

$$\mathrm{BIC}_{12} = -2\left[\log L_0\left(Z;\widehat{\theta_1}, M_1\right) - \log L_0\left(Z;\widehat{\theta_2}, M_2\right)\right] - \left(d_1 - d_2\right)\log n \tag{1}$$

Here, $\widehat{\theta_1}$ and $\widehat{\theta_2}$ correspond to the maximum likelihood estimation of the unknown vectors M_1 and M_2, respectively. Also, d_1 represents the number of parameters in $\widehat{\theta_1}$, and d_2 specifies the total parameters in $\widehat{\theta_2}$ with n representing the size of the sample. $L_0\left(Z;\widehat{\theta_1}, M_1\right)$ represents the likelihood function of the attained data set Z that was assessed with respect to $\widehat{\theta_1}$ and M_1. Moreover, $L_0\left(Z;\widehat{\theta_2}, M_2\right)$ signifies the likelihood function assessed under $\widehat{\theta_2}$ and M_2.

Accordingly,

1. When $\mathrm{BIC}_{12} < 0$, it offers confirmation in supporting M_1.
2. When $\mathrm{BIC}_{12} < 2$, it offers stronger confirmation in supporting M_2.
3. When $0 < \mathrm{BIC}_{12} < 2$, it does not offer a precise confirmation.

In this chapter, the hypothesised correlations among all latent constructs were tested using SEM. For each path, the unstandardised and standardised regression coefficients were calculated. The amount of variation of the dependent variable per single unit increase in the predictor factor is represented by the unstandardised regression model. The standardised regression parameters illustrate how much more of a dependant variable can be assigned to each increase in the predictor factor. The path analysis with independent data is shown in Fig. 1. Accordingly, the variable X_1 corresponds to exercise, X_2 corresponds to sleep, Y_1 corresponds to fitness, Y_2 represents illness, and Y_3 signifies the stress.

This framework will aid in the design and implementation of a complete illness prevention training to increase the HRQoL with respect to the seafarers, as well as understanding the interrelationships of variables connected to different health domains in HRQoL.

4 Results and Discussions

Data collections were based on Xiao et al. [2], and automatic physical activity recording taken was collected from the smartphones. The different variables such as social support, disease-related factors, and biobehavioural factors affect the QoL of seafarers. The correlation between the different variables was analysed in Fig. 2.

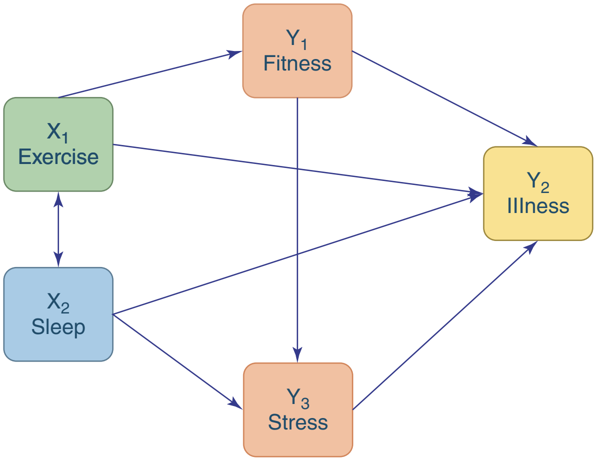

Fig. 1 Path analysis with observed variables

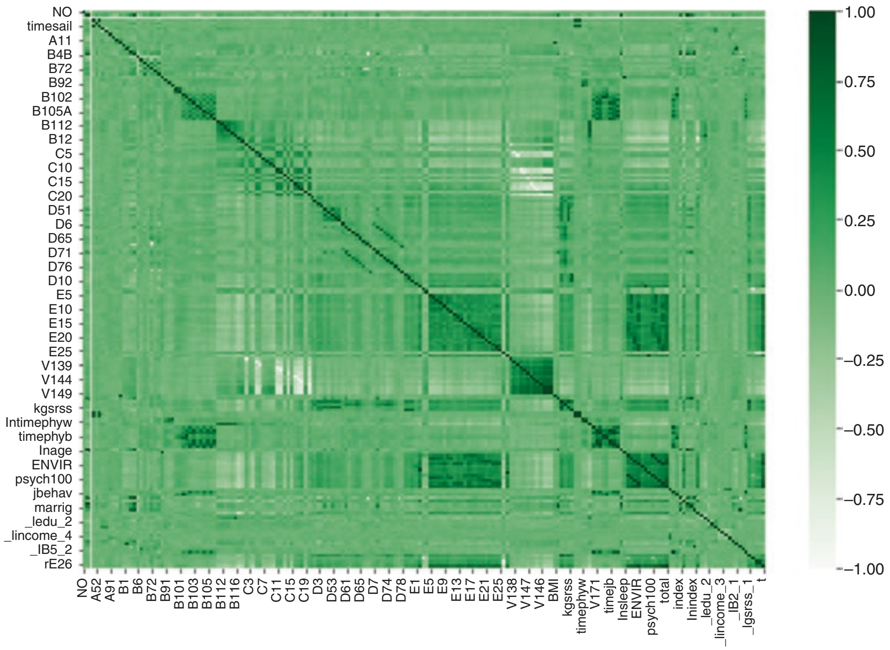

Fig. 2 Correlation matrix

The values of correlation matrix in the descending order are given in Table 1, and it is concluded that physical exercise sailing time variable is highly correlated. The class distribution without chronic disease was 838, and suffering from chronic disease was 79.

Table 1 Correlated score

S. No.	Variable 1	Variable 2	Score
1.	PHYS	phys100	1.000000
2.	Lntimesail	V164	1.000000
3.	E2	V185	1.000000
4.	V147	V149	0.999669
5.	V148	V149	0.999669
6.	C20	V149	−0.737572
7.	rE4	E26	−0.849704
8.	B12	zpjs	−0.926844
9.	V137	C2	−1.000000

Table 2 Data summary

		N	Percent
Sample	Training	647	70.6%
	Holdout	270	29.4%
Valid		917	100.0%
Excluded		0	
Total		917	

The different algorithms that were taken for building the proposed model are as follows:

1. Logistic regression (LR)
2. Linear discriminant analysis (LDA)
3. K-nearest neighbours (KNN)
4. Classification and regression trees (CART)
5. Gaussian naive Bayes (NB)
6. Support vector machine (SVM)

Table 2 enumerates the data summary for training the model.

Tables 3 and 4 show the Bayesian estimate of coefficient and error variance for the predictor model chronic disease with dependent variable of physical activity.

Figures 3 and 4 show the suffering and non-suffering of disease based on Bayesian estimation. Figure 5 shows the model building using nearest neighbourhood algorithm with *k*, considering the value of 3.

The results attained when evaluating the model are shown in Fig. 6. Correspondingly, the distribution and mean accuracy of each model are compared. Because each method was tested ten times, accuracy measures for each algorithm (via tenfold cross validation) are given in Fig. 2.

Table 5 shows the results of different learning models that were used for this present analysis. The results show that the learning model SVM was perhaps a

Table 3 Bayesian estimates

Bayesian estimates of coefficients[a–d]					
	Posterior			95% Credible interval	
Parameter	Mode	Mean	Variance	Lower bound	Upper bound
B2 = suffering	12.681	12.681	0.034	12.320	13.042
B2 = without	13.026	13.026	0.003	12.918	13.134

[a]Dependent variable: PHYS
[b]Model: B2
[c]Regression weight variable: lnsleep
[d]Assume standard reference priors

Table 4 Bayesian estimates of error variance

Bayesian estimates of error variance[a]					
	Posterior			95% credible interval	
Parameter	Mode	Mean	Variance	Lower bound	Upper bound
Error variance	5.332	5.356	0.063	4.886	5.870

[a]Assume standard reference priors

better model in comparison with other models. The value estimated has the best accuracy score at about 0.908 or 91%.

5 Evaluation of the Prediction Model

The prediction model will provide a final check on the best model's performance. A validation data is useful to avoid making a mistake during training, such as generalisation of the training data set or a data leak. Both of these problems will lead to an unduly optimistic outcome. Figure 7 gives the model accuracy with the chronic disease classification or not. The method will assess the predictions by evaluating them over the validating set's predicted outcomes and then estimate the accuracy of classification, a statistical classification, and a classifying report. Table 6 reports the model summary, and Table 7 elaborates the classification summary.

6 Conclusion and Future Recommendations

The findings suggest the assessment of different factors that were affecting a seafarer's health condition. It also includes component health variables that possess the ability to influence sailors' health behaviour and characteristics. Researches encompassing enhanced reliable designs, examining the influence of dissimilar categories of treatment independently, will be required in the future. Because of the study's methodological issues, the findings of behavioural changes and health parameters must be regarded with care. Suggestions for increasing the effectiveness and wellbeing of seafarers can be made depending on the risk factors.

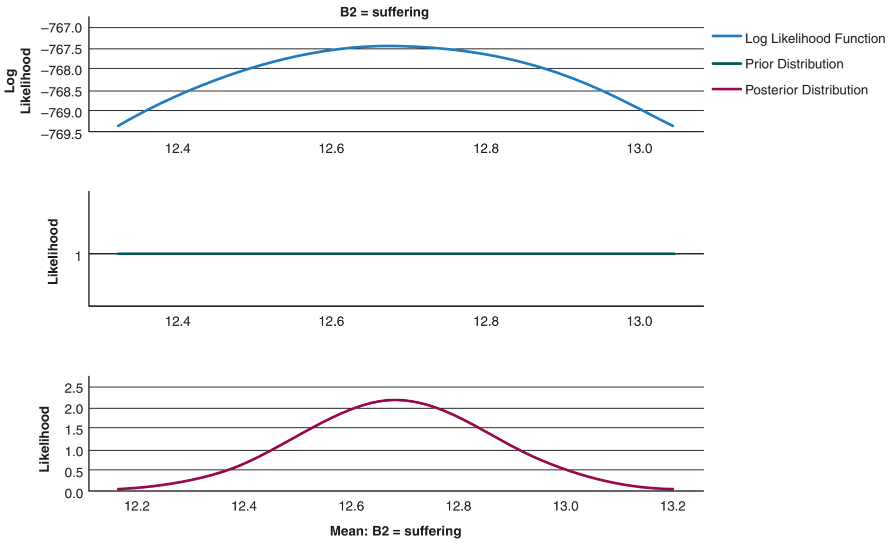

Fig. 3 Bayesian estimate with suffering from chronic disease

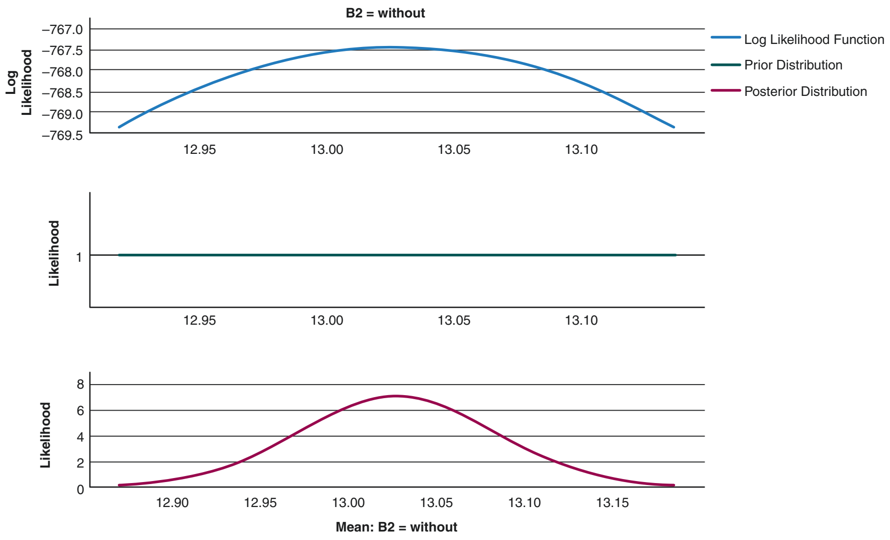

Fig. 4 Bayesian estimate without suffering from chronic disease

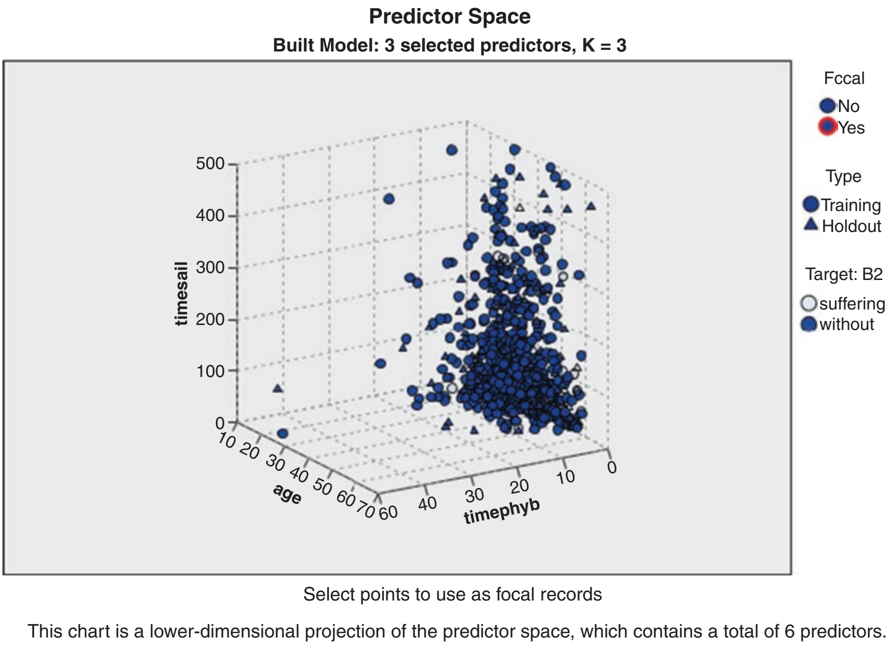

Fig. 5 KNN model prediction

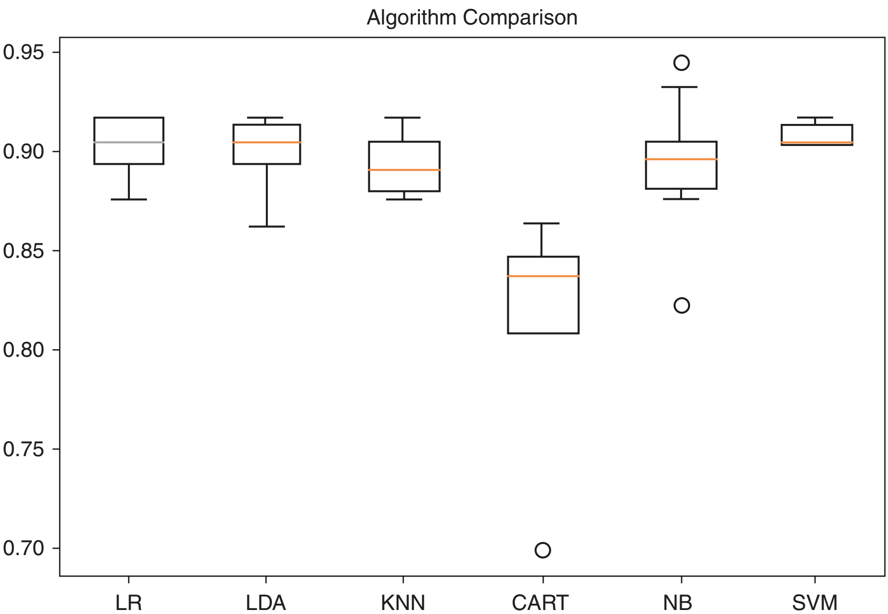

Fig. 6 Learning algorithm comparison

Table 5 Learning models

Model evaluation		
S. No.	Models	Accuracy score
1	LR	0.904498 (0.013711)
2	LDA	0.901759 (0.016053)
3	KNN	0.894946 (0.015084)
4	CART	0.821177 (0.045537)
5	NB	0.894909 (0.031921)
6	SVM	0.908608 (0.006047)

	precision	recall	f1 - score	support
suffering from chornic disease	0.00	0.00	0.00	12
without chornic disease	0.93	1.00	0.97	172
accuracy			0.93	184
macro avg	0.47	0.50	0.48	184
weighted avg	0.87	0.93	0.90	184

Fig. 7 Model accuracy

Table 6 Model summary

Model summary		
Training	Cross entropy error	178.241
	Incorrect prediction percentage	8.8%
	Stopping rule used	1 consecutive step(s) with no decrease in error[a]
	Training time	0:00:00.30
Testing	Cross entropy error	60.686
	Percent incorrect predictions	7.9%
Dependent variable: B2		

[a]Error computations are based on the testing sample

Table 7 Classification summary

Classification			
		Predicted	
Sample	Observed	Data	Percent correct
Training	Suffering	55	0.0%
	Without	573	100.0%
	Overall percent	100.0%	91.2%
Testing	Suffering	19	0.0%
	Without	223	100.0%
	Overall percent	100.0%	92.1%
Dependent variable: B2			

References

1. Kim J, Jang S. Seafarers' quality of life: organizational culture, self-efficacy, and perceived fatigue. Int J Environ Res Public Health. 2018;15(10):2150. https://doi.org/10.3390/ijerph15102150.
2. Xiao J, Huang B, Shen H, Liu X, Zhang J, Zhong Y, Gao Y. Association between social support and health-related quality of life among Chinese seafarers: a cross-sectional study. PLoS One. 2017;12(11):e0187275. https://doi.org/10.1371/journal.pone.0187275.
3. Ciman M, Wac K. Smartphones as sleep duration sensors: validation of the iSenseSleep algorithm. JMIR Mhealth Uhealth. 2019;7(5):e11930. https://doi.org/10.2196/11930.
4. Rusli BN, Edimansyah BA, Naing L. Working conditions, self-perceived stress, anxiety, depression and quality of life: a structural equation modelling approach. BMC Public Health. 2008;8(1) https://doi.org/10.1186/1471-2458-8-48.
5. Youn I-H, Lee J-M. Seafarers' physical activity and sleep patterns: results from Asia-Pacific Sea routes. Int J Environ Res Public Health. 2020;17(19):7266. https://doi.org/10.3390/ijerph17197266.
6. Hjarnoe L, Leppin A. Health promotion in the Danish maritime setting: challenges and possibilities for changing lifestyle behavior and health among seafarers. BMC Public Health. 2013;13(1) https://doi.org/10.1186/1471-2458-13-1165.
7. Sagaro GG, Battineni G, Chintalapudi N, Di Canio M, Amenta F. Telemedical assistance at sea in the time of COVID-19 pandemic. Int Marit Health. 2020;71(4):229–36. https://doi.org/10.5603/IMH.2020.0041.
8. Gardiner L, Akintola A, Chen G, Catania JM, Vaidya V, Burghardt RC, Parrish AR. Structural equation modeling highlights the potential of Kim-1 as a biomarker for chronic kidney disease. Am J Nephrol. 2012;35(2):152–63. https://doi.org/10.1159/000335579.
9. Faller H, Störk S, Schuler M, Schowalter M, Steinbüchel T, Ertl G, Angermann CE. Depression and disease severity as predictors of health-related quality of life in patients with chronic heart failure—a structural equation modeling approach. J Cardiac Failure. 2009;15(4):286–292.e2. https://doi.org/10.1016/j.cardfail.2008.10.02.

Design Telemedical Systems in Control of Pandemics Like COVID-19

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1 Introduction

In December 2019, a 2019 coronavirus (COVID-19) pandemic was observed in Wuhan, China, triggering a major public health catastrophe that quickly grew into a worldwide pandemic [1, 2]. Shandong is a highly populated and massive, economically developed province with a lot of population migration. As a result, in Shandong province, preventing an epidemic was critical. Pneumonia cases were reported in Wuhan, although the cause was yet to be determined [3]. The World Health Organization formally recognized highly contagious coronavirus disease 2019 [4].

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_9

There were 180,000 confirmed cases and more than 7000 deaths caused by the virus worldwide through March 2020. Even if the virus was causing symptoms, the patients were still infected even after the symptoms subsided after 2 weeks [5]. After China, Italy was the first country to be attacked by the virus, which wreaked havoc in the country [6].

Fever, dry cough, breathing difficulty, anosmia, and respiratory failure are some of the symptoms of coronavirus. The disease's therapy is uncertain, although an antiviral approach is being employed to promote immunomodulation in the virus's management [7]. The first case was heard on January 30, 2020, and in March, the government enacted emergency restrictive measures to demobilize social contact [7]. The reduced incidence and mortality rates might imply that the Shandong province's preventative initiatives were successful. "Provincial government and Shandong Health Committee acted rapidly in the face of the outbreak, forming an Anti-epidemic Expert Group to develop diagnostic, treatment, quarantine, and reporting methods" [4]. Telemedicine also offers community residents and medical doctors preventative and treatment data, as well as training of remote consultation from doctors for sick workers before returning to work. Due to the public uncontained spread, healthcare professionals are already observing and are planning for both ill and worried-well patients, which might pressurize hospital care units [3]. Public health provider response processes and practices have been updated to include the use of telemedicine technology to address some of the particular challenges that infectious disease outbreaks such as COVID-19 and others offer. The Anti-pandemic Expert Group discovered that the telemedicine platform helped suppress the "COVID-19 epidemic in Shandong province" as shown in Fig. 1. The

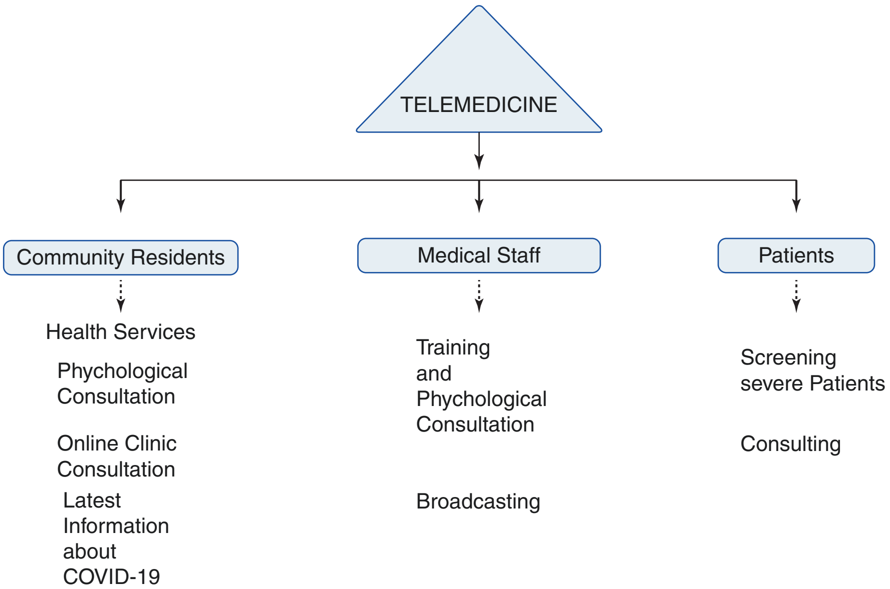

Fig. 1 Functions of telemedicine in the world

results of the trial are presented here, as well as the advantages of employing telemedicine to prevent COVID-19 [5].

Coronaviruses (CoVs) are multispecies, single-stranded RNA virus, which may infect humans, mammals, birds, as well as livestock, providing a public-health, veterinary, and economic danger. Coronavirus infections mostly cause respiratory and gastrointestinal disorders in people and animals [8]. Coronaviruses, like "HCoV-229E and HCoV-OC43," are present in the community, and these together with the more recently discovered "HCoV-NL63 and HCoV-HKU1" can be responsible for typically mild respiratory infections. "SARS-CoV, MERS-CoV, and SARS-CoV-2" [9] are very dangerous viruses that have only recently emerged in people. "SARS-CoV, MERS-CoV, and SARS-CoV-2" damage bronchial epithelial cells, leading to life-threatening disease in humans. The coronavirus spike (S) protein binds to cellular entrance receptors, "which have been found for various coronaviruses and include human aminopeptidase N (APN; HCoV-229E), angiotensin-converting enzyme 2 (ACE2; HCoV-NL63, SARS-CoV, and SARS-CoV-2), and dipeptidyl peptidase 4 (DPP4; MERS-CoV)"; results are pathogenicity by a virus [10].

RNA genomes of coronavirus are very immense, "including 5′ and 3′ untranslated regions that include cis-acting secondary RNA structures required for RNA production. At the 5′ end, the genomic RNA features two large open reading frames (ORFs, ORF1a and ORF1b) that occupy two-thirds of the capped and polyadenylated genome. ORF1a and ORF1b code for 15–16 nonstructural proteins (nsp)" and help in transcription complex, which includes RNA processing and modification, among other things. Now COVID-19 has all claimed lives throughout the world. During the COVID-19 pandemic, doctors relied on modern technology for prevention, early symptom triage, self-isolation, quarantine, and, eventually, resumption of social engagement as compared to the past [11].

2 Emphasis on COVID-19 Evidence

Following the enormous expansion of the "SARS-CoV-2 virus," the WHO has professed a pandemic by coronavirus 2019 sickness (COVID-19) on March 11, 2020 [1, 2, 12, 13]. The COVID-19 outbreak executed a worldwide curfew, wreaking havoc in everyday life and most healthcare systems, which have had to deal with both infected and healthy individuals. It is effects on the farmer's life and the agrarian elements inhibit the COVID-19 in humans [12, 13]. During this important era, the usage of telemedicine has expanded, owing to both favorable evidence from earlier pandemics and technology developments, particularly in developed countries [14]. A flood of new digital technologies have been added to traditional phone interviews. International guidelines should be updated to reflect the emergence of e-health technology, with clear differences made between advice for everyday use and emergency recommendations. Due to the lack of vaccinations or efficient treatments, as well as the use of social boundaries and lockdown as primary preventative measures, telemedicine is the safer means for patients and physicians to connect.

The huge scale of this epidemic has also aided in closing the gap in terms of poor adherence to the usage of digital technologies [15, 16]. Through the COVID-19 contagion, social distance sparked three possible e-health uses, according to existing findings and models [17]. On the other side, there were patients who were at higher risk of contagion, chronic, immunosuppressive, and autoimmune, or those who can lower their risk of infection by electronically interacting with their practitioner/specialist. As a result, only the most end-of-life conditions warranted a referral to a therapeutic center. Furthermore, enhanced telephone triage methods were created, allowing for better screening of suspicious "SARS-CoV-2" patients who were referred to emergency care because they were concerned about "SARS-CoV-2" infection.

Patients, whether "asymptomatic or minimally symptomatic," do not get priority for hospitalization. Nonetheless, COVID-19 health centers, doctors, and local health officials keep a careful eye on them through specific channels. Furthermore, e-health communication has allowed minimally infected professionals to continue their usual practice by allowing them to do so remotely. The practicality of this novel medical method is still a point of contention [18]. On behalf of better global telemedicine acceptance in the future, "the cost-benefit ratio" of these instruments would be enhanced, with a larger focus on chronic illness treatment, beyond the current emergency context.

3 Telemedicine in COVID-19

The new coronavirus (COVID-19) pandemic has disturbed the total health systems of most countries, with over 92 million infected patients and around 2 million deaths. Furthermore, many systems are unprepared due to lack of infrastructure for ensuring comprehensive healthcare. Because of the pandemic's heavy burden on health systems, trustworthy medical treatment was required. This could be gathered using extensive digital tools, which are particularly useful in treating and making decisions. The epidemic of COVID-19 has compelled all healthcare authorities to work together to encourage the use of digital technology [19]. Despite significant legal and ethical concerns, the majority of medical specialists believe that telemedicine may be a valuable healthcare source during epidemics. Telemedicine technology is used to monitor moderate or asymptomatic illnesses that might help to lower the large number of patients that come in. Telemedicine has recently gained a lot of traction as a result of the growing deployment and development of digital technology. It should be considered for inclusion in national and international recommendations when they are updated [20]. Due to enforced social isolation, telemedicine has shown to be the safest engagement mode between patients and doctors during pandemic conditions. Some scenarios for telemedicine use have been proposed based on evidence. Recent studies and technological breakthroughs in diabetic retinopathy (DR) screening via telemedicine have proved efficacy and usability. Furthermore, teleophthalmology has been shown to be cost effective. In the COVID-19 pandemic, lack of data severely restricts the potential of tracking the disease's true treatment, which is only achievable based on previous information under normal circumstances. The epidemic highlighted the significance of remote monitoring even more. However, general practitioners must have easy access to the gadget and digital application used to boost individual screening and track the evolution of retinal disease. In cases of isolation, lockdown, or movement restriction, a digitized care approach should be used, especially in places where healthcare services are not readily available or for patients with limited mobility [21].

Telemedicine is often characterized as a collection of technologies and equipment that may be used to get information about a patient's health state from a distance in order to determine whether or not an intervention is required. For this reason, it might serve as a screening and diagnostic tool, as evidenced by current research, to increase the acceptance and progress of digital technology like smartphones and digital networks. Suitable technologies enable doctors to reach and monitor persons who have difficulty attending specialist consultations, particularly patients with chronic conditions who require ongoing monitoring [22]. Furthermore, if a face-to-face visit is not possible, therapy might be evaluated on a regular basis by transmitting data collected on the digital tool to an expert. Cardiovascular disorders and diabetes, with all of their chronic consequences, can be handled by telemedicine. Retinopathy, the most prevalent diabetic complication, frequently demands an eye-care professional's fundus oculus examination; however, individuals in countryside regions and those who live very far from specialist referral facilities cannot comply with these screenings [23]. Telemedicine platforms are well suited to dealing with a variety of difficulties that healthcare systems encounter in the aftermath of global infectious disease outbreaks. Putting in place telemedicine solutions that cater to the demands of low-acuity patients who are concerned about disease exposure helps to reduce and minimize overcrowding in emergency rooms of hospitals, urgent care clinics, and general care centers and offers advice according to patients' desire. Telemedicine can also be used to manage chronically ill patients' ongoing healthcare requirements, lowering the frequency of in-person clinic visits. Telemedicine applications decrease human exposure to a variety of infectious illnesses (among healthcare personnel and patients) and ensure that medicinal resources are allocated for patients who require them [24].

4 Importance of Telemedicine in Pandemic

In an emergency, telemedicine can treat patients without requiring them to visit a hospital. Telemedicine systems use videoconferencing to provide a direct connection with patients through smartphones. The whole system must be managed by software to ensure stable connections, information flow, and data security. All governments must make numerous efforts to guarantee that diseases like the COVID-19 be able to be efficiently handled. In this context, telemedicine, if fully integrated into a national health system, might prove to be a useful technique in and of itself for maintaining treatment continuity and lowering infection risk. It would also result in less overcrowding in healthcare institutions and just a modest loss of physicians and nurses [25]. It has also been difficult to find places to deploy telemedicine during emergency situations. In 2015, in the epidemic area, few possible evidence-based scenarios were proposed in which e-health can be used for all patients. When there is a suspicion of infection-related symptoms, this "home-based" treatment is extremely successful, allowing individuals to be referred to specialized referral centers. Positive asymptomatic individuals can also be followed up on a regular basis via phone and Web counselling. Beyond that, digital delocalization techniques have contributed to the enhancement of these services in recent years. Telemedicine may be used to care for patients who are in the domiciliary or nosocomial isolation, and for this reason telemedicine provides enough safety for both physicians and caregivers by restricting contact with diseased patients to strictly nondeferrable emergencies [25]. Finally, telemedicine can currently help outpatients' management of periodic visits, which have been discontinued due to local governments' obligatory lockdown.

Telemedicine applications are another telemedicine strategy for identifying and mapping infected people as providing "self-assessment capabilities." The "Coronavirus SUS" app is an example from the Brazilian Government. If this app-assisted analysis indicates a suspected disease, sick people are sent to the nearest emergency department for screening, increasing the efficiency of traditional therapy. Brazilian program also gives evidence-based information on the progression of a pandemic, which helps to reduce the dissemination of false information. A telemedicine tool that combines "prevention, triage, and information" in one app has reduced stresses on Brazil's public healthcare system and, as a consequence, prevented the system's collapse; a similar program is being examined in the United States. Likewise, in the United Kingdom, "King's College London, in collaboration with Guy's and St Thomas' hospitals, has created an app that allows residents to self-report their health status in one minute every day." Citizens are being invited to fill out a survey. They can then report on how they feel on a daily basis, including standard COVID-19 signs like coughing and fever, as well as nontraditional symptoms including weariness, confusion, diarrhea, no taste, and chest discomfort. If the app learns that sick individuals report in clusters across the country, new ailments will be added to the list. Data from the app would be used to estimate how the virus is spreading in different locations, determine "hotspot" locations, and understand how symptoms are connected to basic health issues, which can help identify who is most at risk [26].

Cardiovascular disorders, in particular, demand constant monitoring, which raises infection risk for both patients and clinicians. Remote monitoring has grown beyond emergencies in this setting, with significant advancements in e-health technology observed during epidemics and pandemics. Electrophysiologists, for example, most clinical appointments are now being monitored remotely via telephone for visits for evaluation and post-procedural follow-up should be done remotely [27]. Overcoming the "SARS-CoV-2" coronavirus pandemic has provided a significant enhancement to the management of various chronic illnesses [28]. With the help of telemedicine, doctors may understand the country's current healthcare situation without sacrificing quality and allowing for more effective prevention without "face-to-face interaction." The self-isolation phase, on the other hand, has the ability to isolate and overwhelm society's most vulnerable members. Individuals who have been socially isolated have stated concerns: anxiety, fear, and sadness, as well as post-traumatic stress disorder symptoms in certain circumstances. These negative psychological impacts, as well as the additional pressure on healthcare systems that they may cause, can be minimized by using digital platforms to promote social connections, such as video chats. As a result, such platforms open up further telemedicine possibilities, such as video-based psychotherapy sessions. In the COVID-19 pandemic, "the Australian Government is providing mental health professional support via telemedicine," which ensures the supply of basic services to people in need while considerably decreasing and in some cases completely eliminating face-to-face therapy in hospitals [29].

In addition to fulfilling the needs of individuals with low acuity, telemedicine may provide specialty treatment to patients in locations where such care is unavailable, both domestically and globally. According to studies, COVID-19 death rates in Chinese communities with little contact with doctors have overtaken mortality rates in locations with more access. Telemedicine technologies, especially in low-resource locations, can greatly improve care synchronization for COVID-19 patients. Given that telehealth is designed to address a variety of issues arising from the COVID-19 epidemic, the CDC, as well as other state public health agencies and industry groups, has recommended that telemedical systems be included in healthcare provider coronavirus facilities [30].

Telemedicine has long been advocated as a way to increase healthcare access while cutting costs. Telemedicine has now become a vital tool to give clinical treatment as a result of the coronavirus disease 2019. Healthcare systems across the country did not cancel any urgent clinic appointments or procedures, resulting in a sudden and pressing need to switch to alternate healthcare delivery models. Patients who are asymptomatic will benefit from telemedicine, which will allow them to keep their quarantine period while being monitored via smartphones, laptops, and other devices. If the patient's symptoms become serious, the patient will be transferred to medical treatment quickly. Patients' data is collected through Social Internet of Things (SIoT) and artificial intelligence (AI) approaches in telemedicine. Different digital instruments are used to monitor a patient's vitals, such as a digital sphygmomanometer (to check blood pressure), an oximeter (to check saturation) or a pulse meter, and the patient may use all of these devices independently because they are so simple to use.

5 Effect of Telemedicine on Health

Telemedicine is a technique for decreasing negative health effects and maximizing the usage of health resources. Rapid spread of diseases offers a major threat to the entire globe. The use of social distance measures, like teleworking and training and education, is an effective strategy to minimize the spread of the epidemic, specifically in the realm of public health, prevention, and clinical practices. Telemedicine is a method for lessening the negative health impacts and increasing the use of health benefits. The important strategy is to reduce and mitigate the spread of the epidemic disease and to use social distance measures; that is why telemedicine, like other sectors like teleworking and training and education, supports the health disciplinaries, particularly in the areas of public health and clinical practices. Telemedicine utilizes the Internet and associated technologies to provide easy, low-cost, and speedy access to health-related information and communication. Telemedicine began with the use of telephone consultations and has evolved with each technological advancement and now includes computer technologies to give information and services to clients in multiple locations, which is especially important in pandemics because it can help maintain the moderation phase. It may be utilized for the following purposes in the present situation [31]:

- Reducing the amount of time taken to get a diagnosis, start therapy, quarantine, or stabilize a patient.
- Allowing for close monitoring: residents may be observed from home, minimizing overcrowding in medical facilities, preventing individuals from moving (saving travel time), and lowering the danger of infection within the hospital.
- Organizing medical resources in far-flung areas.
- Preventing the spread of infection, particularly among professionals, who are critical assets to protect: avoiding physical contact, limiting the danger of respiratory secretion exposure.
- Educating citizens • Green effect of telemedicine: cost savings on "antiseptic" materials: disposable gloves and robes, disinfection of guest rooms, etc.
- Educating healthcare professionals who are new to the treatment of coronavirus infections.
- Real-time data monitoring: European Centre for Disease Prevention and Control (ECDC), for example, offers constantly updated information on the pandemic's progress [15, 16].

The disease is more likely to develop in its most severe form in older persons, as well as those with medical conditions such as hypertension, heart disease, or diabetes [32]. "Travel restrictions have been implemented and enforced over the world, and most cities have been quarantined" to limit transmission. Those who have not been infected with COVID-19, especially those who are at a higher risk of developing the virus, should receive daily therapy without the risk of exposure to other hospital patients. Nonessential workers are also strongly prevented to visit the COVID-19 patient's ward due to strict infection control [33]. Natural catastrophes and epidemics create lots of new problems for healthcare providers. As a result, one-of-a-kind and innovative solutions are required to meet the urgent demands of COVID-19 patients and others in need of medical attention. Technological advancements have opened up new possibilities in this regard. Telemedicine has the potential to improve epidemiological research, disease control, and clinical case management during epidemics [34]. Telehealth is a twenty-first-century method that protects patients, physicians, and others by focusing on the patient. Telehealth is defined as the provision of healthcare services over long distances by healthcare professionals who use information and communication technology (ICT) to exchange accurate and trustworthy data. Real-time or store-and-forward techniques are used to offer telehealth services. Patients and healthcare practitioners/doctors may now communicate thanks to the fast innovation and reduction of portable technologies such as smartphones and webcams [35].

To decrease the danger of exposure to others and workers, healthcare programs are also delivered to those who are sick or in quarantine through videoconferencing. Quarantined doctors can use these services to care for their patients while they are confined. Using a tele-physician to cover a large number of locations can also help with some of the workforce's problems [36]. Telehealth has various advantages, especially in routine care and treatments that do not require direct patient-provider interaction, such as mental therapy [37]. This technology is very useful and cost effective. Patients want to use telemedicine, yet obstacles remain. Accreditation, payment systems, and insurance are all major barriers to these programs' implementation. Moreover, doctors are worried about technological quality [38].

6 Management of Diabetic Retinopathy During COVID-19

Many studies have been done across the world to assess the usefulness of telemedicine in various clinical contexts, with a particular focus on ophthalmology. Several studies, for example, have looked into the utility of telemedicine in the diagnosis of glaucoma, with largely similar results. The largest research, which included over 24,000 patients and was done in the United Kingdom, found an 87% agreement between optometrist and ophthalmologist assessments (Cohen's). Tele-glaucoma showed a "sensitivity of 41.3% and a specificity of 89.6%" in Kenya when compared to a standard fundus oculus [39]. Smartphone ophthalmoscopy revealed a substantial agreement with lamp testing. Diabetes, coupled with its multiple complications, puts patients at significant risk of having a bad prognosis, as previously indicated. Telemedicine has shown to be a valuable strategy for managing glycemic levels on a regular basis over the years. Patients' restricted access to specialty visits is caused by a variety of factors. In the case of pandemics, social isolation has an even bigger role [40].

In particular, the introduction of "digital glycemia" monitoring devices like glycemic holders and micropump in both type 1 and type 2 diabetes patients has enabled for simpler "glycemia self-monitoring." Data is immediately collected and delivered to a specialist or general practitioner, who may then consider future therapy changes as well as more in-depth diagnostic and therapeutic investigation. Different studies have shown that users of glycemic monitoring devices had a higher rate of HbA1c goal accomplishment than controls, resulting in a lower risk of complications [41]. The emphasis of screening and monitoring activities has been on diabetic retinopathy. Fundus cameras and other portable devices can be used by doctors and technicians to take retinal photos that can be sent to specialized referral centers for reading. The usefulness and usage of telemedicine in this condition have been proven by data from throughout the world. A comparison of telemedicine and a standard fundus oculus test indicated that the use of non-mydriatic cameras has a good sensitivity and specificity [41]. A recent screening trial in India using fundus on phone (Remidio FOP), a piece of smartphone-based imaging equipment, resulted in the identification of DR in over 3500 individuals. Furthermore, at 6–8-month follow-up, telemedicine was shown to dramatically increase the number of people who have checked for DR. The second research of roughly 100 diabetic patients found that fundus oculus photographs had a sensitivity of 97.1% and a specificity of 95% in diagnosing moderate non-proliferative DR (NPDR) compared to the usual test [42]. In 15.5% of the study population, fundus oculus photographs taken by qualified doctors were diagnostic for diabetic retinopathy [43].

Many smartphone applications for acquiring non-mydriatic photos of any part of the eye have been created in recent years. Recent studies have anticipated a 50–60% rise of screened patients, which is consistent with our estimations, due to a significant improvement in picture quality. Similarly, two screening initiatives in Africa and Canada attempted to recover the quality of life of people with various retinal illnesses, as well as reduce the incidence of complications [42].

Furthermore, teleophthalmology revealed a favorable cost-to-effectiveness ratio, both in terms of human and financial resources and travel expenses for private and public health systems. It was newly established in a "meta-analysis" of cost-effectiveness of telemedicine-based ophthalmologic screening programs in many nations that, despite an initial rise in equipment and training expenses, there is an economic reduction over time. Similarly, employing retinal cameras instead of conventional tests resulted in considerable budgetary savings in our multicenter experience as well as time reductions for both patients and doctors [44].

7 Removal of Telemedicine Barriers

In COVID-19 crisis, politicians in different countries learned how critical it was to eliminate barriers to telemedicine care. Several CMS regulations and standards regulating telemedicine services were temporarily suspended during the COVID-19 emergency situation, according to the "Coronavirus Preparedness and Response Supplemental Appropriations Act," which was signed on March 6, 2020. The law notably waives the rural region requirement as well as the originating location restrictions, enabling patients to be treated anywhere, including reimbursing telemedicine services. The CMS announced on April 30, 2020, that compensation for telephone visits would be temporarily enhanced to match that for in-person and video consultations. Most states have provisionally suspended interstate licensing regulations during the current public health emergency, while others have made it easier to get medical licenses quickly [45]. When these barriers to telemedicine were removed, health systems quickly adopted telemedicine and expanded existing programs to meet the unanticipated demand for remote, synchronous patient care. The results showed that telemedicine visits for urgent and nonurgent ambulatory care have increased significantly, and patient satisfaction with telemedicine treatment has remained consistently high, both associated and unrelated to COVID-19. Telemedicine might be categorized according to the sort of communication used [45].

According to the US CDC, a new coronavirus infection (COVID-19) has spread in China and now to every continent. It impends to overrun the healthcare system in the next few months, with each infected individual predicted to infect two or three other persons and the clinical spectrum of sickness yet unknown. COVID-19 is transforming the way we provide healthcare. We are living in a time when learning and growth are at an all-time high. More medical practitioners are providing remote therapy than ever before, and more patients are seeking care in this manner as well [46]. Despite the fact that many patients will return to the clinic once the epidemic has passed, telemedicine appointments are likely to remain popular. While telemedicine visits have frequently shown to be beneficial and convenient for both patients and physicians, many practices may have obstacles in launching and maintaining these services, and COVID-19 and the need to apply distance measures may resurface in the future. Despite the fact that compensation appears to be aligned with patient needs, there are still barriers to access. State-level initiatives can help in bridging gaps in telemedicine availability. Some states have tried a number of ways to enhance Internet access, including grant funding, income tax credits, and infrastructural collaboration. Unfortunately, these protocols are not in place in all jurisdictions, and these efforts will not solve all telemedicine issues particularly for older patients with cognitive or sensory impairments [47]. The absence of widespread access to communications infrastructure for the general public causes inequitable access to health treatments via telemedicine [23]. Technical failure may be documented as much as possible by the supplier. Infrastructure and access hurdles, operational problems, regulatory barriers, communication barriers, and legislative barriers are among the issues and barriers that must be handled in a methodical manner. Access and communication during a healthcare engagement are critical moderators of outcomes for persons with disabilities. Significant, long-term improvements in technological, regulatory, and legislative infrastructure, as well as customized solutions to a specific patient and health system demands, are required to improve healthcare access and outcomes for persons with disabilities in the future. “Telehealth may become a critical requirement for the general public, healthcare professionals, and COVID-19 patients, especially while they are under quarantine, allowing patients to seek real-time counseling on their health issues through conversation with a healthcare practitioner.” As a result, the focus of this study was to see how telehealth services fared in terms of sickness prevention, diagnosis, treatment, and control during the COVID-19 pandemic [48].

8 Conclusion

Doctors’ first line of defense during the coronavirus pandemic was telemedicine, which preserved social distance and provided treatment for mild patients through phone conferences, allowing them to spend personal attention and limited supplies on the most serious cases. In most cases, latent structures would not be investigated, but they are in this case. It gives us a comprehensive view of how our healthcare systems are doing right now, as well as their strengths and potential. Simple and widely available technology, such as phone calls, has already facilitated the continuity of care throughout past pandemics; new channels of communication between patients and physicians are projected to improve communication fluency, ease, and efficiency. In clinical practice, patients inform about test results, reduce the time it takes to see a specialist doctor, and with a little more modern gadget assistance monitor patients in their homes on a daily basis. Diabetes, heart issues, skin flushes, switch from hospital to primary care, and other illnesses can all benefit from telemedicine now that we know it is good and makes patient-doctor contact easier and more accessible.

References

1. Khan AU, Proma AA, Akter M, Rahaman MM, Das S. A review on coronavirus disease (COVID-19) epidemic threat for global health in 2020. Am J Microbiol Res. 2020a;8(2):57–62. https://doi.org/10.12691/ajmr-8-2-3.
2. Khan AU, Khan FU, Khanom S, Khan AU. Novel coronavirus disease (COVID-19): pandemic situation in Bangladesh. Nujs J Regul Stud. 2020b;5(2):1–10.
3. Lewnard JA, Lo NC. Scientific and ethical basis for social-distancing interventions against COVID-19. Lancet Infect Dis. 2020;20(6):631.
4. Zu, Z. Y., Jiang, M. D., Xu, P. P., Chen, W., Ni, Q. Q., Lu, G. M., & Zhang, L. J. (2020). Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology, 296(2):200490.
5. Dashraath P, Jeslyn WJL, Karen LMX, Min LL, Sarah L, Biswas A, Lin SL. Coronavirus disease 2019 (COVID-19) pandemic and pregnancy. Am J Obstet Gynecol. 2020;
6. Spinelli A, Pellino G. COVID-19 pandemic: perspectives on an unfolding crisis. Br J Surg. 2020;107:785–7.
7. Ruiu G, Ruiu ML. Violation of lockdown norms and peaks in daily number of positive cases to COVID-19 in Italy. Emerald Open Res. 2020;2(25):25.
8. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. J Hosp Infect. 2020;104(3):246–51.
9. Corman VM, Muth D, Niemeyer D, Drosten C. Hosts and sources of endemic human coronaviruses. Adv Virus Res. 2018;100:163–88.
10. Tortorici MA, Veesler D. Structural insights into coronavirus entry. Adv Virus Res. 2019;105:93–116.
11. Letko M, Marzi A, Munster V. Functional assessment of cell entry and receptor usage for SARS-CoV-2 and other lineage B betacoronaviruses. Nat Microbiol. 2020;5:562–9.
12. Khan AU, Akter R, Foyj UK, Khanom S, Khan AU, Afsana AS. Second wave and pandemic situation of COVID-(2020-2021) in Bangladesh. Qubahan Acad J. 2021a;1(4):25–31. https://doi.org/10.48161/qaj.v1n4a74.
13. Khan AU, Talucder MSA, Das M, Noreen S, Pane YS. Prospect of the black pepper (Piper nigrum L.) as natural product used to an herbal medicine. Open Access Macedonian J Med Sci. 2021b;9(F):563–73. https://doi.org/10.3889/oamjms.2021.7113.
14. Chauhan S. Comprehensive review of coronavirus disease 2019 (COVID-19). Biom J. 2020;43(4):334–40.
15. Li Z, Chen Q, Feng L, Rodewald L, Xia Y, Yu H, Li S. Active case finding with case management: the key to tackling the COVID-19 pandemic. Lancet. 2020a;396(10243):63–70.

16. Li W, Yang Y, Liu Z-H, Zhao Y-J, Zhang Q, Zhang L, et al. Progression of mental health services during the COVID-19 outbreak in China. Int J Biol Sci. 2020b;16(10):1732–8.
17. Kumar S. Corona virus outbreak: keep physical distancing, not social distancing. Not Social Distancing. 2020, 2020;
18. Hollander JE, Carr BG. Virtually perfect telemedicine for COVID-19. N Engl J Med. 2020;382(18):1679–81.
19. Doshi A, Platt Y, Dressen JR, Mathews BK, Siy JC. Keep calm and log on: telemedicine for COVID-19 pandemic response. J Hosp Med. 2020;15(5):302–4.
20. Battineni G, Pallotta G, Nittari G, Amenta F. Telemedicine framework to mitigate the impact of the COVID-19 pandemic, vol. 16. J Taibah Univ Med Sci; 2021. p. 300–2.
21. Caetano R, Silva AB, Guedes ACCM, Paiva CCND, Ribeiro GDR, Santos DL, Silva RMD. Challenges and opportunities for telehealth during the COVID-19 pandemic: ideas on spaces and initiatives in the Brazilian context. Cad Saude Publica. 2020;36:e00088920.
22. Portnoy J, Waller M, Elliott T. Telemedicine in the era of COVID-19. J Allergy Clin Immunol Pract. 2020;8(5):1489–91.
23. Bashshur R, Doarn CR, Frenk JM, Kvedar JC, Woolliscroft JO. Telemedicine and the COVID-19 pandemic, lessons for the future. Telemed J Health. 2020;26:571–3.
24. Calton B, Abedini N, Fratkin M. Telemedicine in the time of coronavirus. J Pain Symptom Manag. 2020;60(1):e12–4.
25. Smith AC, Thomas E, Snoswell CL, Haydon H, Mehrotra A, Clemensen J, Caffery LJ. Telehealth for global emergencies: implications for coronavirus disease 2019 (COVID-19). J Telemed Telecare. 2020;26(5):309–13.
26. Kang L, Li Y, Hu S, Chen M, Yang C, Yang BX, et al. The mental health of medical workers in Wuhan, China dealing with the 2019 novel coronavirus. Lancet Psychiatry. 2020;7(3):e14. https://doi.org/10.1016/S2215-0366(20)30047-X.
27. Ploux S, Varma N, Strik M, Lazarus A, Bordachar P. Optimizing implantable cardioverter-defibrillator remote monitoring: a practical guide. JACC Clin Electrophysiol. 2017;3(4):315–28. https://doi.org/10.1016/j.jacep.2017.02.007.
28. Slotwiner D, Varma N, Akar JG, et al. HRS expert consensus statement on remote interrogation and monitoring for cardiovascular implantable electronic devices. Heart Rhythm. 2015;12(7):e69–e100. https://doi.org/10.1016/j.hrthm.2015.05.008.
29. Khairat S, Meng C, Xu Y, Edson B, Gianforcaro R. Interpreting COVID-19 and virtual care trends: cohort study. JMIR Public Health Surveill. 2020;6(2):e18811.
30. Dorsey ER, Topol EJ. Telemedicine 2020 and the next decade. Lancet. 2020;395(10227):859.
31. Chauhan V, Galwankar S, Arquilla B, Garg M, Di Somma S, El-Menyar A, et al. Novel coronavirus (COVID-19): leveraging telemedicine to optimize care while minimizing exposures and viral transmission. J Emerg Trauma Shock. 2020;13(1):20.
32. Zhou X, Snoswell CL, Harding LE, Bambling M, Edirippulige S, Bai X, et al. The role of Telehealth in reducing the mental health burden from COVID-19. Telemed E Health. 2020;
33. Canady VA. COVID-19 outbreak represents a new way of mental health service delivery. Ment Heal Wkly. 2020;30(12):1–4.
34. Greenhalgh T, Wherton J, Shaw S, Morrison C. Video consultations for covid-19. Br Med J Publishing Group; 2020. https://doi.org/10.2196/18378.
35. Mehrotra A, Jena AB, Busch AB, Souza J, Uscher-Pines L, Landon BE. Utilization of telemedicine among rural Medicare beneficiaries. JAMA. 2016;315(18):2015–6.
36. Valle J, Godby T, Paul DP III, Smith H, Coustasse A. Use of smartphones for clinical and medical education. Health Care Manag. 2017;36(3):293–300.
37. Jahanshir A, Karimialavijeh E, Sheikh H, Vahedi M, Momeni M. Smartphones and medical applications in the emergency department daily practice. Emergency. 2017;5(1)
38. Campion EW, Dorsey E, Topol E. State of telehealth. N Engl J Med. 2016;375(2):154–61.
39. Gasmi A, Tippairote T, Mujawdiya PK, Peana M, Menzel A, Dadar M, Bjørklund G. Micronutrients as immunomodulatory tools for COVID-19 management. Clin Immunol. 2020;220:108545.

40. Mittal M, Battineni G, Goyal LM, Chhetri B, Oberoi SV, Chintalapudi N. Cloud-based framework to mitigate the impact of COVID-19 on seafarers' mental health. Int Marit Health. 2020;71(3):213–4.
41. Rho MJ, Kim HS, Chung K, Choi IY. Factors influencing the acceptance of telemedicine for diabetes management. Clust Comput. 2015;18(1):321–31.
42. Natarajan S, Jain A, Krishnan R, Rogye A, Sivaprasad S. Diagnostic accuracy of community-based diabetic retinopathy screening with an offline artificial intelligence system on a smartphone. JAMA Ophthalmol. 2019;137(10):1182–8.
43. Bilong Y, Katte JC, Koki G, Kagmeni G, Obama OPN, Fofe HRN, Sharma A. Validation of smartphone-based retinal photography for diabetic retinopathy screening. Ophthalmic Surg Lasers Imag Retina. 2019;50(5):S18–22.
44. DeBuc DC. The role of retinal imaging and portable screening devices in tele-ophthalmology applications for diabetic retinopathy management. Curr Diab Rep. 2016;16(12):1–11.
45. Zhai Y. A call for addressing barriers to telemedicine: health disparities during the COVID-19 pandemic. Psychother Psychosom. 2020;1:64–6.
46. V'kovski P, Kratzel A, Steiner S, Stalder H, Thiel V. Coronavirus biology and replication: implications for SARS-CoV-2. Nat Rev Microbiol. 2021;19(3):155–70.
47. Nittari G, Khuman R, Baldoni S, Pallotta G, Battineni G, Sirignano A, et al. Telemedicine practice: review of the current ethical and legal challenges. Telemed e-Health. 2020;26(12):1427–37.
48. Indria D, Alajlani M, Fraser HS. Clinicians perceptions of a telemedicine system: a mixed method study of Makassar City, Indonesia. BMC Med Inform Decis Mak. 2020;20(1):1–8.

IoT in Healthcare: Using Cloud Computing and Natural Language Processing for a Superior Approach

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1 Introduction

The Internet of Things (IoT) is a mix of a mechanical push and a human draw for more and steadily expanding availability with anything occurring in the prompt and more extensive climate, an intelligent expansion of the processing power in a solitary machine to the climate: the climate as an interface. This push-pull blend makes it exceptionally solid, relentless, quick, and incredibly troublesome. The IoT vision, basically, is that practically any electronic gadget can be worked by an association with the Internet, empowering a standard independent gadget to turn into a savvy-arranged gadget.

For instance, a nursery sprinkler framework can complete its watering task all the more productively on the off chance that it knows the climate gauge or the dampness needs of the plants it waters. Moreover, an association worked between a PC and a seat can turn on the PC at whatever point there is an individual sitting in a seat associated with it. All way of gadgets can utilize Internet-determined data to work on their essential activity and become more astute, more proficient, and savvy. The IoT implementation provides tangible benefits to patients, medical personnel, and facility managers, from patient well-being to power efficiency in a hospital. The healthcare space is increasingly dependent on data for effective and secure operations as more information becomes accessible via connected devices.

The recent advances in wireless communication technology can allow the health problems of patients to be communicated in real time to caregivers. What is more, fundamental human health metrics can be determined by numerous accessible sensors and versatile gadgets with a solitary touch. While it is still in the early stage of

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_10

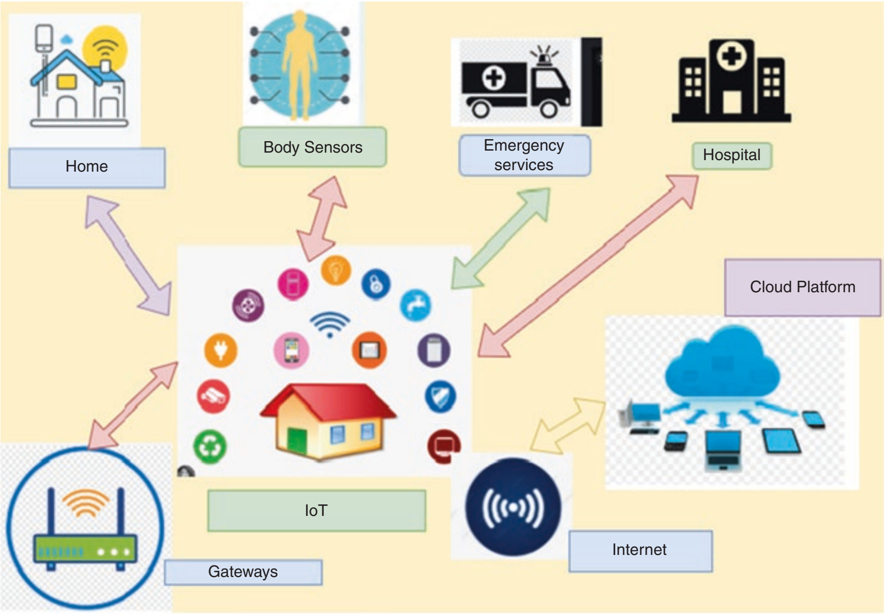

Fig. 1 A healthcare system based on the IoT and cloud computing

growth, the IoT has increasingly incorporated the power of companies and industries in their current systems. Nonetheless, there are numerous obstructions for incorporating the IoT innovation into healthcare, including data stockpiling, data handling, sharing of data among gadgets, and unidentified and omnipresent access. Cloud computing technology is one potential approach that can overcome these problems. Using this IoT in healthcare turns out to be a suitable approach with not many issues with storage of data and accessing the data ubiquitously. Figure 1 demonstrates the integration of the IoT and cloud computing in healthcare.

Distributed computing conveys registering administrations including servers, datasets, system administration, programming, and data investigation over the Web to give quicker sending, versatile resources, and economies of scale. As an arising innovation, mobile cloud computing incorporates various advancements for expanding limit and execution of the current foundation for the IoT gadgets. Concerning the combination of the Internet of Things and cloud computing, some past investigations have been made. Such integration assists with understanding the full sharing, free flow, on-request use, and ideal designation of different assembling assets and abilities.

2 Literature Review

The IoT urges medical care experts to be more mindful and proactively draw in with patients. Information accumulated from the IoT gadgets will assist clinicians in deciding the best healthcare decision system and produce the ideal outcomes.

A significant problem for patients in hospitals is the spread of infections. The IoT helps in minimizing this concern. The study of associations with yearly incomes of more than $100 million likewise uncovered that 79% of the medical care suppliers are as of now utilizing the IoT in their creation processes. In medical services, as per Gartner, there has been 10% development in planning for the IoT in every one of the beyond 2 years, with a 13% financial plan increment for the following monetary year. So, the IoT in healthcare having this significance is the need of the hour; huge data is being processed by the healthcare industry day to day, and the data segregation and processing are equally important in order to act according to the need and requirement of the patients in emergency situations.

This review [1] proposes a worldwide exploration of networks, which are eagerly taking part to make a reliable change, which the IoT and dispersed forecasting bring to the clinical benefits. This assessment can be utilized for enthusiastic clients to learn different technologies in the IoT domain and circulated processing of clinical applications. It provides a spread-handling structure using the IoT for clinical applications that upholds IoT services and circled enrolling spine, which enables to transfer clinical data among healthcare gadgets and distant workers or allows it to be passed onto prediction stages. During the blend example of the IoT and circled handling in clinical thought, different considerations and applications are dependably added, so this helps concentrate also quickly on gatherings and sums them up. By then, at that point, we additionally do a sweeping study on appropriated handling, especially mist joining up, recalling standard models and existing methods for forecasting in clinical thought applications. Beginning now and for a significant length of time, the existing inventive work measure can be packed in the clinical thought industry by areas, applications, and end client, and sometime later fundamental accomplishments that show the sensibility of getting sorted out the IoT and scattered handling in clinical advantages are depicted. The review moreover contemplates different vulnerabilities, weaknesses, and assaults that should be thought of, and dissects and sums up basic security models to obstruct conceivable security prospects. Procedures from lawmaking bodies over the world that energize the progress of the IoT and appropriated figuring in clinical advantages are in like way alluded to. At long last, different difficulties that forestall the progress of the IoT and dispersed enlisting in clinical thought, for example, information security, framework revisions, and methodologies, are appeared.

With the IoT and cloud computing [2] in place in healthcare, we need more technology to read the content of the user input to make decision and design the IoT devices accordingly. One such technology that can be used is natural language processing that can help the IoT device to understand the user input which is in the form of text and act accordingly. For instance, when a doctor is collecting data regarding the health issues of a patient through an IoT device, the device should be able to segregate which patient needs an emergency help from the doctor and serve them accordingly than the FIFO methodology. Natural language processing has been in research since years and is making lot of improvements in the technology we use in our daily routine. The context of the review is to discuss the integration of natural language processing to process the input and output of the IoT devices and use of cloud storage to incorporate data of the IoT devices.

The point of the IoT-empowered medical care [3] is to ultimately give a minimal expense, cutting-edge innovation, and high-availability care administrations for patients and customers. A few countries have developed the IoT-enabled healthcare applications and procured pleasing outcomes. In this chapter, an innovative model has been developed to concentrate on the IoT dispersion in broad daylight, and the model's utilization to concentrate on the level of the IoT is acknowledged. Also, study survey was created to gather information from people in general and subsequently recognize the hindrances for Malaysia to accept the IoT into medical care area. Subsequent to going through the information assortment, the IoT-empowered medical service application is acknowledged by the greater part of the respondents. The IoT medical care application is arriving at the choice stage that Malaysians need more influence to urge them to settle on the choice of utilizing the IoT medical care application.

Wearable medical devices using wireless sensors make a tremendous extent of data that should be regulated and taken care of. Appropriate registering with the IoT thought is a new craze for compelling regulation and treatment of sensor data on the Web. The authors in [4] present a phase subject to distributed cloud computing for the leading group of compact and wearable clinical benefits sensors, showing this way the IoT perspective applied on unpreventable clinical benefits.

Cloud computing (CC) and IoT have emerged as new developments in the ICT domain of the twenty-first century. The gathering of the CloudIoT worldview in the healthcare field can convey a couple of applications to clinical IT, and clinical experts acknowledge that it can essentially foster healthcare industries and add to its steady and exponential growth. The authors in [5] present an intensive composition of CC and IoT dealing with various issues in tele-health services like savvy centers, prescription control, and remote clinical applications. In like manner, a short introduction to appropriated processing and IoT with an application to clinical services is given. This chapter presents a blend of CC and IoT for healthcare applications, called as CloudIoT Health worldview, which makes a clear vision to organize current trends of CC and the IoT in clinical applications.

In the review [6], the authors presented the research challenges in creating down-to-earth security-saving investigation in medical service data frameworks. The review depends on kHealth, a customized computerized medical care data framework that is being created and tried for sickness checking. We break down the information and insightful necessities for the elaborate gatherings, recognize the protection resources, examine existing security substrates, and talk about the expected trade-off among security, productivity, and model quality.

The authors in [7] presented the exchange of the processing knowledge from cloud to edge organization. Haze figuring works nearer to the client, on network edge, empowering exact help conveyance with low reaction time staying away from postponements and organization disappointments that might hinder or defer the choice cycle and medical care administration conveyance. An engineering model is proposed, and a bunch of utilization cases delineate the advantages of the IoT and haze processing reconciliation.

The authors in review [8] proposed another arrangement for the execution of the IoT to store and oversee adaptable sensor information (colossal information) for clinical advantage applications. The proposed planning contains two focal sub-developments, explicitly meta fog-redirection (MF-R) and grouping and choosing (GC) plan. MF-R planning utilizes tremendous information types of progress like Apache Pig and Apache HBase for assortment and breaking point of the sensor information (monstrous information) produced using different sensor contraptions. The proposed GC setup is utilized for getting compromise of dinkiness selecting with disseminated figuring. This planning in like way utilizes key association and information approach work for giving security associations. The system also utilizes MapReduce-based expectation model to anticipate the heart infections. Execution examination limits like throughput, accuracy, precision, and f-measure and shows the practicality of the proposed system as the forecast model.

In the review [9], novel methodology to utilize the IoT inside the field of coherent and shrewd medical services are presented. The majority of the audits exist about the different clinical consideration approaches used in the IoT, similar to far-off success noticing, U-clinical care, E-clinical benefits, and so forth. The creators proposed an all-out checking presence cycle and strong clinical benefits noticing structure arranged by using the IoT and RFID marks. The experimental results in this review show the great output against different health-related crises. In this structure, to get the extended evaluation results, coordinate and actually take a look at the success status of patient health, and develop the power of the IoT, the mix of microcontroller with sensors is introduced.

Authors in the review [10] proposed a creative technique that comprises two primary advances. Right off the bat, by utilizing natural language processing, they investigated the experiments' determinations and transformed them into a numeric vector. Furthermore, by utilizing the obtained information vectors, each experiment was ordered into a reliant or an autonomous class. A managed learning approach was completed utilizing various strategies for taking care of imbalanced datasets.

As of late, different investigations [11] in the space of medical care data framework referenced that the fractures of the health data are one of the main difficulties with the circulation of patient data records. Subsequently, in this part, we gave an exhaustive outline in regard to the recent concerns confronting the well-being area in accordance with the IoT advances. Furthermore, a full portrayal of benefits and hindrances has been featured for utilizing IoT in medical care, which are answers for the referenced issues.

In the article [12], the course of action of ubiquitous sensor design is introduced for diagnosis of various physiological signs, like the ECG, EEG, and PPG. As these sensors are melded with a similar gadget, the proposed sensor design can be utilized to assess heartbeat and pulse rate without additional wires and gadgets. The sensor design contains a middle board for getting the signal, a power supply and charging batteries, and three sensors for checking signs. Each of the parts is organized in a standard structure, which can be with no issue when joined to the human body for distant healthcare monitoring. The sensors can be confined for changed appraisals of a specific physiological sign to lessen energy consumption. Assessments are facilitated to help the presentation of the proposed sensor design by evaluation with a business-based contraption. With the trade-off of a cutback Bluetooth module, the proposed sensor framework can give physiological appraisals from a distance to a doorway. Information encryption is used on both the sensor design and ways of ensuring information for protection during transmission. An adaptable entryway and a suitable passage are organized as the stage dividing the ubiquitous sensor framework and the Internet cloud, where thriving information can be dealt with and further investigated. The exploratory outcomes exhibit the achievability of the generally speaking stage for IoT-associated medical care applications.

In the early stages of the COVID-19 pandemic with no particular solution or immunization, the method for breaking the disease chain was self-separation and keeping up with the physical distancing. In the article [13], a possible use of the IoT in medical care is presented and actual distance observing for health crisis circumstances. The proposed system comprises the following modules, respectively: a low-power low-cost IoT hub, a mobile phone, and machine learning (ML) instruments for data analysis. The IoT hub tracks well-being boundaries, including internal heat level, heartbeat rate, pulse rate, and blood oxygen, and refreshes the mobile application to show the client medical issue. The application notifies the client to keep an actual separation of 2 m, which is a critical component in controlling the disease spread. Likewise, a Fuzzy Mamdani framework thinks about the ecological danger and client medical issue to foresee the danger of spreading contamination progressively. The ecological danger passes on from the virtual zone idea and gives refreshed data to better places. Two situations are taken for the correspondence between the IoT hub and haze server, 4G/5G/Wi-Fi, or LoRa, which can be chosen depending on ecological limitations. The necessary power utilization and data transfer rate are analyzed for different occasion situations. The COVID-SAFE structure can help with limiting the COVID hazard.

Nowadays, NLP has been used for data processing in clinical care applications [14]. NLP helped in acquiring information from an area, for example, intrinsic qualities under the field assessment of biomedical arrangement. The NLP can be interfaced to get the healthcare information, patient interaction, telemedicine, reaction medical therapy, etc. Getting information in the medical space will equip doctors with strong expertise, which will be useful for healthcare applications. In such healthcare databases, electronic health record (EHR) is one of the important documents, which encompass patient health profile, health history, disease history, diagnostic reports, clinical consulting, medicines, food habits, and so forth. With the recent advances in EHR information, applied with NLP, the clinical experts are able to extract the specific health-related data by performing clinical data research faster.

Information gained [15] in the space should in like manner be assessed the extent that nature of database made, as this is one of the huge hardships looked by information-based structures. A clinical investigation revealed in [16] addresses this test connecting with the clinical field database, using rule-based expert system and text classifier. The obtained results show that the majority of the disease classification was false positive, enlightening data acquired from clinical research.

An empirical investigation by authors in [17] targets perceiving patient towards cardiovascular (CV) risk analysis and its severity with the assistance of the NLP in EMR. The author attempts to see the counter-inflammatory prescription utilization of the patient from EMR utilizing NLP, which reveals the severity and hazard factor for CV diseases. This review had limitations; for instance, the text ought to be utilized explicitly for over-the-counter prescription and more data is needed fairly from self-report.

Research by authors in [18] recommends that NLP can be utilized as the information communication tool for analyzing if there is any association among HIV and smoking history, bowel habits, etc., and the association could be faster or free. The study also shows that less controlled HIV had less likely chances of stopping smoking habits, and it is considered to be more inevitable in HIV-based patients when stood apart from the typical model.

Embedding the clinical thoughts for higher data depiction had been tended to in the review [19], where the NLP framework is used on sharp learning plan prepared for consolidating the medical documentation with logical analysis and lab manuals. The result shows that the model was useful in foreseeing the severity alerts depending upon the blueprint of medical document and manual, and expert clinicians confirm that the proposed model is obviously better contrasted with standard model in expecting the sums for three out of six contaminations and for the trust to pick outstandingly they had isolated evaluation now completely concurred that the new NLP system had good aggregate results. The essential impediment the review had incredibly less or exceptional rehash are dismissed during pre-handling.

The review [20] was focused to foster a clever model and computerized text-mining strategy to extricate point-by-point organized medicine data from free-text remedies and investigate their inconstancy in essential consideration research data sets. Strategies: This study presented a solution model that gives least and most extreme qualities to portion number, recurrence, and stretch, permitting to display inconstancy and adaptability inside a medication remedy. We fostered a text-mining framework that depends on rules to concentrate such organized data from remedy free-text measurement directions. The framework was applied to medicine remedies from an anonymized essential consideration electronic record information base. The proposed methodology gives a precise, computerized method of coding remedy free-text data, including data about adaptability and inconstancy inside a solution. The strategy permits the analyst to choose how best to set up the remedy information for drug viability and security examinations in some random setting, and test different situations and their effect.

Data extraction for illness-recognizable proof, for example methicillin-safe *Staphylococcus aureus* (MRSA) [21], and unfriendly medication response had been executed utilizing the NLP frameworks such as broad design for text designing (GATE) and unstructured data in the board engineering (UIMMA). The examinations propose that the NLP framework helps ahead of time-recognizable proof of possible ADE from EHR, and executing the NLP framework can be promising for the ID of microbe observation information.

3 Problem Statement

The utilization of innovation in the medical care area has soared lately. Innovation makes medical care more savvy and solid, and it conveys better outcomes for patients. It has as of late become a major worry to work on the nature of care, and the Internet of Things has shown goliath potential to make clinical facilities safer and more capable. The Internet of Things, or IoT, is an association of Web-related items that can send and get data. IoT advancement can be related with a wide scope of things, including facility wristbands and medical equipment.

In this developing number of sensors, shrewd gadgets and associated things where tremendous volumes of information is being created each day which is trying for the IoT and use of cloud computing advances can help away of these huge information that is being produced each day. IoT-empowered gadgets have made remote checking conceivable, releasing the possibility to keep patients protected and solid. However, the developing populace and need for more well-being exams are taking off high where remote checking additionally ends up being awkward. On any aggravation or changes in the normal exercises of an individual, ready component conveys messages to relatives and concerned medical service suppliers. This may not always be an emergency. And the healthcare provider might get multiple requests for appointing multiple patients at the same time. So, this situation should be monitored by these devices by processing the data and prioritizing the situations of each one of them accordingly. In this chapter, we present an approach where we process the data by first segregating it and then analyzing it and prioritize the requests accordingly, which allows patients to consult healthcare providers on time and makes this IoT in healthcare better.

4 Methodology

The main methodology of this project is the hybrid of IoT and cloud computing in place in healthcare to read the content of user input in the smart devices to make decisions accordingly. Natural language processing is one such technology that can assist IoT devices to understand and function accordingly on user input that is in the form of text. For example, when a doctor gathers information from an IoT device about the patient's health problems, the device should be able to segregate and process which patient needs the healthcare provider's emergency assistance immediately and serve them rather than using the technique of first come first serve. The production of natural language has been in study for years and is making many changes in the technology we use in our everyday routine. The goal is to address the implementation of natural language processing to process IoT system input and output and the use of cloud storage to integrate IoT data.

4.1 Cloud Computing for Healthcare

In recent years, one of the trending subjects in information technology has been the cloud computing model. Through following on-request processing foundation (e.g., capacity, administrations, organizations, servers, programming, and equipment) for clients, it has adaptability, openness, and security benefits. Distributed computing has as of late arose as a foundation for IoT medical care frameworks, as indicated by a report. The capacity to trade information among the well-being experts and parental figures in a more organized and coordinated manner is one more extraordinary benefit of cloud computing. Therefore, the advancement of technology such as the IoT and cloud computing has benefited healthcare facilities and applications. An m-Health management system platform based on cloud computing technology comprising three main layers was suggested, which is shown in Fig. 2.

The cloud storage and access control layer for quite a long time has been the foundation of the organization that gets well-being information during ordinary exercises by sensors like BG and sphygmomanometers. Through executing the cloud stage, the creators decreased the cost of putting away and keeping up with information. What is more, a different inhabitant access control module is presented between the occupant information base and the common dataset to further develop patient information assurance and security. The healthcare data annotation layer addresses the problem of data heterogeneity that usually exists during the processing of data. Since facilities differ from hospital to hospital, the data produced is often heterogeneous, raising the difficulty of automated sharing and interpretation of healthcare data between medical agencies. In order to annotate personal health data and incorporate scattered data into a patient-centered pattern for the cloud application, the authors suggested open connected life datasets.

In order to aid in clinical decision-making, the healthcare data analysis layer analyzes healthcare data stored in the cloud since similar past data are useful tools for making a treatment plan for a similar case of illness. Mining algorithms are implemented, as seen in the above figure, to induce clinical pathways from personal health data. A similarity estimation module is then designed to compare the healthcare data of patients with historical events. Each layer has been specifically designed to handle a predefined role and can be applied using a cloud platform and service-oriented architecture to meet a variety of healthcare requirements. This platform allows clinicians to observe and determine health conditions by transmitting end-user raw sensor data to the cloud storage and then showing results to physicians.

Many cloud data centers, however, are geographically centralized and located well away from end users. Thus, contact time between users and remote cloud servers poses major problems for applications needing immediate real-time feedback, such as remote monitoring or telehealth, or for taking appointments, which includes high round-trip latency, network congestion, and other problems. Therefore, data processing and segregation using natural language processing can be used to prioritize the requests for appointments or remote healthcare feedback based on emergency.

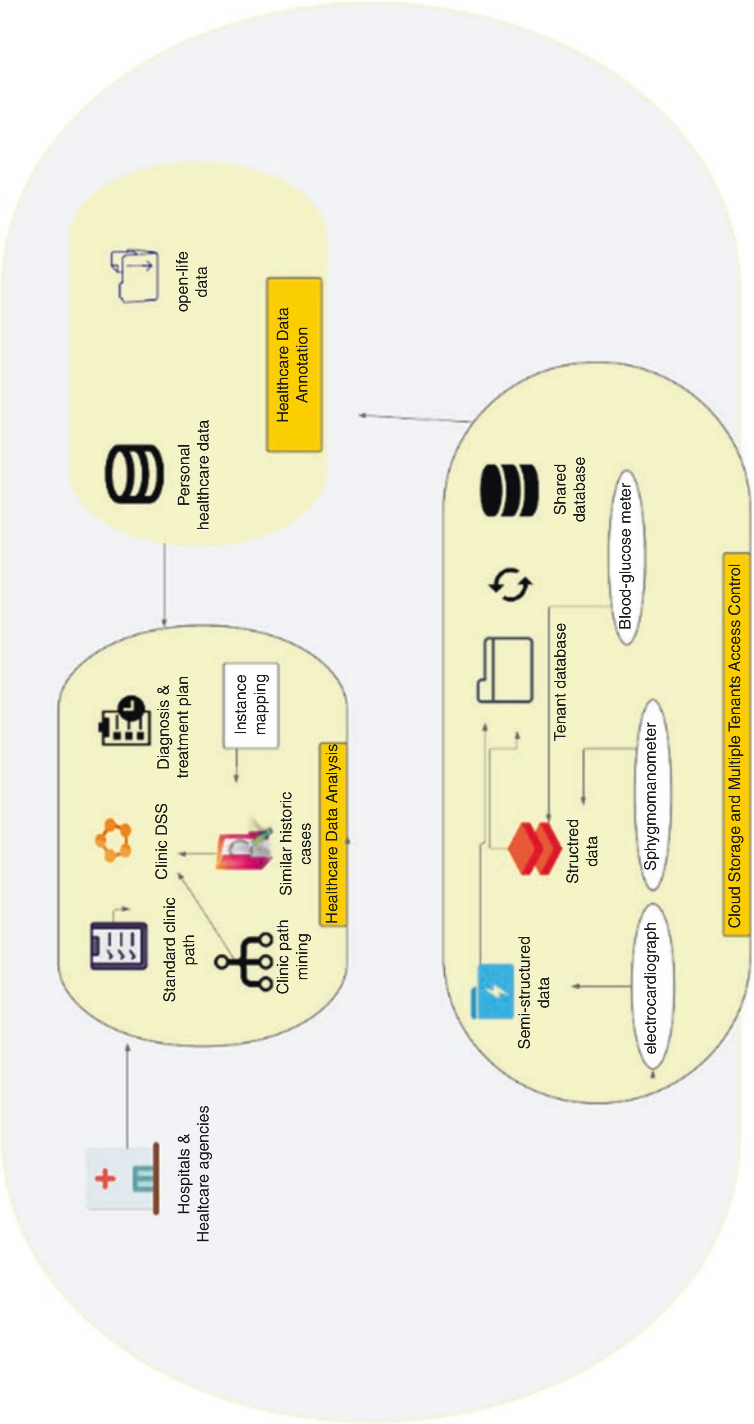

Fig. 2 Cloud computing-based m-Health monitoring system

4.2 Natural Language Processing for Prioritizing Data

The innovation used to permit PCs to comprehend the normal language of people is natural language processing. Encouraging PCs to see how we interface is certainly not a straightforward work. Regular language processing, normally abbreviated as NLP, is a part of man-made consciousness that plans with the composed exertion among PCs and people utilizing the standard language. A definitive target of NLP is to analyze, unravel, understand, and figure out the human languages in a way that is huge. Most NLP strategies depend upon AI to get importance from human voices.

For processing and prioritizing the data, we use natural language processing to make sure that the patient with the highest emergency is consulted by the doctor. The NLP upheld by information the board removes/catches the data. The board helps in the coordination of information of cross-space data stream. The medical care space is wealthy in information, where data is required for each little and important choice. This data can be extricated with the assistance of normal language handling. Figure 3 delineates how information the board upholds the NLP in removing the data from the healthcare space.

4.3 Text Processing with Natural Language Processing

An NLP for healthcare application is shown in Fig. 4. Initially, input is collected from the user, which might vary from small to large sizes, and we need a good model to detect the content of the user input and let the IoT devices work accordingly. The below picture shows a method of how natural language processing helps understand the IoT devices and the meaning of the data.

Tokenization is a typical assignment in NLP by detaching a piece of text into more inconspicuous units. It can be widely organized into three sorts: word, character, and subword. Tokenization is performed on the corpus to acquire tokens. The tokens are then used to set up a language, which insinuates the course of action of striking tokens in the corpus. Remember that language can be created by considering each exceptional token in the corpus or by considering the top K regularly

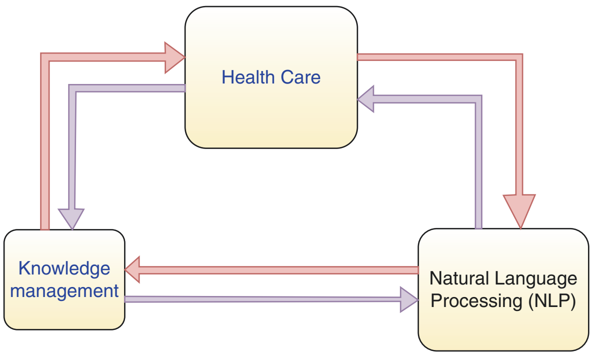

Fig. 3 Knowledge flow using NLP for healthcare

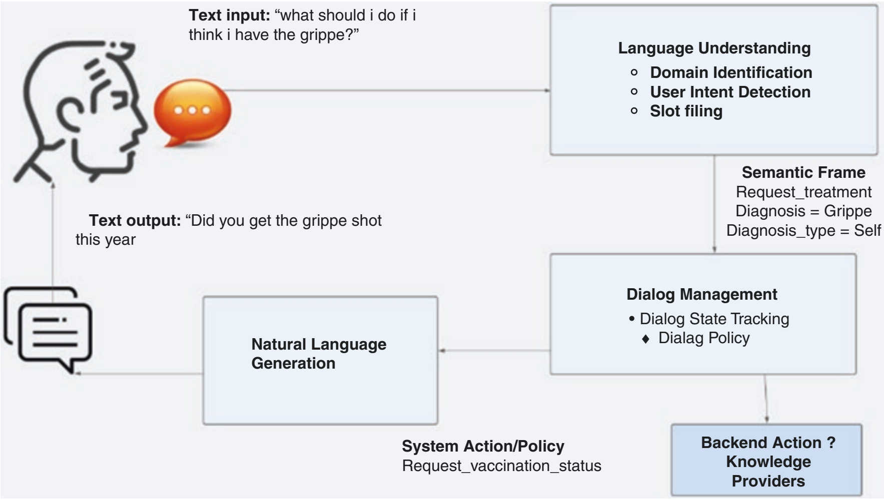

Fig. 4 Natural language processing for healthcare

appearing texts. Next comes deriving feature vectors from latent semantic text similarity using NLP techniques. This step of the method takes the tokens, which are the outcome of the tokenization, and then projects them on to the space as vectors. This method helps to see similarity between different contexts in the text and also helps dividing contrast meaning words. For instance, in terms of health issues, any word regarding danger and that needs quick assistance project in an angle on a plane and those words which do not indicate any sort of emergency incline differently.

Classification part in the above figure describes the process of training a model based on the meaning of the words and generalizing into one class based on the meaning. Therefore, in the context of health issues, the classification can be to segregate words into two categories as dangerous and not dangerous that helps the IoT devices to process easily. Finally, this labeled dataset will be fed into the IoT device and the process continues. In this way, we can prioritize data using natural language processing and help patients get the appointment for consultation immediately or help with remote healthcare feedback based on emergency and make this IoT in healthcare a better option for healthcare providers and patients.

5 Conclusion

In this chapter, we proposed a technique of processing the text using tokenization followed by semantic analysis to prioritize the data by labeling with the help of training a classifier, which in whole is termed as natural language processing technique that serves patients according to the level of emergency that is learned from the health issues mentioned. In this context, as the data will always be huge, we use cloud computing for the storage, analysis, and retrieval of data for the IoT in healthcare. The future direction of research can lie in applying different natural language processing techniques combined with the IoT devices integrated with cloud storage in different real-word scenarios.

References

1. Dang LM, Piran MJ, Han D, Min K, Moon H. A survey on internet of things and cloud computing for healthcare. Electronics. 2019;8:768. https://doi.org/10.3390/electronics8070768.
2. Ray PP. A survey of IoT cloud platforms. Future Comput Inform J. 2016;1(1–2):35–46.
3. Yuan YS, Cheah TC. A study of internet of things enabled healthcare acceptance in Malaysia. J Crit Rev. 2020;7(3):25–32. https://doi.org/10.31838/jcr.07.03.04.
4. Doukas C, Maglogiannis I. Bringing IoT and cloud computing towards pervasive healthcare. 2012 Sixth international conference on innovative mobile and internet services in ubiquitous computing; 2012, pp. 922–926. https://doi.org/10.1109/IMIS.2012.26.
5. Darwish A, Hassanien AE, Elhoseny M, et al. The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems. J Ambient Intell Human Comput. 2019;10:4151–66. https://doi.org/10.1007/s12652-017-0659-1.
6. Sharma S, Chen K, Sheth A. Toward practical privacy-preserving analytics for IoT and cloud-based healthcare systems. IEEE Internet Comput. 2018;22(2):42–51. https://doi.org/10.1109/MIC.2018.112102519.
7. M. Mittal, G. Battineni, P. Kumar, P. Sharma and A. Panwar, IoT based image defogging system for road accident control during winters, 2020 5th international conference on computing, communication and security (ICCCS); 2020, pp. 1–5. https://doi.org/10.1109/ICCCS49678.2020.9277430.
8. Manogaran G, Varatharajan R, Lopez D, Kumar PM, Sundarasekar R, Thota C. A new architecture of Internet of Things and big data ecosystem for secured smart healthcare monitoring and alerting system. Future Generation Comput Syst. 2018;82:375–87.
9. Khan SF. Health care monitoring system in Internet of Things (IoT) by using RFID, 2017 6th International conference on industrial technology and management (ICITM); 2017, pp. 198–204, https://doi.org/10.1109/ICITM.2017.7917920.
10. Tahvili S, Hatvani L, Ramentol E, Pimentel R, Afzal W, Herrera F. A novel methodology to classify test cases using natural language processing and imbalanced learning. Eng Appl Artif Intell. 2020;95:103,878.
11. Dauwed M, Meri A. IOT service utilisation in healthcare. In: Ismail Y, editor. Internet of things (IoT) for automated and smart applications. IntechOpen; 2019. https://doi.org/10.5772/intechopen.86014. https://www.intechopen.com/chapters/67035.
12. Wu T, Wu F, Qiu C, Redouté J-M, Yuce MR. A rigid-flex wearable health monitoring sensor patch for IoT-connected healthcare applications. EEE Internet Things J. 2020;7(8):6932–45. https://doi.org/10.1109/JIOT.2020.2977164.
13. Vedaei, et al. COVID-SAFE: an IoT-based system for automated health monitoring and surveillance in post-pandemic life. IEEE Access. 2020;8:188,538–51. https://doi.org/10.1109/ACCESS.2020.3030194.
14. Iqbal, et al. ADEPt, a semantically-enriched pipeline for extracting adverse drug events from free-text electronic health records. PLoS One. 2017;12(11):e0187121. https://doi.org/10.1371/journal.pone.0187121.
15. Shiner B, D'Avolio LW, Nguyen TM, Zayed MH, Watts BV, Fiore L. Automated classification of psychotherapy note text: implications for quality assessment in PTSD care: NLP of PTSD psychotherapy notes. J Eval Clin Pract. Jun. 2012;18(3):698–701. https://doi.org/10.1111/j.1365-2753.2011.01634.x.

16. MacRae J, et al. Identifying influenza-like illness presentation from unstructured general practice clinical narrative using a text classifier rule-based expert system versus a clinical expert. BMC Med Inform Decision Making. 2015;15(1) https://doi.org/10.1186/s12911-015-0201-3.
17. Pakhomov S, Shah N, Hanson P, Balasubramaniam S, Smith S. Automated processing of electronic medical records is a reliable method of determining aspirin use in populations at risk for cardiovascular events. J Innov Health Inform. 2010;18(2):125–33. https://doi.org/10.14236/jhi.v18i2.762.
18. Chintalapudi N, Battineni G, Di Canio M, Sagaro GG, Amenta F. Text mining with sentiment analysis on seafarers' medical documents. Int J Inform Manag Data Insights. 2021;1:100005. https://doi.org/10.1016/j.jjimei.2020.100005.
19. Bai T, Chanda AK, Egleston BL, Vucetic S. EHR phenotyping via jointly embedding medical concepts and words into a unified vector space. BMC Med Inform Decision Making. 2018;18(S4) https://doi.org/10.1186/s12911-018-0672-0.
20. Karystianis G, Sheppard T, Dixon WG, Nenadic G. Modelling and extraction of variability in free-text medication prescriptions from an anonymised primary care electronic medical record research database. BMC Med Inform Decision Making. 2015;16(1) https://doi.org/10.1186/s12911-016-0255-x.
21. Iqbal E, et al. Identification of adverse drug events from free text electronic patient records and information in a large mental health case register. PLoS One. 2015;10(8):e0134208. https://doi.org/10.1371/journal.pone.0134208.

Internet Technologies for Personalized Care

Shama Siddiqui, Anwar Ahmed Khan, and Indrakshi Dey

1 Introduction

Information and communication technology (ICT) has been playing a crucial role in developing solutions, which could offer personalized care, improved health, and quality social life to populations worldwide. Internet technology offers enormous advantages to patients by connecting them with family and caregivers, whenever required. The mobile healthcare is delivered via mobile wearable and handheld devices that are used to track diverse types of data, ranging from monitoring heart rate and fitness levels to recommending medication dosages and sleep schedules [1]. The increased prevalence of smartphones worldwide has taken mobile health to a whole new level; today, there are thousands of mobile health applications available offering access to critical health services, tracking personal data, receiving consultation from doctors regardless of their location, and offering remote health monitoring and management support along with future risk analysis and recommendations for disease prevention.

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_11

The key players of the healthcare sector including pharmaceuticals, health insurers, caregivers, and even large employers are encouraging people to use wearable devices. The wearable devices do not only provide an insight into the health statistics but also provide details about physical activity levels and adherence to medication behaviors of patients [2]. Customized modules, interfaces, and devices have increasingly been introduced into the market to fit millions of users based on their diverse needs in terms of medical history, personality, motivation factors, and values. Internet technology for offering personalized health has been inspired by other sectors, which became digital earlier; for example, Netflix tracks the viewers' preferences and suggests contents; similarly, companies track behavior and health trends of population to provide customized solutions.

This chapter presents a detailed insight on the major Internet technologies used for personalized care today, namely, smartphone applications, voice-enabled assistants, and IoT. We also highlight major challenges often faced by the medical professionals and network designers while developing healthcare solutions and also provide a glimpse into future trends.

2 Smartphone Application

The use of smartphone applications (apps) has been prevailing worldwide for health monitoring and fitness tracking. Use of these apps facilitates people in becoming more aware about their health risks, and as a result, they become cautious towards improving their lifestyle and well-being [1]. The apps provide highly personalized assessment and input about the users' health based on data collected from sensors embedded within the smartphones or by integrating with wearable or implantable devices. Some of the major uses of smartphone applications in personalized care are described below:

2.1 Fitness Assistance and Tracking

Hundreds of fitness mobile apps are available to support the fitness goals of users. The fitness apps help the users to track and record their activity routine, suggest customized routines based on their own needs, and maintain a community link with the like-minded users. Many apps integrate with the GPS and other sensors embedded with the wearable devices to offer exercise recommendations based on the health statistics and to track the distance covered, running or cycling path. In addition to fitness tracking, the smartphone apps also play a crucial role in motivating the people continue exercising and achieving their fitness goals [3]. In this regard, most apps offer features of rewards such as earning badges or stars. Moreover, users can easily share their progress with their friends using social media sharing options.

Some representative applications available for Android and/or iOS from this category are listed in Table 1.

Table 1 Smartphone apps for fitness monitoring

App name	Features
MyFitnessPal [4]	• Offers features to lose weight • Tracks food intake and activity • Tracks calories for food consumed and exercises performed • Offers customized weight loss plans by recommending diet and exercise • Supports flexible diets such as the South Beach Diet, the Zone, Atkins, and others • Maintains a food diary with the help of a food database of over 300 million records • Users can add their food and recipes • Offers discussion board for community support in the form of making friends, sharing, and receiving tips and motivation
Runkeeper [5]	• Tracks runs, walks, and other physical activities • Offers training guidance and community support • Facilitates the goals of losing weight, training for race, or maintaining a certain pace • Offers a dashboard for customized training plans • Asks a series of questions to develop the training schedule • Uses GPS to track, save, and discover new routes • Offers rewards for workouts • Provides options to share progress with friends
Strava [6]	• Developed on the concept of social training • Works on the concept of developing a global team of athletes • Tracks key statistics including speed, pace, elevation gained, distance covered, and calories burnt • Displays an interactive map • Connects millions of runners, cyclists, and adventurers and offers an insight into their training patterns • Allows the user to compare performance against others • Offers leaderboard to design friendly competitions for continuous motivation
Yoga Studio [7]	• Yoga app • 70 ready-made exercises for yoga and meditation • Customized level with activity duration ranging from 15 to 60 min • Classes can be customized based on the requirement of gaining each balance, flexibility, strength, relaxation, or all of these • Provides easy-to-follow commentary for instructions to do a pose and how to seamlessly move between poses • Offers step-by-step instructions for 280 poses along with the benefits, modifications, variations, and cautions for each • Offers synchronizing of the classes with calendar for schedule assistance
Sworkit [8]	• Customizable workout app • Offers workout dashboard with numerous exercises for yoga, strength, and cardio trainings • Offers customized dashboard to compile individual exercise plan • Workout plans to become fitter, leaner, or stronger • Custom plans for high interval intensity training (HIIT) and Tabata

(continued)

Table 1 (continued)

App name	Features
JEFIT [9]	• App for maintaining workout logs of gyms • Offers gym plans with more than 60 routines • Offers thousands of plans contributed by community • Displays 1300 weight-lifting and cardio exercises • Offers visual step-by-step instructions on how to complete exercise • Community support from millions of users • Logs the repetitions and weight on each gym machine with a single click • Provides graphical visualizations and logs based on the information of active and resting time

2.2 Chronic Health Monitoring

Several apps have been developed with the focus on monitoring chronic conditions. The major goal of these apps is to ensure that the patients, physicians, as well as the loved ones remain aware about the health conditions of the patients with chronic illnesses such as depression, type 2 diabetes, stroke, heart diseases, asthma, chronic obstructive pulmonary disease (COPD), and certain types of cancers. These chronic diseases are crucial to be monitored because they serve as the leading cause of deaths worldwide and result in increasing the global healthcare burden [10]. Using the commercially available smart apps, the patients become able to self-manage their risks by observing and tracking their bodily sensations, symptoms, cognitive processes, and daily activities. The patients collect their data, enter it into the apps, and get immediate recommendations on how to deal with the situation. These apps also offer help for remembering medicines and appointments. Some of the apps from these categories have been listed in Table 2.

2.3 Mental Health Monitoring

Mental health refers to how a person feels and thinks. It affects the psychological, social, emotional, and even physical well-being. The mental health issues such as depression, anxiety, phobias, post-traumatic stress disorder (PTSD), panic disorders, and eating disorders can result in creating various physical health problems. Also, since the mental health of a person can change anytime based on the circumstances, it is important to monitor the mental health state. The use of digital technologies impacts the behavior and mental health of people, and these have specifically been used for bringing improvements for mental health of users [17]. Various smartphone apps have been developed for offering meditation and relaxation exercises, consultation with psychotherapists, community support, and self-management opportunities. Most apps provide an insight into the health trends not only for the patients, but also for the doctors in the form of summarized reports and trend charts. Table 3 presents some of the apps targeting the mental health of patients.

Table 2 Smartphone apps for chronic disease management

App name	Features
Medisafe [11]	• Medication management app • Offers information sharing with friends and pharmacists • Links with the pharmaceutical companies to offer timely refill services to patients • Offers cloud-based links with clinical support
Mango Health [12]	• Offers reminders for medicines. Offers reward points for taking medicines on time which can later be redeemed as gift cards of charities • Alerts for refills • Informs about possible reactions when certain medications are taken together
GOLD COPD Strategy [13]	• COPD management app • Follows the Global Initiative for Chronic Obstructive Lung Diseases (GOLD) standards • Allows the doctors to track patient's symptoms • Connects community of patients, public health officials, and healthcare professionals worldwide
mySugr Junior [14]	• Juvenile (type 1) diabetes management app for kids • Offers fun ways to users to measure and log the blood glucose levels • Offers an interactive game character that recommends insulin dosage for patients • Kids can tame their online game character by eating healthy • Connects with blood glucose meters for automated data entry • Connects patients with the caregivers or parents, if opted for • Provides graphs to track patient's record • Provides estimates for HbA1c and clear reports
SmartBP [15]	• Blood pressure (BP) management app • Allows patients to record, track, and analyze their BP data • Offers color codes to guide the patients about their risk levels • Offers option for sharing information with family and caregivers • Tracks relationship of diets and medication with the BP status • Offers a chance to upload ECG and provides analysis • Creates multiple users • Connects with Apple Watch • Offers sharing and printing of PDF reports
MyPainDiary [16]	• Pain management app • Tracks over 60 chronic health conditions including fibromyalgia, Crohn's disease, migraines, rheumatoid arthritis, back pain, depression, etc. • Offers patients to log their pain throughout the day using a customized scale • Provides a color-coded calendar to view the pain progress at a quick glance • Allows the patients to share pain information with the doctors • Offers calendar for managing appointments • Allows to take pictures to log symptoms and to set reminders for logging regular entries • Tracks weather changes and offers an insight on how pain changes in relation to weather • Creates interactive graphs presenting pain symptoms and helps to identify the major source of pain

Table 3 Smartphone apps for mental health management

App name	Features
Moodfit [18]	• Customized for users • Suggests daily mental workout goals for remaining fit • Maintains a mood journal • Maintains a gratitude journal to encourage positive thinking • Offers cognitive behavioral therapy (CBT) for managing issues such as personalizing, overgeneralizing, or overthinking • Offers standard assessments for mental health such as GAD-7 and PHQ-9 • Offers meditation and breathing exercises • Suggests sleep and lifestyle routines • Connects with the most appropriate therapist or coach • Tracks activity and its impact on mood • Conducts data analysis and offers summarized, customized reports
eMoods [19]	• Tracks issues related to disorders of anxiety, PTSD, depression, and bipolar I and II • Helps to identify the triggers and patterns related to stress with the help of rich visualizations • Integrates with the weather updates to evaluate the impact on mood • Provides reminders for logging in the details, taking medications, etc. • Maintains mood and symptom diary including details about sleep and medications • Provides configurable graphs • Offers detailed reports to the doctors via email every month • Offers access to a dedicated member-only forum where patients can interact with other community members with similar mental health issues
Bearable [20]	• Tracks patient-reported outcomes • Keeps track of daily activities, mood, symptoms, medication, exercise, and food intake • Can synch with physical parameter monitoring such as number of steps, blood pressure, heart rate, and weight • Customized interface • Offers unique insights into the factors which affect mood • Develops reports comprising graphs and key health statistics. Sets reminders. Works ensuring security and encryption of data
Shine [21]	• Offers guidelines for personalized self-care • Provides daily tips for meditations based on weekly intention and daily mood • Offers a library of over 1000 meditation exercises • Offers community support from other users and mental health experts
MY3 [22]	• Suicide prevention app • Provides customized safety plans • Tracks warning signs and timely offers coping strategies to deal with the situation • Connects to the community and helpful resources • Connects to three people in case of developing suicidal thoughts • Connects to a direct contact from National Suicide Prevention Lifeline and 911

Table 3 (continued)

App name	Features
What's Up [23]	• Manages anxiety, anger, depression, and stress using therapies of CBT and acceptance commitment therapy (ACT) • Tracks mood throughout the day and evaluates any historical patterns • Tracks positive and negative habits and recommends the coping strategies • Maintains a diary where users can maintain their feelings, thoughts, and mood ratings • Provides well-being awareness and encourages the users to set goals • Provides "Get Grounded" to gauge the exact feelings of users • Provides "Thinking Patterns" to avoid negative internal monologues • Connects to local and national mental and well-being professionals and provides direct messaging feature • Provides daily motivational and inspirational quotes • Facilitates mental health and well-being management at the workplace • Users may show concern and identify risks for colleagues

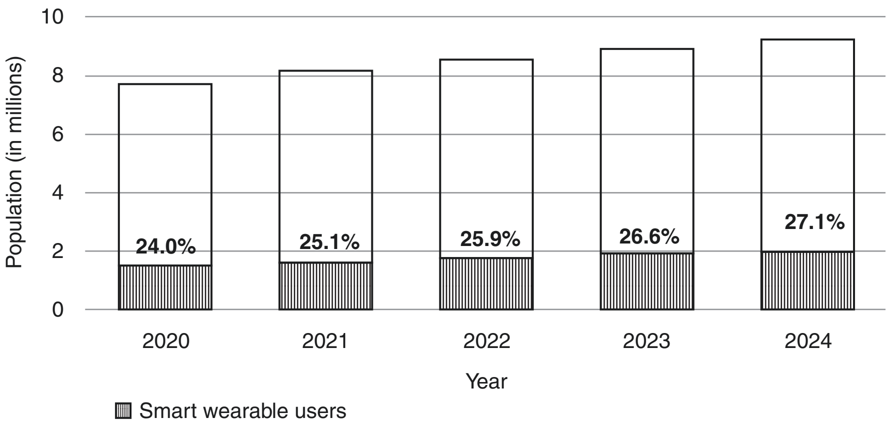

Fig. 1 Trends in the usage of wearable devices

3 Internet of Medical Things (IoMT)

IoMT refers to the collection of sensors, user handheld/wearable/implantable devices, servers, and software applications that allows data collection from users and reporting it to the remote users [24]. The data collected from IoMT devices is stored on cloud for easy storage and retrieval by the caregivers. IoMT has been used for hospitalized as well as at-home patients. Furthermore, the users may wish to acquire an IoMT solution for tracking their day-to-day fitness routines. Some of the major areas of IoMT offering personalized care are described in this section:

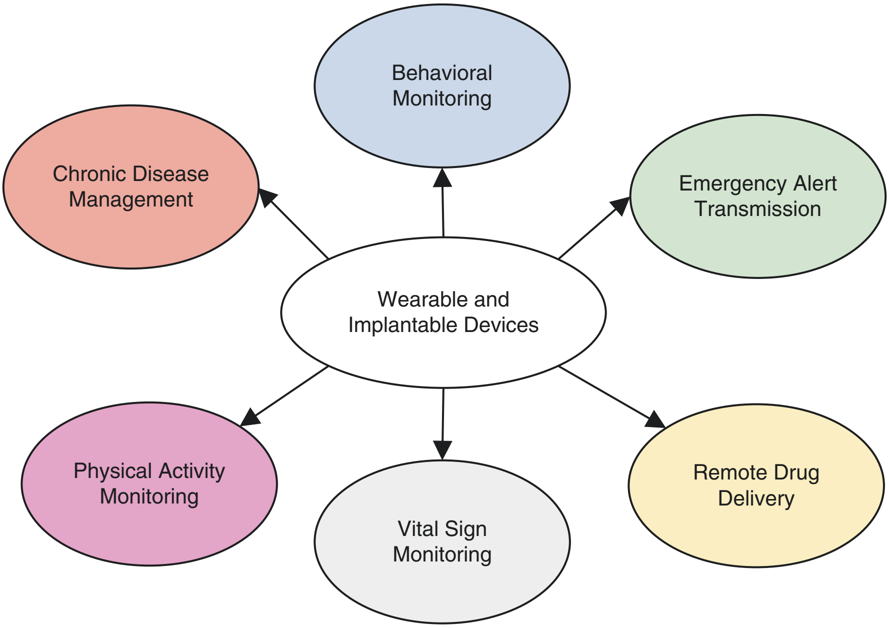

Fig. 2 Healthcare applications of wearable and implantable devices

3.1 Wearable and Implantable Devices

The use of wearable devices has been increasing over the past decade, and the trend is expected to continue in the future. Figure 1 shows an estimate of the number of smart wearable users during the period 2020–2024 in the US adult population. Use of wearable devices provides a sense of better control over health to the users as they continuously receive their health statistics, and they can also remain connected with the emergency care providers. Some of the core applications of wearable and/or implantable devices are presented in Fig. 2.

IoMT technology has also advanced beyond wearable technology, and the domain of implantable devices is the new future. Dedicated technologies and materials such as Tera-Hz and molecular communication [25] and graphene sensors [26] function inside the human body, from where critical biological parameters can be detected much earlier than the wearable devices. Some of the major applications which could be facilitated with the help of implantable devices are presented in Fig. 3.

3.2 Ambient Assisted Living (AAL)

Ambient assisted living (AAL) is the emerging concept that refers to providing care to the independently living elderly with the help of technology. Various technologies such as smart devices, medical sensors, Web and mobile applications, and

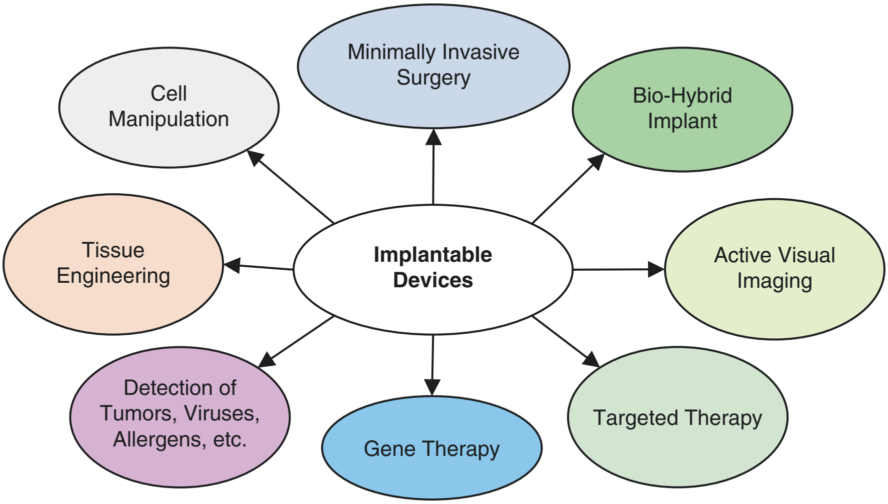

Fig. 3 Applications of implantable devices

wireless networks assist elderly to live safely at their homes, without the need of dedicated attendants [27]. To some extent, AAL has been designed to make the elderly self-dependent and reduces the healthcare burden on families and state. IoT solutions to support AAL are designed to be highly customizable to integrate with the unique lifestyle of elderly customers. There are various examples where AAL comes into play: automating the home as per the user requirement, behavioral monitoring, detection of smoke or emergency situations, protection against intrusion/burglary, etc. [24]. In addition to offering continuous remote health monitoring with the help of ambient, wearable, and implanted sensors, AAL also provides preventive measures and treatment strategies based on the analysis of regularly collected data.

3.3 Alternative Medicine

Stress is an integral part of our day-to-day life. Stress when magnified can lead to depression. Stress can result in increase in a person's heartbeat, blood pressure, cortisol level, and several other parameters. Stress can be reduced by conventional methods like taking pills, which in turn can have several side effects. Music therapy is an emerging alternative medicinal technique capable of reducing stress effectively. Music therapy helps a person to calm down his/her brain waves. This, in turn, would reduce the stress of a person and consequently all the parameters of stress like heartbeat, blood pressure, and cortisol level. The concept of the IoT is used to confirm whether music therapy is effective on stress or not. Sensors are used to measure the body parameters related to space, and sensor observations are used to keep track of the person's body parameters and the effect playing music will have on the body parameters and how music playing will help in bringing down stress.

The adaptation of value cycles to address the rapid changes in customer expectations requires agile digital platforms with dynamic software ecosystem interacting with multiple actors that can be enabled through the IoT networks. Agile digital platforms can provide tailored services to particular requirements of different demographics. An agile platform is developed in [28] to manage activities of clinical and nonclinical service providers where the platform design is based on the data collected from a large group of aged population. Agile platform is also developed in [29] to support patients suffering from psychological ailments leveraging benefits of technologies like IoMT, AI, and natural language processing.

3.4 Integration with Artificial Intelligence

For most deployment of the IoT relating to healthcare, artificial intelligence (AI) has been playing a vital role. Various IoT solutions integrate with machine learning algorithms for the purpose of identifying trends and risks in individual health [30]. Essentially, IoT systems hold the capability of generating massive amounts of data, whereas AI techniques use this data to describe the interesting trends. Similarly, the data collected from multiple users via IoT solutions have been used to train machine learning models and to perform predictive analysis for the patients with similar presenting symptoms. For example, data about heart health may be collected from patients suffering from chronic heart diseases, and population risk level may be defined with the help of machine learning techniques; this could help care providers with a chance to develop effective prevention and treatment strategies. Hence, the data which smart sensors and devices generate becomes much more valuable after going through the machine learning algorithms, as useful insights are generated, and anomalies are identified.

3.5 Integration with Big Data Analytics

Since the core of the IoT application in healthcare is data generation, it is used for generating knowledge and wisdom about the health status of users. The knowledge generation pyramid for the IoT applications based on the data collected from physiological and psychological sensors is illustrated in Fig. 4. The data is transformed into information, knowledge, understanding, and finally wisdom. For a specific scenario of the IoMT, the data is collected from wearable or implantable devices, health trends are identified, relationship between health trends and lifestyle choices as well as disease history is sought, and big data analytics techniques are used for predicting disease risk in the future. Finally, based on the predictive analytics, effective treatment strategies and preventive measures are devised. Hence, the raw data which was of low value for the patients and medical professionals is transformed into high-quality decisions by virtue of IoMT.

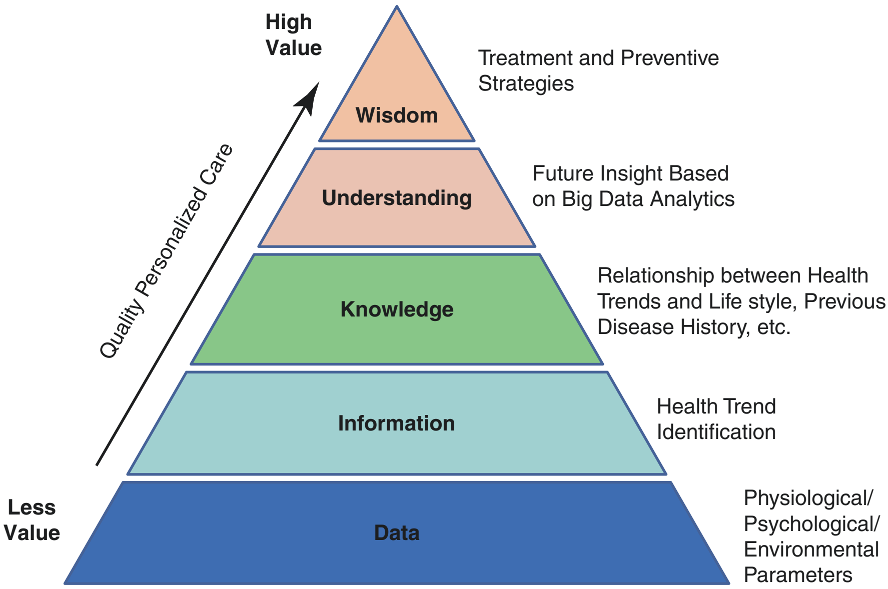

Fig. 4 Transforming data into wisdom via the IoMT

4 Challenges for Using Technology for Personalized Care

4.1 User Privacy

The core of using the Internet for delivering personalized healthcare lies at collecting data from diverse types of devices, operating in heterogenous communication environments. This data is subsequently stored and accessed via cloud from remote locations. Ensuring that data remains secured and protected from the third-party access has been a unique challenge.

4.2 System's Reliability

Although there have been rapid advancements in the use of Internet technologies for offering innovative healthcare services to the patients, questions have often been raised about the integration of evidence-based treatment strategies. Mostly, systems are designed based on clinical studies where the impact of using digital devices was not incorporated [31]. Therefore, a gap exists for conducting and reporting clinical trials for the thousands of smart applications and hardware solutions available.

4.3 Digital Literacy

Medical professionals often do not possess the digital skill set required to offer high-quality and seamless consultation/counseling for patients in the online environment. The lack of skills creates serious hurdles in managing intervention for patients in the digital environment, as compared to the conventional physical clinics [32]. Doctors, nurses, and other medical staff should be able to seek, find, and understand health information from the digital resources, to apply it to solve a health problem. On the other hand, it is also crucial for the patients and their attendants to possess a basic level of digital literacy. This is because the IoT sensors meant for providing remote care for patients at their homes may, at times, need reconfiguration or resetting. In case the patients are not aware of even the basic usage of wearable and handheld devices, the performance and reliability of IoT solutions for healthcare degrade.

4.4 Network Infrastructure Security

As the healthcare industry is moving towards digitization, hospitals become responsible for keeping patients' data private and secure. Hospitals not only access electronic medical records (EMRs), medical management systems, imaging, biomedical information, patient accounting, hospitalization information, material management, and online claim submissions digitally, but also often capture data from the mobile devices as well. As a result, hospitals face novel security threats where hackers and intruders, computer viruses, and human errors may pose serious risks to the patients' security [33]. Mostly, hospitals develop formal security policy to define acceptable use, roles, responsibilities, and security practices. Vulnerability assessment is regularly conducted for the network infrastructure using established best practices; these activities guide the management to identify the potential vulnerabilities and implement security strategies to deal with them. Although there are network security tools available for preventing the security breaches, hospitals need to regularly evaluate their infrastructure and policies to avoid data leakage.

4.5 Legal and Ethical Dimensions

Since the use of Internet technologies in the domain of healthcare is still in infancy, one of the major challenges is to design and implement the relevant ethical and legal aspects. The range of devices and applications used in the healthcare environment makes it difficult to develop a unified set of policies. The law is not construed to keep up with the rapidly progressing applications and technologies of IoT in the healthcare, due to which the ownership of data often becomes debatable [34]. Another challenge is that some digital health solutions claim to improve the privacy, but at the same time deliver patients' data to remote locations for continuous monitoring; for example, the mobile applications providing mental health services to patients in the comfort of their homes, without the need to consult therapists, deliver data to the mental health experts, which defies the goal of maintaining privacy.

Today, most of the IoT solutions can capture data about patients and can deliver to the third party even without the user's knowledge. The users may not be aware of the permissions the healthcare applications ask for, and as a result, they may become vulnerable to intrusions and data theft. Therefore, usage of Internet technologies in the health sector has the potential to bring improvement to individual and population health and well-being; at the same time, there is a need to develop comprehensive policies and laws to protect informational and personal privacy of the users.

5 Future Directions

L'Oréal introduced a smart hairbrush designed to minimize the damage of split ends and breakage associated with forceful hair brushing. It is also capable of monitoring the effects of different hair care routines and providing customized product recommendations. The product called Kérastase Hair Coach has multiple sensors embedded in the brush that send data via Wi-Fi or Bluetooth to a dedicated app, which provides information about the quality of hair and brushing patterns. In addition, the product considers weather factors such as humidity, temperature, UV, and wind to provide user experience of a new generation.

Another bright perspective that the IoT technology trend brings is related to personal care for senior citizens. The demographic trend for the past couple of decades is negative in most of the developed countries. Logically, the senior population (age 65+) is only going to grow percentage-wise. The IoT can help our loved ones live their golden years to the full extent and take better care of themselves. This personal care technology trend is, in fact, part of many active aging strategies supported by Western governments.

The IoT-based technology can collect health, emotional, and cognitive data from sensors, smart meters, and video and audio devices. Then, it can provide recommendations for a healthy diet, lifestyle, and hobbies. More importantly, such personal care technology is capable of monitoring a person's vital signs and medication, which can prevent potentially fatal incidents caused by unawareness of a senior citizen.

Still, if a problem arises (e.g., physical injury), IoT-based devices can immediately notify the person's loved ones, caretakers, or emergency services, significantly reducing the chance for a fatal outcome. The only thing holding back this personal care technology trend is the high price of IoT-connected devices at the moment. However, we expect this to change in the near future, and in the next few years, the mass consumer is likely to possess at least a few personal care connected devices.

5.1 Improvements in AI Algorithms and Integration with the IoT

Since the use of the IoT and AI, both in the healthcare sector, is somewhat recent, there is a chance for lots of improvement in these technologies independently, as well as in the methods used for integrating these. On the one hand, there is a need to improve the reliability and accuracy of the data generated by IoT sensors, and on the other hand, the self-learning and improving technologies of AI are continuously evolving.

The brightest example of artificial intelligence technology in healthcare is chatbots. They have become a valuable asset to companies of all scales because the technology is good for various purposes including personal care, customer service, or information acquisition.

Still, as this is an arguable topic, we must clarify that not all chatbots classify as AI. The majority of the simpler versions scan for keywords within the input and then pull a reply with the most matching keywords, or the most similar wording pattern, from a database. On the other hand, advanced chatbots are equipped with natural language processing systems that allow them to analyze human speech and learn based on the conversation.

In future, AI based on ML algorithms is going to derive most operations involving automation through decision-making without any human intervention. AI is also going to pervade personal healthcare technology assisting in data analysis and then activating proper care-and-cure or emergency action.

Having this in mind, it is not surprising that healthcare companies have been exploring the possibilities that artificial intelligence provides. There have been reports of startups acting on this technology trend to determine the best skincare routines for people based on their skin type and needs, and we expect this personal care technology trend to continue in the next years.

5.2 Investments in Digital Platforms

The outbreak of COVID-19 and its lingering effect have enforced new challenges on people and organizations. Such challenges have driven the introduction and adaptation of new concepts like social distancing and technologies like cloud computing, IoT, ML, and AI for different application scenarios. The largest technology drive has been in the form of the IoT for healthcare and will continue to grow and accelerate as the pandemic continues. Based on the IEEE's global survey, 42% out of 350 CIO and CTO participants announced that they will enhance and accelerate their strategies regarding the adoption of IoT technologies in different application scenarios.

Risk of human loss can be largely reduced through small wearable and environmental monitoring devices that can predict and inform patients through real-time collection and analysis of body and environmental parameters. Relevant data can be shared with physicians and emergency responders to activate appropriate action as and when required.

IoT devices can also be deployed within hospital facilities in order to cater to the needs of the admitted patients as per requirement, thereby reducing any waiting time in receiving the treatment. Collecting body parameters from the patients can also be automated without necessitating any human intervention. All the IoMT devices can communicate data over a cloud computing platform via gateways in globally shared data and take action over a single architecture, a system referred to as health information management system.

The IoT for healthcare or the IoMT evolved manifold to reach its current form that is capable of delivering personalized and industrial requirements. The global healthcare IoT market size is expected to grow from $72.5 billion in 2020 to $188.2 billion in 2025 at a CAGR of 21.0% over a period of 5 years. Highly populated countries like China, Japan, and India are resorting more and more to IoT technologies to manage the ever-increasing demands of the healthcare industry.

5.3 Emerging Applications

There have been numerous novel healthcare applications that have recently been introduced with which the information technology or mobile applications have been integrated. For example, a few years ago, there was no application present for detecting or helping with anxiety, but today, we have hundreds of such applications. Similarly, the concepts of smart healthcare are rapidly evolving with the developments made in the domain of smart city. Privacy, cost, and personalization are the major features of healthcare technologies due to which they are being heavily accepted among the society. Therefore, it is expected that as the new healthcare applications will continue to introduce, so would the development of new sensors and new mobile applications for supporting the notion of advanced personalized care.

6 Summary

The Internet technologies have increasingly been used for offering users to take control of their own healthcare. Patients are provided with smartphone applications and wearable/implantable devices with the help of which they can not only self-manage their conditions but also provide detailed real-time data to the caregivers. Chronic disease management, mental health management, and fitness tracking are the most common areas where Internet technologies are used today. In future, it is expected that as the sensor technologies further improve, new opportunities using intra-body communication methods shall be introduced commercially. In short, use of technology promises to revolutionize the healthcare soon while enhancing the quality of life and reducing the healthcare burden.

References

1. Chhetri B, Goyal LM, Mittal M, Battineni G. Estimating the prevalence of stress among Indian students during the COVID-19 pandemic: a cross-sectional study from India. J Taibah Univ Med Sci. 2021;16(2):260–7. https://doi.org/10.1016/j.jtumed.2020.12.012.
2. Tasnim F et al. Towards personalized medicine: the evolution of imperceptible health-care technologies. Foresight; 2018.

3. Cannata R et al. The relationship between intensity of fitness tracker usage and motivation. Williams Honors College, Honors Research Projects. [Online]; 2020. November 5, 2021. https://ideaexchange.uakron.edu/honors_research_projects/1047.
4. MyFitnessPal Fitness starts with what you eat. [Online]. MyFitnessPal; 2021. November 5, 2021. https://www.myfitnesspal.com/.
5. RunKeeper Join the running community. [Online]. RunKeeper; 2021. November 5, 2021. https://runkeeper.com/cms/.
6. Strava Building the home for your active life [Online]. Strava, 2021. November 4, 2021. https://www.strava.com/about.
7. Yogastudio Beautiful HD Video Yoga Classes for Everyone [Online]. Yoga Studio, 2021. November 5, 2021. https://yogastudioapp.com/.
8. Sworkit Fitness Made Simple [Online]. Sworkit, 2021. November 5, 2021. https://sworkit.com/.
9. JEFIT Manage & Track all your workout in one place [Online]. JEFIT, 2021. November 5, 2021. https://www.jefit.com/.
10. Viegi G, et al. Global burden of chronic respiratory diseases. J Aerosol Med Pulmon Drug Deliv. 2020;33:171–7.
11. Medisafe supporting patients in their moments [Online]. Medisafe, 2021. November 3, 2021. https://www.medisafe.com/solutions/.
12. MangoHealth digital hub and patient engagement platform [Online]. Mango Health, 2021. November 4, 2021. https://www.mangohealth.com/.
13. GOLD global initiative for chronic obstructive lung disease—GOLD [Online]. GOLD, 2021. November 2, 2021. https://goldcopd.org/.
14. MySugrJunior Your diabetes data, simply there [Online]. MySugr, 2021. November 3, 2021. https://www.mysugr.com/en/.
15. SmartBP A smarter way to manage your blood pressure [Online]. SmartBP, 2021. November 5, 2021. https://www.smartbp.app/.
16. MyPainDiary My Pain Diary: Gold Edition [Online]. MyPainDiary, 2021. November 5, 2021. http://mypaindiary.com/.
17. Battineni G, Chintalapudi N, Amenta F. AI chatbot design during an epidemic like the novel coronavirus. Healthcare (Basel). 2020;8(2):154. https://doi.org/10.3390/healthcare8020154.
18. Moodfit Moodfit: Fitness for Your Mental Health [Online]. Moodfit, 2021. October 28, 2021. https://www.getmoodfit.com/.
19. eMoods eMoods Insights Mood Tracking App Features [Online]. eMoods, 2021. November 8, 2021. https://emoodtracker.com/features.
20. Bearable Track anything and discover how it affects your health. [Online]. Bearable, 2021. November 8, 2021. https://bearable.app/.
21. Shine Your self-care ritual, made easy [Online]. Shine, 2021. October 25, 2021. https://www.theshineapp.com/.
22. MY3 MY3 Mobile App [Online]. MY3, 2021. November 8, 2021. https://zerosuicide.edc.org/resources/resource-database/my3-mobile-app.
23. Whatsup? We Put Your Wellbeing Team into Your People's Pockets. [Online]. Whatsup? 2021. November 8, 2021. https://www.thewhatsupapp.co.uk/.
24. Mittal M, Battineni G, Singh D, Nagarwal T, Yadav P. Web-based chatbot for frequently asked queries (FAQ) in hospitals. J Taibah Univ Med Sci. 2021;16(5):740–6. https://doi.org/10.1016/j.jtumed.2021.06.002.
25. Yang K, et al. A comprehensive survey on hybrid communication in context of molecular communication and terahertz communication for body-centric nanonetworks. IEEE Trans Mol Biol Multi-Scale Commun. 2020;6:107–33.
26. Kulakowski P, Turbic K, Correia LM. From nano-communications to body area networks: a perspective on truly personal communications. IEEE Access. 2020;8:159,839–53.
27. Cicirelli G, et al. Ambient assisted living: a review of technologies, methodologies and future perspectives for healthy aging of population. Sensors. 2021;21(21):3549.
28. Trattner A, Hvam L, Forza C, Herbert-Hansen ZNL. Product complexity and operational performance: a systematic literature review. CIRP J Manuf Sci Technol. 2019;25:69–83.

29. Mittal M, Battineni G, Goyal LM, Chhetri B, Oberoi SV, Chintalapudi N, Amenta F. Cloud-based framework to mitigate the impact of COVID-19 on seafarers' mental health. Int Marit Health. 2020;71(3):213–4. https://doi.org/10.5603/IMH.2020.0038.
30. Pawar U. et al. Explainable AI in healthcare. IEEE international conference on cyber situational awareness, data analytics and assessment (CyberSA); 2020.
31. Maksimović M, Vujović V. Internet of things based e-health systems: ideas, expectations and concerns. Cham: Springer; 2017.
32. Lee H, et al. Discrepancies in demand of internet of things services among older people and people with disabilities, their caregivers, and health care providers: face-to-face survey study. J Med Internet Res. 2020;22(4):e16614.
33. Butpheng C, Yeh KH, Xiong H. Security and privacy in IoT-cloud-based e-health systems—a comprehensive review. Symmetry. 2020, 12(7):1191.
34. El-Khoury M, Arikan CL. From the internet of things toward the internet of bodies: ethical and legal considerations. Strategic Change. 2021;30(3):307–14.

Smartphone Applications for Monitoring Physical Activities

Rashmi Gupta and Jeetendra Kumar

1 Introduction

Ambient assisted living involves the use of devices to assist older people to live independently, and it also assures the safety of older people. Ambient assisted living is a subarea of ambient intelligence. Nowadays, the trend of nuclear families has increased, which has left older people single-handed at home. This condition has pushed them into an unsafe situation. AAL has assisted people who are living alone and ensured their safety. Human activity recognition is one of the important subareas of ambient assisted living. In human activity recognition, activities like walking, jumping, running, and sitting are recognized automatically by analyzing time-series signals generated from various sensors. In many smart home contexts, it has garnered great attention, particularly to regularly monitor human behavior in the environment in order to provide care and rehab for aged people.

The population of older aged people is increasing continuously. The main reasons behind the increase in the population of older aged people are (1) availability of good health services and (2) increasing trend towards having less number of children. According to one report of Mordor Intelligence [1], "Number of people aged above 80 years was projected to increase by more than threefold between 2017 and 2050, rising from 137 million to 425 million, and according to the UN data, in 2019, there were 703 million people aged 65 or older, and the number is projected to reach 1.5 billion by 2050." Due to the increase in the population of elder people, many of them are living alone. Many potential plans have been underlined for addressing problems related to the population. On the other hand, with the expansion of electronic communication networks, remote monitoring has been adopted as

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_12

a resource for caring for elderly people while at the same time maintaining their independence in modern lifestyles.

According to a new report of Grand View Research, “The global virtual sensors market size is expected to reach USD 1.4 billion by 2025, expanding at a CAGR of 27.2%. Growing use of virtual sensors in the human activity recognition and in the healthcare domain is driving the market” [2]. Applications of human activity recognition are activity monitoring, unsafe activity (like unintentional fall) monitoring, suspicious activity monitoring, security-related applications, etc.

1.1 Human Activity Recognition

Human activity recognition exploits sensor technologies, machine learning technologies, communication technologies, and Internet of Things. Sensors like accelerometer, gyroscope, magnetometer, and vision-based sensor are used for sensing the surrounding, body movement, and hand or leg movements. All the sensed data is transferred to the computing devices. Machine learning algorithms are used to learn the patterns of sensor signals for specific activities. Using machine-based developed models, specific activities can be identified. Earlier, only some specific activities like running, walking, sitting, and climbing could be identified, but nowadays some specific activities like making tea, reading the newspaper, studying, and hand movements can also be identified. Now, many activity recognition algorithms are implemented in the Internet of Things (IoT) scenario. Implementing activity recognition algorithms in the IoT enables remote monitoring and real-time activity prediction. Figure 1 shows the general framework of human activity recognition.

Human activity recognition is a very broad area and can be categorized as follows (Fig. 2):

- Based on device
  - Sensor-based activity recognition
  - Vision-based activity recognition

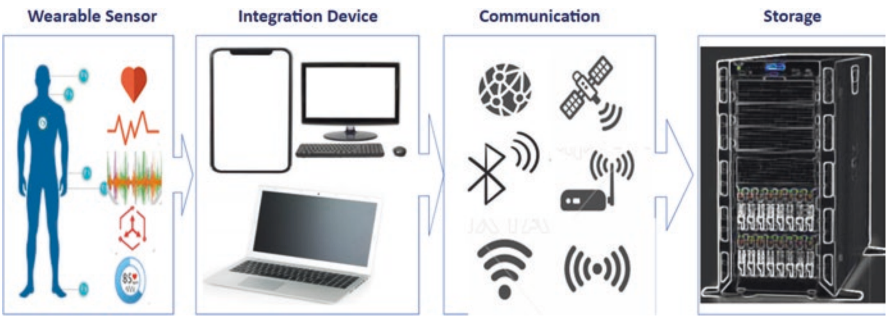

Fig. 1 General framework of human activity recognition

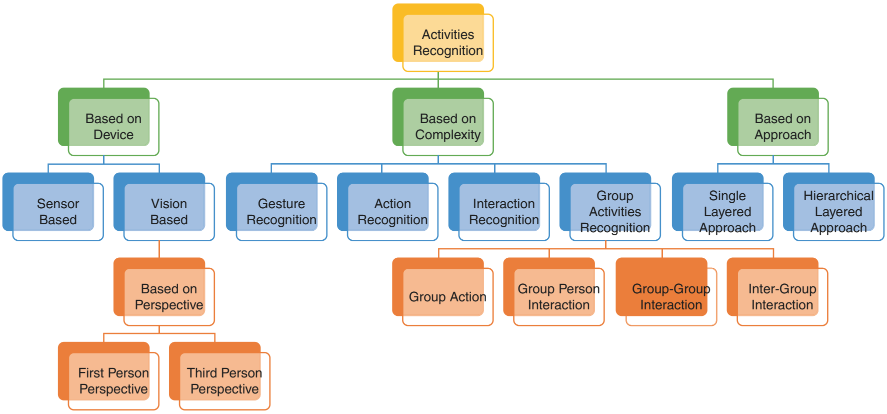

Fig. 2 Categories of human activity recognition

- Based on complexity
  - Gesture recognition
  - Activity recognition
  - Interaction recognition
  - Group activity recognition
- Based on approach
  - Single-layered approach
  - Hierarchical approach

Human activities are generally categorized as follows:

- **Ambulation Activities:** Walking, running, standing, sitting, walking upstairs and downstairs, etc.
- **Transportation Activities**: Riding bicycle, driving, cycling, etc.
- **Living Activities:** Eating, brushing, cooking, reading, clapping, washing clothes, wearing clothes, shaving, sweeping, opening doors, falling, etc.
- **Exercise:** Jogging, spinning, doing pushups, riding cycle, doing yoga, etc.

1.2 Attributes Measured for Human Activity Recognition

The following signals are measured for human activity recognition:

(a) **Environmental Attributes:** Temperature, humidity, audio level, and other factors are used to convey the context information about the individual's surroundings. For example, if the audio volume and light intensity are both low, the individual may be sleeping. Microphones, light sensors, humidity sensors, and thermometers have all been used in previous systems. Individuals can conduct each activity in a variety of contextual variables in terms of weather, audio volume, and illumination; therefore, those sensors alone may not provide enough information. As a result, accelerometers and other sensors are frequently used in conjunction with environmental sensors.

(b) **Ambulation Attributes:** The most widely used sensors for detecting ambulation activities are triaxial accelerometers (e.g., walking, running, lying). Accelerometers are inexpensive, need little power, and are found in the majority of today's mobile phones. Other common actions, such as eating, working at a computer, or brushing one's teeth, are, however, perplexing in terms of acceleration. Because of the arm motion, eating could be mistaken for brushing teeth.

(c) **Location Attributes:** All location-based services rely on the global positioning system (GPS). Because modern cellular phones include GPS devices, this sensor is ideal for context-aware applications such as recognizing the user's method of mobility.

(d) **Physiological Attributes:** A few works have also considered vital sign data (e.g., heart rate, respiration rate, skin temperature, skin conductivity, ECG). Tapia et al. [3] suggested an activity recognition system that uses data from five triaxial accelerometers and a heart rate monitor to recognize users. They determined, however, that the heart rate is ineffective in a HAR context because, after doing physically demanding activities (e.g., jogging), the heart rate remains elevated for a period of time, even if the subject is lying or sitting.

1.3 Smartphone

Nowadays, smartphones are penetrating the society and becoming the basic needs. Smartphone-based sensors are becoming increasingly common, as the balance between accuracy and usability of data obtained has demonstrated this specific technology to be the reason for the popularity of smartphones, which are not only for call or text facilities but also for computing and communication facilities. Advances in smartphones make them equipped with a variety of sensors like motion sensor, environmental sensor, position sensor, ambient light sensor, proximity sensor, barometer sensor, compass sensor, pedometer sensor, hall sensor, IR sensor, and camera; communication modules like Wi-Fi, Bluetooth, and NFC and having quad-core CPU facilities for performing computation renovate a simple phone to a smartphone.

Due to the handy and simple-to-use nature of smartphone, it is being used for activity recognition also. Human activity recognition exploits the use of accelerometer, gyroscope, and magnetometer for real-time prediction of human activities. These sensors generate different signals based on the body movement of the person. In some methods, sensor data is itself analyzed in smartphones, and other data is transferred to the cloud or nearby fog node.

Advantages of Using Smartphones for Activity Recognition

1. **Users are familiar with the use of a smartphone:** In the case of using extra devices for activity recognition, many people do not want to learn the

functionality of new devices. Elderly people can freely use the smartphone, and they are aware of its functionality. So, activity recognition methods implemented on smartphone are very well accepted by elderly people.

2. **Not required to purchase extra device:** In many cases, it has been seen that many elderly people resist to keep an extra device with them all the time. Purchasing activity recognition devices incurs extra expenditure on people. When activity recognition is done through a smartphone, no extra device is required to purchase.
3. **Availability of computing facilities:** Availability of computing facilities enables the smartphone to perform activity recognition tasks within itself. In the case of the IoT or fog computing, preprocessing of data can be performed on smartphones, and for further analysis, data can be transferred to the cloud.
4. **Variety of sensors:** Smartphones are equipped with a variety of sensors. So, using the smartphone for activity recognition does not need to purchase extra sensors and to develop programs for their interfacing.
5. **Easy communication:** Smartphones have many communication modules like GSM, Wi-Fi, Bluetooth, and NFC, which enables them to transfer data in every condition. With the usage of communication modules, sensed data can also be transferred to the cloud.
6. **Almost every person has smartphone:** One more reason for using activity recognition is that every class of people, either poor or rich, either older or younger, have smartphones. So, activity recognition methods implemented in the smartphone can easily be part of society.

Disadvantages of Using Smartphones for Activity Recognition

1. **Battery drain:** Implementing activity recognition algorithms on smartphones results in fast battery drain. Because when smartphone sensors like accelerometer and gyroscope continuously generate data (with 50 Hz or 100 Hz frequency), then handling and analyzing continuously generated data require continuous CPU usage that can cause frequent battery drain.
2. **Phone calls can disrupt the Internet connection:** Smartphones are not dedicated devices for activity recognition, so continuous phone calls can disrupt the Internet connection.
3. **Slow processing with heavy ML model:** Sometimes, activity recognition models have been built upon machine learning methods that consume heavy batteries and need additional storage, so these ML models can slow the working of the smartphone.
4. Some activities like heavy exercise, running, and sleeping cannot be detected using a smartphone. These activities are generally not recognized because during these activities people do not want to keep mobile in their pocket.
5. Users are forced to keep smartphone with them continuously: While running activity recognition algorithms on smartphone, users are forced to keep smartphone with them all the time. This can irritate old people sometimes even when sleeping also.

1.4 Enabling Sensors

In smartphone-based activity recognition, the most commonly used sensors are accelerometer, gyroscope, and magnetometer.

(a) **Accelerometer:** Accelerometer is an electronic device that measures linear acceleration in *x*-, *y*-, and *z*-directions. The accelerometer sensor embedded in the smartphone is used to detect the orientation of the smartphone. Accelerometers are electromechanical devices that detect both static and dynamic acceleration forces. Gravity is an example of a static force, whereas vibrations and movement are examples of dynamic forces. The accelerometer is a low-power device that generally requires 5 V supply voltage. Figure 3 shows the pattern of accelerometer signals.

(b) **Gyroscope:** A gyroscope is a device that detects the departure of an object from its target orientation by using a fast-rotating wheel or a circulating beam of light. "The basic effect upon which a gyroscope relies is that an isolated spinning mass tends to keep its angular position with respect to an inertial reference frame, and, when a constant external torque (respectively, a constant angular speed) is applied to the mass, its rotation axis undergoes a precession motion at a constant angular speed (respectively, with a constant output torque), in a direction that is normal to the direction of the applied torque (respectively, to the constant angular speed)" [4]. Figure 4 shows the pattern of gyroscope signals.

(c) **Magnetometer:** The most widely used sensors for activity recognition are accelerometer and gyroscope, but in some research work magnetometer is also used. "The magnetometer sensor in your tablet or smartphone also utilizes the

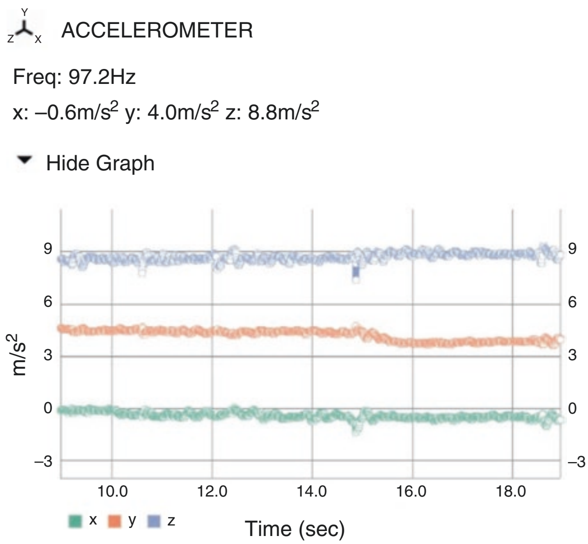

Fig. 3 Accelerometer signals

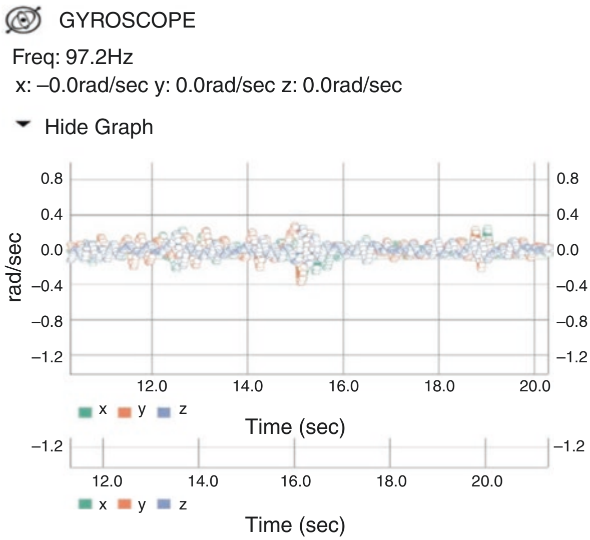

Fig. 4 Gyroscope signals

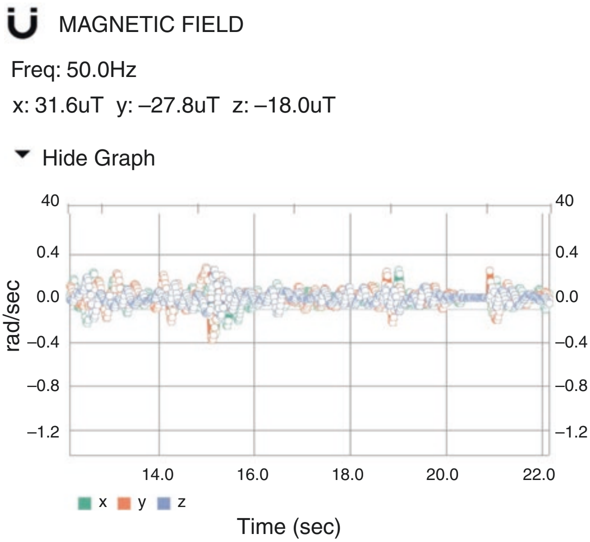

Fig. 5 Magnetometer signals

modern solid-state technology to create a miniature Hall-effect sensor that detects the Earth's magnetic field along three vertical axes *X*, *Y*, and *Z*. The Hall-effect sensor produces voltage, which is proportional to the strength and polarity of the magnetic field along the axis each sensor is directed. The sensed voltage is converted to digital signal representing the magnetic field intensity" [5]. Figure 5 shows the pattern of magnetometer signals.

1.5 Communication Modules

(a) **Wireless fidelity:** The wireless technology used to link computers, tablets, cellphones, and other devices to the Internet is known as Wi-Fi. Wi-Fi is a radio signal transmitted from a wireless router to a nearby device, which converts the signal into data that can be seen and used. The gadget sends a radio signal back to the router, which is wired or cabled into the Internet. IEEE 802.11 standards define protocols that enable wireless communication over Wi-Fi. It is generally thought that Wi-Fi is an acronym of "wireless fidelity," but it is a misconception. Wi-Fi is a stand-alone word. Wi-Fi provides the flexibility to connect with the Internet under Wi-Fi coverage without a wired connection. Wi-Fi uses radio waves to send data from your wireless network to your Wi-Fi-enabled devices such as your TV, smartphone, tablet, and computer. Because they connect through radios, your gadgets and personal information may become subject to hackers, cyberattacks, and other risks. This is especially true when connecting to a public Wi-Fi network in public locations such as a coffee shop or airport. It is recommended to connect to a password-protected wireless network or a personal hotspot whenever available.

(b) **Bluetooth:** Bluetooth innovation is a fast low-fueled remote innovation interface that is intended to associate telephones or other versatile gear together. It is a particularity (IEEE 802.15.1) for the utilization of low-power radio correspondences to connect telephones, PCs, and other organization gadgets over brief distances without wires. Remote signs communicated with Bluetooth cover brief distances, regularly up to 30 ft (10 m). It is accomplished by installing minimal expense handsets into the gadgets. It upholds the recurrence band of 2.45 GHz and can uphold up to 721 kbps alongside three voice channels. This recurrence band has been saved by peaceful accord for the utilization of modern, logical, and clinical gadgets. It can interface up to "eight gadgets" all the while, and every gadget offers an interesting 48-piece address from the IEEE 802 norm with the associations being tried to point or multipoint.

2 Accelerometer-Based Human Activity Recognition

Due to the ease of use and availability of sensors in smartphones, many methods have been developed to use a smartphone for monitoring physical activities. These smartphones do not create an extra burden on the user to purchase a new device or to learn the working of new devices. Accelerometer is a sensor that is used in most smartphones for sensing the orientation of the phone. Along with the orientation detection of phones, an accelerometer can also be used for detecting monitoring activities. It is one of the most popular sensors for activity identification and human fall detection. The accelerometer measures linear acceleration in *x*-, *y*-, and

Table 1 Accelerometer-based human activity recognition

Work	Year	Activities	Methodology	Dataset used	Results
[6]	2017	Walking, jogging, sitting, standing, upstairs, downstairs, walking, race walking, running, standing, bouncing ball, moving ball, passing ball, throwing ball	MCODE	WISDM Lab dataset Race walking recognition dataset Basketball playing recognition dataset	86% accuracy
[7]	2019	Walking, walking upstairs, walking downstairs, sitting, standing, lying, 12 activities from PAMAP2 dataset	SVM CNN BLSTM LSTM MLP	UCI PAMAP2	Highest 91% accuracy with CNN
[8]	2018	Walking, walking upstairs, walking downstairs, sitting, standing, lying	DBN ANN SVM	UCI	Highest 95.85% accuracy with DBN
[9]	2020	Lying down, standing, bicycling, sitting, running	Context-independent HAR	Extra sensory dataset	87.1% accuracy with RF classifier
[10]	2021	Walking, jogging, going upstairs, going downstairs, siting, standing	Spiking neuron network model	WISDM dataset	Better performance in terms of low computation cost

z-directions. If some person moves or does some activities, then accelerometer reading in *x*-, *y*-, and *z*-directions also changes. Changes in values of accelerometer also follow some pattern according to the type of activity, which helps to identify the type of activities. A lot of research has also been done for detecting physical activities for accelerometer sensors. For discussion purposes, we have selected some recent research methods (shown in Table 1) on activity recognition that use accelerometer sensors only.

3 Sensor Fusion for Human Activity Recognition

It has been seen in many research works that only accelerometer data is not enough for recognizing daily living activities. So, many researchers have used gyroscope and magnetometer sensors along with accelerometers to increase efficiency. In some research works, high accuracy is also achieved along with accelerometer only, but the accuracy of different work depends on the size of the dataset used and number of subjects under study. Accelerometer, gyroscope, and magnetometer sensors can be easily found in every smartphone. Table 2 shows sensor fusion-based human activity recognition.

Table 2 Sensor fusion-based human activity recognition

Work	Sensor used	Year	Methodology	Dataset used	Results
[11]	Accelerometer, gyroscope	2018	DT SVM KNN AdaBoost Bagging Stacking	Own collected	Highest 99.4% accuracy with SM
[12]	Accelerometer, gyroscope, gravity	2019	Multilayer perceptron	Self-collected data Fusion of smartphone sensor data	87.1% accuracy on internal dataset 76.8% accuracy on external dataset
[13]	Accelerometer and gyroscope	2019	Sequential floating forward search and SVM	UCI dataset	98.13% accuracy
[14]	Accelerometer, gyroscope	2018	GCHAR	UCI HAR dataset	94.1636%
[15]	Accelerometer, gyroscope, magnetometer	2019	FR-DCNN	Own dataset	95.27% accuracy
[16]	Accelerometer and gyroscope	2019	Stacked LSTM	UCI dataset	93% accuracy
[17]	Accelerometer, magnetometer, gyroscope	2019	CNN	Own dataset	98% accuracy
[18]	Accelerometer and gyroscope	2017	Nearest neighbor random forests and support vector machines	Own dataset	96.26%
[19]	Accelerometer, gyroscope	2019	MFAP	UCI dataset Own dataset	98.85%
[20]	Accelerometer, gyroscope	2021	CNN LSTM network	UCI dataset	99.39%
[21]	Accelerometer, gyroscope	2020	Graph neural network	MobiAct WISDM MHEALTH PAMAP2 HHAR USC-HAD	Approx. 100% accuracy
[22]	Accelerometer, gyroscope	2020	EnsemConvNet	WISDM MobiAct UniMiB	Highest 99.7% accuracy
[23]	Accelerometer, gyroscope	2020	FFDRT	UCI HAR repository	98.27%
[24]	Accelerometer, gyroscope	2021	ConvLSTM	Own dataset	73% accuracy
[25]	Accelerometer, gyroscope	2021	Multihead CNN	WISDM dataset UCI dataset	98.18%

4 Artificial Intelligence Methods for Human Activity Recognition

There are many AI techniques for human activity recognition. Approximately all classifiers have been used to classify human activities. Some of the machine learning methods have been discussed here.

(a) **Support Vector Machine (SVM):** Among all well-known machine learning algorithms, the foremost strong and correct technique may be a support vector machine (SVM). Within the case of a two-class learning problem, the target of the SVM is to work out the simplest classification strategy to differentiate activities into two classes. For a linearly separable dataset, a linear classification function represents a separating hyperplane that passes through the center of the two classes. Because there are numerous such hyperplanes, SVM demonstrates that the optimum function is chosen by maximizing the difference between two classes. The margin denotes the amount of space between the two classes. Due to the robustness of this classifier, many human activity recognition methods have used the SVM classifier and achieved good results. In 2017, Chen et al. [26] proposed CT-PCA and online SVM for activity recognition. They considered orientation, placement, and subject variations while detecting activities. They collected data from Google's NEXUS smartphone. They achieved 98.43% accuracy. In 2017, Nurhanim et al. [27] proposed SVM-based human activity classification. They used accelerometer, gyroscope, and magnetometer for data collection. Using multiclass support vector machine with linear and polynomial kernel, they achieved 98.57% accuracy with linear kernel. In 2019, Batool et al. [28] proposed human activity analysis based on SVM optimization. They used an accelerometer and gyroscope sensor for data collection. They achieved 87.50% accuracy with the proposed method. In 2019, Dewi et al. [29] proposed human activity recognition using feature selection and random forest. They achieved high accuracy of 98.16% with a random forest classifier.

(b) **Random Forest:** Random forest is a learning algorithm that is supervised. It is suitable for both classification and regression. It is also the most adaptable and straightforward algorithm. Trees make up a forest. A forest is thought to be more strong the more trees it has. Random forests generate decision trees based on randomly picked data samples, obtain predictions from each tree, and then vote on the best answer. It also serves as a decent indicator of how important a feature is. The random forest, as the name suggests, is made up of a huge number of individual decision trees that work together as an ensemble. The random forest's trees each provide a class prediction, and the class with the highest votes becomes our model's prediction. In 2018, Sandeep et al. [30] proposed a human activity recognition with a modified random forest algorithm. They performed their analysis on the UCI HAR dataset. Using a modified machine learning algorithm, they were able to achieve 92.86% accuracy. In 2019, Dewi et al. [29] proposed a method for human activity recognition using feature selection and random forest learning. For their study, they also used the UCI machine learning dataset. With their method, they were able to achieve 98.57% accuracy with random forest classifier.

(c) **K-NN**: The K nearest neighbor method is a type of supervised learning algorithm that is often used for classification and regression. It is a flexible approach that may also be used to resample datasets and impute missing values. It uses K nearest neighbors (data points) to forecast the class or continuous value for a new datapoint, as the name indicates. Characteristics of the KNN classifier include instance-based learning, lazy learning, and nonparametric learning. In 2018, Menhour et al. [31] proposed human activity recognition from smartphone data. Using a combined approach of LDA, KNN, and SVM, they achieved 99.2% accuracy. In 2021, Saeed et al. [32] proposed human activity recognition using the KNN model. With their proposed method, they achieved 90.96% precision score.

(d) **Artificial Neural Network (ANN):** The term "artificial neural network" describes a branch of artificial intelligence that is influenced by biology and modeled after the brain. An artificial neural network is a computer network based on biological neural networks that create the structure of the human brain. Artificial neural networks, like real brains, contain neurons that are connected to one another at various levels. These neurons are referred to as nodes. Neural networks develop and improve their accuracy over time by utilizing training data. However, once these learning algorithms have been fine-tuned for accuracy, they transform into powerful instruments in computer science and artificial intelligence, allowing us to rapidly categorize and cluster data. In 2018, Mehedi et al. [8] proposed activity recognition using deep learning. They processed extracted features using KPCS algorithm. They trained their model with deep belief networks (DBN). For the purpose of analysis, accelerometer and gyroscope data were used. Using the proposed method, they achieved 95.85% accuracy. In 2019, Myo et al. [33] proposed activity recognition using artificial neural networks. For analysis purposes, they used UCI-HAR dataset, and for classification purpose, they used multilayer perceptron. Using the proposed model, they achieved 98.32% accuracy.

(e) **Convolutional Neural Networks (CNN):** Convolutional neural networks are built from neurons with learnable weights and biases. Each neuron gets input, does a dot product, and then employs nonlinearity if desired. On the one end of the spectrum, the network as a whole still gives a single differentiable scoring function, spanning from raw image pixels to class scores. They still contain a loss function (e.g., SVM/Softmax) on the last (fully connected) layer, and all of the principles and strategies we discovered for learning ordinary neural networks apply. In 2018, Wenchao et al. [34] proposed human activity recognition using the CNN model. They collected data from smartphone accelerometer sensors. With the CNN model, they were able to achieve 91.97% accuracy. In 2019, Wei et al. [35] proposed activity recognition using the CNN model. They also used UCI-HAR dataset for analysis purposes. Using Gramian angular field transform, they converted signal to image form, and then they applied eight-layer convolutional neural network for building the model. Using the proposed method, they achieved 94% precision.

(f) **Long Short-Term Memory (LSTM):** Long short-term memory blocks are used by the recurrent neural network to offer context for how the program accepts inputs and generates outputs. The long short-term memory block is a complex unit with weighted inputs, activation functions, prior block inputs, and eventual outputs. The unit is referred to as a long short-term memory block because the software applies a framework based on short-term memory processes to generate longer term memory. Natural language processing, for example, makes an extensive use of these systems. In 2019, Mohib et al. [16] proposed human activity recognition using stacked LSTM. For the purpose of regularization, they used an L2 regularizer. They performed their analysis on the UCI dataset. Using the proposed method, they achieved 93% accuracy. In 2019, Fabio et al. proposed [36] the use of bidirectional LSTM for human activity recognition. Using bidirectional LSTM, they were able to achieve 92.67% accuracy. In 2021, Sakorn et al. [20] proposed the use of LSTM for activity recognition. They also used UCI-HAR dataset for analysis. With four-layer CNN-LSTM network, they achieved 99.39% accuracy.

5 Human Activity Recognition in IoT/Fog Computing Scenario

Human activity recognition is not a task performed on smartphones only. In smartphone-based human activity recognition, data is collected from smartphone sensors like accelerometers, gyroscopes, and magnetometers. This collected data is preprocessed at smartphones, and preprocessed data is transferred to the cloud. The reason for sending preprocessed data to the cloud which is the basic phenomenon of the Internet of Things is that the smartphone is not a dedicated device for activity recognition. It is used for many other purposes like calling, texting, and Internet surfing. If heavy machine learning algorithms run on the smartphone, then it will be hanged and will consume much battery which will be problematic. So, most of the activity recognition algorithms have been implemented on the Internet of Things scenario. Here, some recent activity recognition research works which have been implemented in the Internet of Things scenario have been discussed in Table 3.

6 Activities that Cannot Be Recognized Using a Smartphone

One of the main limitations of smartphone-based activity recognition is that with the smartphone, all activities cannot be recognized. The reason behind this limitation is that approximately all people carry mobile phones either in their pant pocket or shirt pocket. The activities which cause the movement in the smartphone are recognized like walking, sitting, standing, walking upstairs, walking downstairs,

Table 3 Human activity recognition in IoT/fog computing scenario

Title	Year	Objective	Scenario	Methodology	Results
[37]	2017	To create HAR-IOT system	IoT	C4.5 Naïve Bayes classifier	95.83% correct classification
[38]	2018	To create a mobile healthcare system	IoT	SVM KNN ANN Random forest CART C4.5	99.89% accuracy with SVM
[39]	2018	Energy-efficient human activity recognition system	IoT	Hyperdimensional computing	Accuracy was improved
[40]	2020	Human activity recognition using deep learning	IoT	LSTM	97% accuracy
[41]	2021	Personalized human activity recognition	IoT	Deep recurrent neural networks	99.43% accuracy
[42]	2019	To recognize activities using smart devices	Fog computing	KV-SVM HMM	78% accuracy
[43]	2021	To develop an intelligent system for human activity recognition	IoT	1D-HARCapsNe	98.67% accuracy
[44]	2020	To develop human activity recognition in IoHT	IoT	LSTM with attention	97.5% accuracy
[45]	2021	To develop energy-efficient human activity recognition system	IoT/fog computing	Less interaction between device and cloud	The proposed method required less storage

and running. But the activities which do not cause movement like reading a newspaper while sitting or working on a laptop while sitting cannot be identified using smartphone-based activity recognition methods. These activities can be termed micro-activities. Some other examples of micro-activities are operating the phone, working on the computer, cooking, eating, drinking, and talking on the phone.

7 Conclusion

Human activity recognition is one of the major subareas of ambient assisted living. The task of activity recognition is done by using many sensors. These sensors can be wearable sensors, pervasive sensors, and vision-based sensors. Smartphones are also being used as a device for human activity recognition because smartphones are embedded with a variety of sensors like accelerometers, gyroscopes, and magnetometers. Accelerometer alone can be used for activity recognition, but accelerometer along with gyroscope and magnetometer is also being used to increase the accuracy of human activity recognition methods. Human activity recognition methods are implemented in IoT or fog computing scenarios for real-time notification. Even smartphones can be efficiently used for activity recognition, but some activities that do not cause movement in smartphones cannot be recognized using it.

References

1. Medical Sensors Market | 2021–26 | Industry share, size, growth—Mordor Intelligence. https://www.mordorintelligence.com/industry-reports/medical-sensors-market. Accessed 7 Sep 2021.
2. Virtual Sensors Market Size Worth $1.4 Billion By 2025 | CAGR: 27.2%. https://www.grandviewresearch.com/press-release/global-virtual-sensors-market. Accessed 23 Nov 2021.
3. Tapia EM, Intille SS, Larson K. Activity recognition in the home using simple and ubiquitous sensors. Lect Notes Comput Sci (including Subser Lect Notes Artif Intell Lect Notes Bioinformatics). 2004;3001:158–75. https://doi.org/10.1007/978-3-540-24646-6_10.
4. Passaro VMN, Cuccovillo A, Vaiani L, De Carlo M, Campanella CE. Gyroscope technology and applications: a review in the industrial perspective. Sensors. 2017;17:2284. https://doi.org/10.3390/S17102284.
5. What is magnetometer sensor? | GearBest Blog. https://www.gearbest.com/blog/how-to/what-is-magnetometer-sensor-2866. Accessed 22 Nov 2021.
6. Lu Y, Wei Y, Liu L, Zhong J, Sun L, Liu Y. Towards unsupervised physical activity recognition using smartphone accelerometers. Multimed Tools Appl. 2016;768(76):10701–19. https://doi.org/10.1007/S11042-015-3188-Y.
7. Wan S, Qi L, Xu X, Tong C, Gu Z. Deep learning models for real-time human activity recognition with smartphones. Mob Networks Appl. 2019;252(25):743–55. https://doi.org/10.1007/S11036-019-01445-X.
8. Hassan MM, Uddin MZ, Mohamed A, Almogren A. A robust human activity recognition system using smartphone sensors and deep learning. Futur Gener Comput Syst. 2018;81:307–13. https://doi.org/10.1016/J.FUTURE.2017.11.029.
9. Asim Y, Azam MA, Ehatisham-Ul-Haq M, Naeem U, Khalid A. Context-aware human activity recognition (CAHAR) in-the-wild using smartphone accelerometer. IEEE Sensors J. 2020;20:4361–71. https://doi.org/10.1109/JSEN.2020.2964278.
10. Suriani NS, Rashid F, Atyka N. Smartphone sensor accelerometer data for human activity recognition using spiking neural network. Int J Mach Learn Comput. 2021;11:298–303. https://doi.org/10.18178/IJMLC.2021.11.4.1051.
11. Bulbul E, Cetin A, Dogru IA. Human activity recognition using smartphones. ISMSIT 2018—2nd Int Symp Multidiscip Stud Innov Technol Proc; 2018. https://doi.org/10.1109/ISMSIT.2018.8567275.
12. Voicu RA, Dobre C, Bajenaru L, Ciobanu RI. Human physical activity recognition using smartphone sensors. Sensors (Basel). 2019;19 https://doi.org/10.3390/S19030458.
13. Ahmed N, Rafiq JI, Islam MR. Enhanced human activity recognition based on smartphone sensor data using hybrid feature selection model. Sensors. 2020;20:317. https://doi.org/10.3390/S20010317.
14. Cao L, Wang Y, Zhang B, Jin Q, Vasilakos AV. GCHAR: an efficient group-based context—aware human activity recognition on smartphone. J Parallel Distrib Comput. 2018;118:67–80. https://doi.org/10.1016/J.JPDC.2017.05.007.
15. Qi W, Su H, Yang C, Ferrigno G, De Momi E, Aliverti A. A fast and robust deep convolutional neural networks for complex human activity recognition using smartphone. Sensors. 2019;19:3731. https://doi.org/10.3390/S19173731.

16. Ullah M, Ullah H, Khan SD, Cheikh FA. Stacked Lstm network for human activity recognition using smartphone data. Proc—Eur Work Vis Inf Process EUVIP 2019-October; 2019. pp. 175–180. https://doi.org/10.1109/EUVIP47703.2019.8946180.
17. Zhou B, Yang J, Li Q. Smartphone-based activity recognition for indoor localization using a convolutional neural network. Sensors. 2019;19:621. https://doi.org/10.3390/S19030621.
18. Chen Y, Shen C. Performance analysis of smartphone-sensor behavior for human activity recognition. IEEE Access. 2017;5:3095–110. https://doi.org/10.1109/ACCESS.2017.2676168.
19. Chen Z, Xiang S, Ding J, Li X. Smartphone sensor-based human activity recognition using feature fusion and maximum full a posteriori. IEEE Trans Instrum Meas. 2020;69:3992–4001. https://doi.org/10.1109/TIM.2019.2945467.
20. Mekruksavanich S, Jitpattanakul A. LSTM networks using smartphone data for sensor-based human activity recognition in smart homes. Sensors. 2021;21:1636. https://doi.org/10.3390/S21051636.
21. Mondal R, Mukherjee D, Singh PK, Bhateja V, Sarkar R. A new framework for smartphone sensor-based human activity recognition using graph neural network. IEEE Sensors J. 2021;21:11,461–8. https://doi.org/10.1109/JSEN.2020.3015726.
22. Mukherjee D, Mondal R, Singh PK, Sarkar R, Bhattacharjee D. EnsemConvNet: a deep learning approach for human activity recognition using smartphone sensors for healthcare applications. Multimed Tools Appl. 2020;7941(79):31,663–90. https://doi.org/10.1007/S11042-020-09537-7.
23. Mohammed Hashim BA, Amutha R. Human activity recognition based on smartphone using fast feature dimensionality reduction technique. J Ambient Intell Humaniz Comput. 2020;122(12):2365–74. https://doi.org/10.1007/S12652-020-02351-X.
24. Moreira D, Barandas M, Rocha T, Alves P, Santos R, Leonardo R, Vieira P, Gamboa H. Human activity recognition for indoor localization using smartphone inertial sensors. Sensors. 2021;21:6316. https://doi.org/10.3390/S21186316.
25. Khan ZN, Ahmad J. Attention induced multi-head convolutional neural network for human activity recognition. Appl Soft Comput. 2021;110:107,671. https://doi.org/10.1016/J.ASOC.2021.107671.
26. Chen Z, Zhu Q, Soh YC, Zhang L. Robust human activity recognition using smartphone sensors via CT-PCA and online SVM. IEEE Trans Ind Inform. 2017;13:3070–80. https://doi.org/10.1109/TII.2017.2712746.
27. Nurhanim K, Elamvazuthi I, Izhar LI, Ganesan T. Classification of human activity based on smartphone inertial sensor using support vector machine. 2017 IEEE 3rd int symp robot manuf autom ROMA 2017 2017-December 1–5; 2017. https://doi.org/10.1109/ROMA.2017.8231736.
28. Batool M, Jalal A, Kim K. Sensors technologies for human activity analysis based on SVM optimized by PSO algorithm. 2019 Int Conf Appl Eng Math ICAEM 2019—Proc; 2019. pp. 145–150. https://doi.org/10.1109/ICAEM.2019.8853770.
29. Dewi C, Chen RC. Human activity recognition based on evolution of features selection and random forest. Conf proc—IEEE int conf syst man cybern 2019-October; 2019. pp. 2496–2501. https://doi.org/10.1109/SMC.2019.8913868.
30. Kumar Polu S. Human activity recognition on smartphones using machine learning algorithms. IJIRST Int J Innov Res Sci Technol. 2018:5.
31. Mittal M, Battineni G, Singh D, Nagarwal T, Yadav P. Web-based chatbot for frequently asked queries (FAQ) in hospitals. J Taibah Univ Med Sci. 2021;16(5):740–6. https://doi.org/10.1016/j.jtumed.2021.06.002.
32. Mohsen S, Elkaseer A, Scholz SG. Human activity recognition using K-nearest neighbor machine learning algorithm. Smart Innov Syst Technol. 2021;262 SIST:304–13. https://doi.org/10.1007/978-981-16-6128-0_29.
33. Myo WW, Wettayaprasit W, Aiyarak P. Designing classifier for human activity recognition using artificial neural network. 2019 IEEE 4th int conf comput commun syst ICCCS 2019; 2019. pp 81–85. https://doi.org/10.1109/CCOMS.2019.8821638.

34. Xu W, Pang Y, Yang Y, Liu Y. Human activity recognition based on convolutional neural network. Proc—Int Conf Pattern Recognit; 2018 August, pp. 165–170. https://doi.org/10.1109/ICPR.2018.8545435.
35. Wu W, Zhang Y. Activity recognition from mobile phone using deep CNN. Chinese Control Conf CCC; 2019 July, pp. 7786–7790. https://doi.org/10.23919/CHICC.2019.8865142.
36. Hernández F, Suárez LF, Villamizar J, Altuve M. Human activity recognition on smartphones using a bidirectional LSTM network. 2019 22nd Symp image, signal process Artif vision, STSIVA 2019—Conf proc; 2019. https://doi.org/10.1109/STSIVA.2019.8730249.
37. Rodriguez C, Castro DM, Coral W, Cabra JL, Velasquez N, Colorado J, Mendez D, Trujillo LC. IoT system for human activity recognition using bioharness 3 and smartphone. ACM Int Conf Proceeding Ser Part F130522; 2017. https://doi.org/10.1145/3102304.3105828.
38. Battineni G, Nittari G, Sirignano A, Amenta F. Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic? J Taibah Univ Med Sci. 2021;16(3):305–6. https://doi.org/10.1016/j.jtumed.2021.02.009.
39. Kim Y, Imani M, Rosing TS. Efficient human activity recognition using hyperdimensional computing. ACM Int Conf Proceeding Ser; 2018. https://doi.org/10.1145/3277593.3277617.
40. Zhou X, Liang W, Wang KIK, Wang H, Yang LT, Jin Q. Deep-learning-enhanced human activity recognition for internet of healthcare things. IEEE Internet Things J. 2020;7:6429–38. https://doi.org/10.1109/JIOT.2020.2985082.
41. Javed AR, Faheem R, Asim M, Baker T, Beg MO. A smartphone sensors-based personalized human activity recognition system for sustainable smart cities. Sustain Cities Soc. 2021;71:102970. https://doi.org/10.1016/J.SCS.2021.102970.
42. Concone F, Lo Re G, Morana M. A fog-based application for human activity recognition using personal smart devices. ACM Trans Internet Technol. 2019;19 https://doi.org/10.1145/3266142.
43. Khaled H, Abu-Elnasr O, Elmougy S, Tolba AS. Intelligent system for human activity recognition in IoT environment. Complex Intell Syst. 2021;1:1–12. https://doi.org/10.1007/S40747-021-00508-5.
44. Abdel-Basset M, Hawash H, Chakrabortty RK, Ryan M, Elhoseny M, Song H. ST-DeepHAR: deep learning model for human activity recognition in IoHT applications. IEEE Internet Things J. 2021;8:4969–79. https://doi.org/10.1109/JIOT.2020.3033430.
45. Mukherjee A, Bose A, Chaudhuri DP, Kumar A, Chatterjee A, Ray SK, Ghosh A. Edge-based human activity recognition system for smart healthcare. J Inst Eng Ser B. 2021;2021:1–7. https://doi.org/10.1007/S40031-021-00663-W.

Interpretation of Biosignals and Application in Healthcare

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1 Introduction

The living entity on this planet is made up of cells. As the organizational complexity of living entity proceeds from prokaryotic to eukaryotic, the complexity inside and between the cells increases. All higher animals and plants consist of many organ systems, wherein each organ system specializes in a particular physiological process. Thus, it is evident that a higher degree of the intercellular and intracellular interaction network exists, which enables a coordinated operation of these organ systems. These organ systems consist of many different tissues composed of various cells. A diverse range of physiological processes like digestion and absorption of food and circulation of blood and locomotion proceed enabled by biosignals, either in biochemical (for example, hormones and neurotransmitters), mechanical (like changes in pressure, temperature, or material transmission across the cell), or electrical (for instance, nerve impulse transmission or muscle movement) form, depending on the underlying physiological process. Any alteration in the normal physiological processes leads to a diseased state, and these altered physiological processes can be associated with deviations in the respective biosignaling machinery involved. The interpretation of these deviated biosignals can be harnessed to assess the corresponding biosystem [1].

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_13

Biosignals are signals from living organisms (including both eukaryotes and prokaryotes) that can provide an insight into the biological, physiological, and dynamics-related aspects of a biosystem. Any continuous physiological changes of a living entity that can be computed and recorded can be termed a biosignal. In general, biosignals or bioelectrical signals are composed of both nonelectrical and electrical signals, the interpretation of which can bring forth information about the functioning and status of the biosystem. These signals are generated when any mechanical, electrical, or chemical activity occurs inside the living system. Various tissues (for example, cardiac, nervous, and skeletal) develop electrical potential across their cell membrane, measurable using external devices. Skin and eye tissues also show minute potential differences across their cell membrane.

The monitoring of biosignals in humans is an ancient health assessment practice. In 1791, the Italian physician Luigi Galvani discovered "animal electricity," later validated as biological impulses by Humboldt. They described "biosignals" as fluctuations of nonstationary characteristics of animals that are subject to dynamic change in time-frequency content.

There are various ways in which bioelectrical signals can be detected, including electrocardiograms (ECG), electroencephalograms (EEG), heart rate variability monitoring (HRV), myograms (EMG), or galvanic skin responses (GSR). Biosignals can exhibit distinct morphological patterns depending on the source of origin and tissue involved, which may be interpreted, quantified, and analyzed using specific sensors and equipment [2].

Biomedical signal processing is an emerging area that intertwines clinical research with engineering in this regard.

2 Interpretation of Biosignals

In simple terms, any physiological activities that can be measured and monitored as electronic signals are called biosignals. The sheer diversity in the types of physiological systems and biosignals is limitless. Biosignal processing attempts to bring more detail to the flow of information on physical parameters, as shown in Fig. 1 [3].

Transducers, preamplifiers, amplifiers, filters, and analog-to-digital signal-converting devices are required at the signal data acquisition stage. These devices acquire data in the relevant format, which can be used for further processing. The transducer detects the physiological parameter on input under observation and converts it into a suitable usable electrical form. The preamplifier and amplifier array is essential in filtering out the signals from the background noise, such that only the relevant signal is relayed forward. Then, additional amplifiers amplify the relevant signals, acting as signal filters. Analog-to-digital conversion converts that analog signal into a digital domain. The next step is signal processing, which includes the removal of "artifacts" (or noise) and the detection of relevant events and components. Thus, biomedical signal processing tools can extract meaningful interpretations from medical signals while enhancing their accuracy through noise reduction. Based on these signals, different events and underlying signal components can also

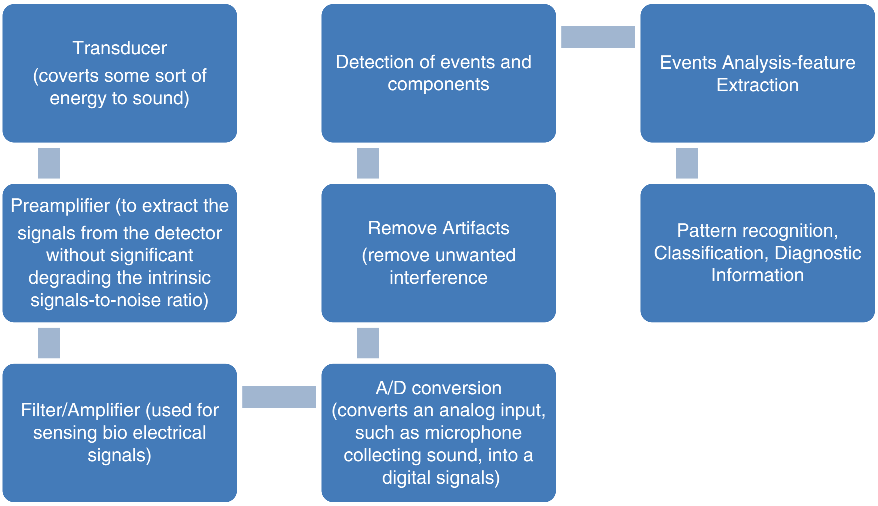

Fig. 1 A series of functions and processes ranging from biomedical signal detection to analysis

be detected with clarity. Further steps like feature extraction, pattern recognition, and diagnostic decision can help the medical practitioner carry out an accurate diagnosis and treatment.

A wide range of biological signals can be generated in the human body, ranging from those assessable directly through visualization to those that need complex signal-amplifying arrays. In broad terms, these signals can be classified into four classes, which have been described as follows:

- **Electrical signals**, which are generated in the form of voltages and currents. These can be assessed using various biomedical measurement systems and adequate signal-conditioning techniques.
- **Mechanical signals**, which can be in the form of pressure, viscosity, and other flow characteristics.
- **Magnetic signals**, which are generated in almost all cells of the body.
- **Optical signals** can mainly be assessed by focusing light on particular body parts and then analyzing the reflection, refraction, scattering, and other characteristics of the same.
- **Impedance signals**, which generally manifest as changes in resistance characteristics of the skin.

3 Applications of Biosignals

It can be said that biosignaling-based techniques are highly relevant in the present scenario, especially in healthcare. Specific biosignal analyses, which detect the emotions of a patient/subject using the user's skin sensors, can be a reliable and accurate method for assessing the emotional state. More closely related to the autonomic and limbic nervous system, signals associated with internal body science are more readily externally operated. On the other hand, recognizing emotional states directly through biosignal analysis is difficult. Further in-depth discussions of some of the features have been provided in the following chapter, in their research, for a variety of goals [4]. Although some analytical methods are available worldwide (for example, using filters to extract parts of a specific frequency range), multiple aspects of these biological features require using a different set of processes. As a result, a basic understanding of how these signals are performed is beneficial before investigating the analytical approaches for collecting the required data [5].

3.1 Action Potential

Information within living systems and from the external environments is relayed through neurons as chemical and electrical signals. These signals are produced by temporary changes in the concentration gradient of ions across the plasma membrane (neurolemma). The gated ion channels in the neurolemma allow the movement of ions, particularly sodium, potassium, and calcium ions, across the neurolemma. The difference of ion gradient concentration across neurolemma creates electrical potential or membrane potential (V_m), as shown in Eq. (1):

$$V_m = V_{in} - V_{out} \quad (1)$$

(V_{in} = potential on the cytoplasmic side of the plasma membrane, and V_{out} = potential on the extracellular side of the plasma membrane.)

When the cell (neuron) is at rest, called resting membrane potential, it is conventionally defined as zero ($V_{in} = V_{out}$). The potassium ion concentration at resting membrane potential is equilibrium potential (Nernst potential) for that particular ion. When nerve cells drive information, an influx of sodium ions turns the resting membrane potential to a slightly positive value, and potassium ions diffuse out of the cell. The Na+-K+ pump regulates the diffusion of sodium and potassium ions. Simultaneously, chloride ions diffuse out actively as well. During signal transmission, the action potential (AP) is generated by the substantial changes in the concentration of sodium, potassium, and chloride ions. In a nutshell, changes in plasma membrane relative permeability to sodium, potassium, and chloride ions establish AP and cause the inception of an electrical biosignal. The AP, in turn, drives the biosignal transmission. Most of the biosignal monitoring devices record AP through microelectrodes.

Resting Potential: It is related to the concentration difference of many ions across the cell membrane. The ionic separation (difference in concentration of ions) at the cell membrane creates chemical (concentration) gradients across the membrane. The subsequent difference in net charge (due to K^+, Na^+, and Cl^-) across the membrane creates an electrochemical gradient, giving rise to membrane potential. Most neurons have a stable electric charge difference across their cell membrane without input [4]:

- Inside the nerve cell, the sodium ion concentration is much lower than outside.
- The positive charge outside the nerve cell is higher than inside.
- To balance charging, more potassium ions enter the nerve cell, resulting in higher potassium ion levels.
- Charge balance is impossible due to differences in fluid concentration in and out of the cell for different ions.
- At a resting stage, the membrane potential is zero, and the nerve cell is at a polarized stage. At the polarized stage, the nerve cell achieves electrochemical equilibrium (i.e., the concentration gradient and the electrogradient for each ion are equal and opposite). The potential is termed as resting potential (Fig. 2).

Depolarization: The interaction between a neurotransmitter and a receptor molecule at the synaptic interface triggers the opening of a ligand-gated ionic channel. It allows specific ions to flow inside the cell. For example, the ligand-gated sodium channel enables sodium ions to flow into the cell, making the inside less negative, changing the strength of the membrane from bad to good. Once the inside of the cell is fully charged, the cell breakdown is complete, and the channels close again.

Repolarization: The internal charge of the cell changes for the last time after being removed from cooling. Voltage-gated sodium ion channels open during polar degradation shutdown once the cell is removed. Potassium channels are activated due to the increase in positive charge within the cell. The potassium

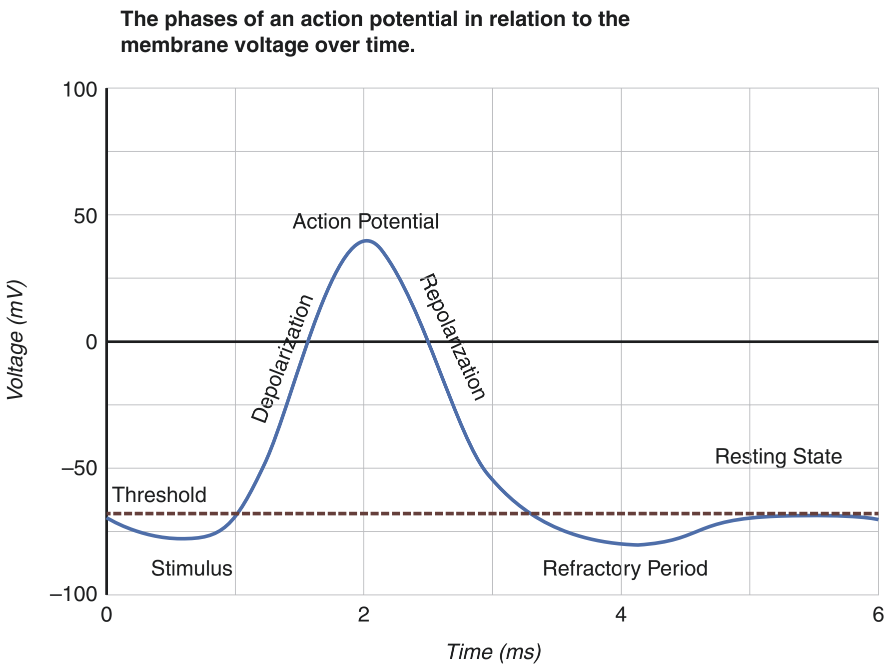

Fig. 2 Diagram showing the phases of an action potential about the membrane voltage over time

(K+) ions begin to decline at the electrochemical gradient (harvesting concentration gradient and newly formed electrical gradient). The energy inside the cell decreases as potassium leaves the cell and returns to its resting state. Throughout the process, the sodium-potassium pump is active. Notably, the voltage-dependent change in K+ input is caused by a different phase of ion channels than those that control the resting force. The Na+-K+ pump is a mechanism that releases Na+ ions by exchanging K+ ions that are transported back to the cell. However, compared to ion channels, this mode of transport carries a much smaller current and offers only a tiny amount in the recovery process. The Na+-K+ pump must reset the Na+-K+ cell balance, although the process takes longer than the action period. With a maximum duration of action of about 1 ms, nerve cells and muscles reunite quickly. For as long as possible, the heart muscle cells multiply slowly. This event explains how the power of a cell action remains unchanged regardless of the mode of excitement or intensity of the motive beyond the limit. Total resting power arises after vigorous activity, in which the cell can respond to any stimulus (approximately one mE in nerve cells) [6].

Propagation of an action potential: The following shows how the action may propagate near muscle fiber or unmyelinated fiber:

The current passes through the intracellular fluid from the molten surface to nearby inactive areas, removing them. After that, the current is transmitted through the extracellular fluid via the depolarized layer and then back into the intracellular region. The fiber itself provides the energy needed to keep running. A protective layer of myelin surrounds myelinated nerve fibers. The shaft is separated every few millimeters by Ranvier nodes, which expose the filament to the fluid in the center. There are only excitement and changes in the membrane lining and the current stream in the nodes of Ranvier, wherein a process called “saltatory conduction” occurs. This means the neural impulse “jumps” from one node to another, traversing the axon at specific locations.

3.2 The Electroneurogram (ENG)

The electrical activity of the central nervous system neurons (brain and spinal cord) and peripheral nervous system is recorded and visualized through electroneurogram (ENG).

The functioning of an electroneurogram is similar to that of an electromyogram (EMG). An electroencephalogram (EEG) is a specific type of electroneurogram in which several electrodes are placed around the head, and the general activities of the brain are recorded without having a very high resolution to distinguish between the actions of a different group of neurons. An electroneurogram is usually obtained by placing an electrode in the neural tissue. The electrical activity generated by neurons is recorded by the electrode and transmitted to an acquisition system, which allows visualizing the neuron’s activity. Each vertical line is an electroneurogram that represents one neuronal action potential. Depending on the precision of the electrode used to record neural activity, an electroneurogram can contain the activity of a signal neuron to thousands of neurons. Researchers adapt the accuracy of their electrode to focus on either the action of a single neuron or the general activity of a group of neurons, both strategies having their advantages [7].

3.3 The Electromyogram (EMG)

An electromyography device records an electromyogram (EMG), which measures the electrical potential of the muscular tissues. The brain, spinal cord, and peripheral nerves constitute the central nervous system, which directs the action of muscle fibers, resulting in movement. Muscles are specialized cells that can contract and relax and are governed by innervated motor unit (neuron) simulations. There are two ways to record EMG: surface EMG (SEMG, which records EMG using electrodes implanted on the skin) is more popular than intramuscular EMG (which involves inserting a needle electrode into the muscle) because it is less intrusive [8]. Motor unit action potentials (MUAPs), as measured by SEMG, are muscle fiber action potentials of a single (or more) motor unit. The actual potential is about 100 mV, but SEMG is a complex signal with very low amplitudes (typically around 5 mV) due to connective tissue and skin layers. When a brain signal triggers each motor unit, it generates an electrical signal that combines all of its constituent cells of action potentials. A single-motor-unit action potential (SMUAP or simply MUAP) is a type of action potential that can be recorded using needle electrodes implanted in a muscle. SMUAPs are usually biphasic or triphasic, with durations ranging from 3 to 15 ms, amplitudes ranging from 100 to 300 pV, and frequencies ranging from 6 to 30 Hz. The size of the recorded SMUAP is affected by the type of needle electrode employed, its placement relative to the active motor unit, and the projection of the electric field of activity [9]. The three channels of the needle electrode simultaneously record the activity of some motor units. Although SMUAPs are biphasic or triphasic, the size of a single SMUAP varies from channel to channel. (The first two monophasic action potentials in the channel are biphasic, and the third SMUAP in the same signal is triphasic.) The disease affects the form of SMUAP [4]. Muscle contractions are graded on a scale of 1–10. The level of muscle contraction is controlled in two ways: (1) spatial recruitment, which involves activating new motor units as effort increases, and (2) temporary recruitment, which involves increasing the frequency of discharge (firing rate) of each motor unit as effort increases. Asynchronous contraction occurs when motor units fire multiple times and at different frequencies. The individual motor units combine to produce tetanic contractions and increased power. Due to the lack of voluntary effort, the motor units fire at about 5–15 PPS due to the lack of pulse per second. As the tension increases, an interlocking pattern (EMG) emerges, with components and active motor units firing in the range of 25–50 times per second. The component and functional motor units tend to fire in the range of 25–50 pps, resulting in an interfacing pattern EMG when the tension is increased. As fatigue occurs, the MUAPs tend to cluster together, resulting in less high-frequency content and higher amplitude in the EMG. Muscle EMG is generated by connecting the MUAPs of all active motor

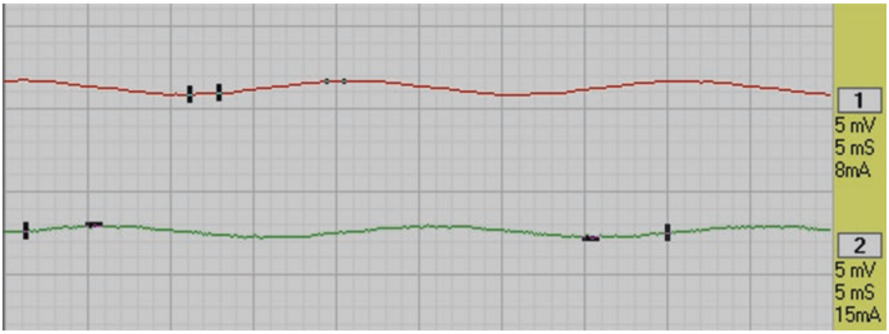

Fig. 3 EMG readings of a healthy patient, collected from the median wrist (1) and elbow (2) regions of the left hand. The patient was supplied with varying currents of 8 mA and 15 mA, respectively, for a duration of 5 ms to obtain the above EMG

units in a spatiotemporal manner. Evaluating EMG signals collected with surface electrodes is challenging because they contain interference patterns of multiple MUAP trains. The degree of muscle activity is indicated by an EMG signal, which can diagnose neuromuscular diseases such as neuropathy and myopathy. Fine-wire electrodes lined with muscle fibers and spaced 10 mm apart were used to record an EMG signal from a dog's crural diaphragm. An interval of breathing is represented by a signal (breathing is the active part as far as muscles and EMG are concerned). During the initial breathing period, the overall level of activity in the signal increases. It shows the starting sections of the same signal on an enlarged timescale. At the onset of contraction, SMUAPs appear, followed by a progressively complex interference pattern, including multiple MUAPs [9] (Fig. 3).

3.4 The Electrocardiogram (ECG)

The heart rhythm is regulated by pacemaker cells called the sinoatrial (S.A.) node, and the ECG describes the heart's electrical activity. A PQRST wave represents a complete ECG cycle. The impulse moves to the atrium when the S.A. node is activated, causing atrial contraction. When a stimulus travels from the atrium to the ventricles (enabling full blood flow in a close direction), the propagation delay is called the P.Q. interval (isometric segment). The QRS complex is formed when an impulse is transmitted to the ventricles and causes ventricular contraction. The S.T. segment is the time between ventricular depolarization and ventricular repolarization. When the stimulus travels to the ventricles, it causes ventricular contraction. The S.T. segment is when the ventricles are depolarized and ventricular repolarization (relaxation) begins, and the T wave is when the ventricles return to their resting position. Electrodes are implanted in specific areas of the body, and electrical impulses are recorded in the hospital with a 12-channel ECG or a 3-channel ECG in that area. For electrode alignment, the most standard arbitrary isthmus triangle is used. This arrangement requires placing four-limb electrodes on the right and left arms and legs and a fourth limb electrode on the right leg that serves as a reference channel. The 12-lead ECG collected during sleep is commonly called the ECG NB. Other devices, such as the Holter monitor, can record the heart's electrical activity, and some smartwatch models can also record the ECG (starting with the Apple Watch in 2018). Other devices may be used to record ECG signals in different situations. P wave, which refers to the depolarization of the atrium; QRS complex, which refers to the depolarization of the ventricles; and T wave, which indicates ventricular resorption, are the three basic components of the ECG [10]. The depolarization progresses gradually during each heartbeat in a healthy heart, beginning with the pacemaker cells in the sinoatrial node and spreading throughout the region. A simple ECG trace is formed from this systematic pattern of depolarization. The ECG provides information on the structure and function of the cardiovascular system to a qualified physician. The ECG can help us evaluate the pulse and cadence, and the size and area of the heart chambers, regardless of whether there is any harm to the heart muscle cells or the circulatory framework, the impacts of the heart drug, and the activity of the pacemaker [11, 12] (Figs. 4 and 5).

Axes are formed by six limb lead directions. Einthoven's triangle is a hypothetical equilateral triangle formed from leads I, II, and III. The center of the triangle represents Wilson's central terminal. In this diagram, the heart is considered at the center of the triangle. Measure three-dimensional (3D) cardiac electrical vector projections on six significant axes—the six axes model the 0″–180″ range in approximately 30″ increments. The projections make it easy to see and analyze the heart's electrical activity from different angles in the frontal plane.

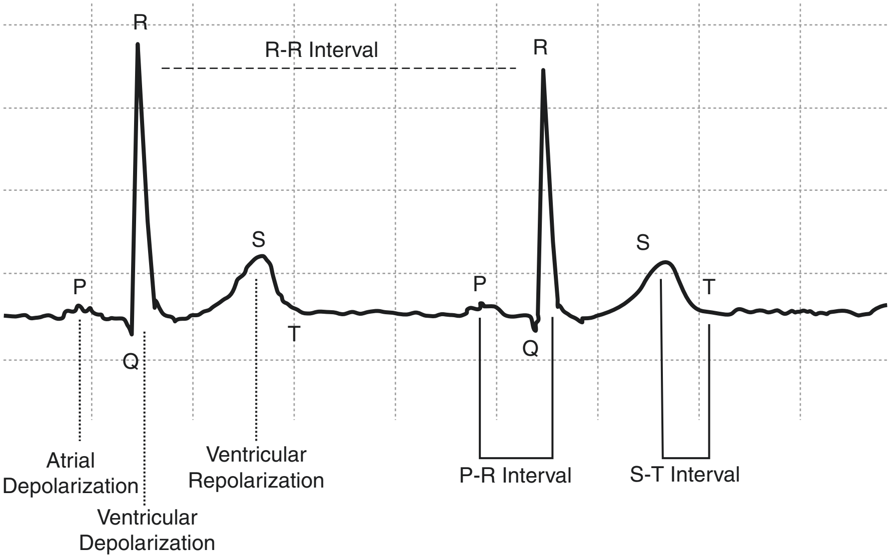

Fig. 4 A portion of the ECG obtained from a healthy patient showing the *P* wave, the QRS complex, and the *T* wave

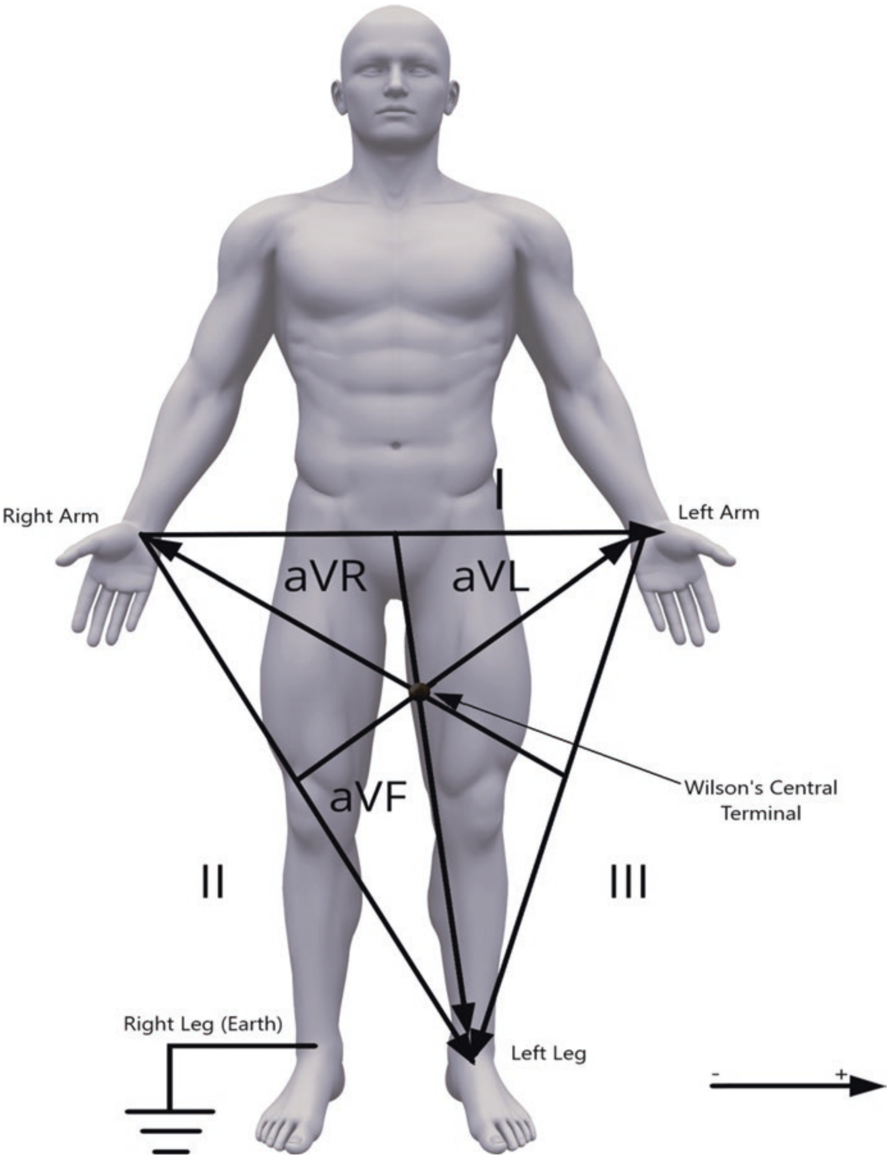

Fig. 5 Einthoven's triangle and the axes of the six ECG lead shaped with four limb leads

The six chest leads (*V*1–*V*6) are derived from six defined places on the chest. The pericardial (chest) leads should be placed in the positions. The *V*1 and *V*2 leads are located immediately to the right and left of the sternum, respectively, in the fourth intercostal gap. *V*4 is placed on the left midclavicular line, on the fifth intercostal hole. The *V*3 lead is halfway between the *V*2 and *V*4 leads, while the *V*5 and *V*6 leads are at the same level as the *V*4 lead but at the anterior and midaxillary lines, respectively. The six chest leads let you look at the cardiac electrical vector from different angles in a cross-sectional plane: *V*5 and *V*6 are most sensitive to left ventricular activity, *V*3 and *V*4 are best for septal activity, and *V*1 and *V*2 are best for right-half activity.

3.5 The Electroencephalogram (EEG)

Electroencephalography (EEG) is a technique for capturing an electrogram of electrical activity on the skull, which has been shown to indicate macroactivity below the surface layer of the brain. Electrodes are usually inserted into the scalp, making it noninvasive. Intracranial EEG is a term used to describe electrocardiography, which involves invasive electrodes. An electroencephalogram (EEG) monitors voltage changes in neurons in the brain caused by the ionic current. EEG is electroencephalography, a recording of the abrupt electrical activity of the brain over time using multiple electrodes on the scalp. (1) Generally, clinical applications focus on one thing only: event-related probability or EEG spectral information. The former looks at potential time-off fluctuations such as "stimulus start" or "button press." The latter observes the different types of nerve oscillations (also known as "brain waves") followed in EEG signals in the frequency domain. The EEG (also known as "brown waves") is a recording of the brain's electrical activity [13]. Some of the salient features of the brain organization are as follows: The cerebrum, cerebellum, and brain stem are the three essential components of the brain (including the midbrain, pons, medulla, and reticular formation). The cerebrum, cerebellum, brain stem (contains the midbrain, pons, medulla, and reticular formation), and thalamus are the significant parts of the brain (between the midbrain and the hemisphere). A longitudinal fracture divides the broadest connecting band of cerebral fibers, the corpus callosum, into two hemispheres. The cerebral cortex, which covers the outer surface of the cerebral hemispheres, comprises neurons (gray matter) arranged in complex patterns and divided into regions by fissures. The nerve fibers that connect the cortex to the brain and other body parts run beneath it (the white matter) [14] (Fig. 6).

The excitatory and inhibitory postsynaptic potentials produced by pyramidal neuron cells and dendrites produce cortical potentials. Physical control systems, mental processes, and external stimuli have signals in the brain that can be recorded using surface electrodes on the skull. The scalp EEG combines the activity of several small areas of the cortical surface beneath the electrodes. Multiple EEG channels from numerous points on the head are recorded simultaneously in clinical practice for comparative observation of activity in different brain regions. Electrode placement procedure prescribed by the International Federation of Societies for Electroencephalography and Clinical Neurophysiology for Clinical EEG Recording [13], E.G., has been used as a first-line method for diagnosing tumors, strokes, and other localized brain diseases. Still, its use has increased with the development of high-resolution structural imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). The EEG remains a necessary research and diagnostic tool despite poor spatial clarity. CT, PET, and MRI are some of the few

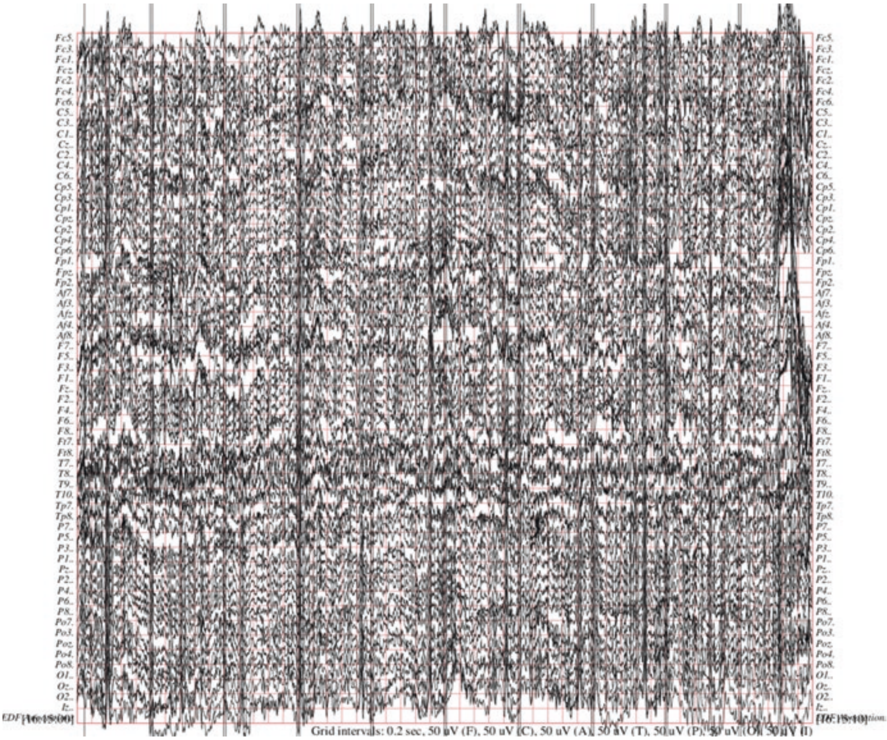

Fig. 6 EEG readings of a healthy patient over a span of 10 s in the 60-electrode arrangement. The activity under each electrode represents the activity of neuronal bundles at the specific instant

mobile methods with a millisecond-range temporal resolution that cannot match the EEG-derived evoked potential (EP) used to display any stimuli. Time-blocked EEG responses to more complex stimuli are called event-related potentials (ERPs). This technique is used in cognitive science, psychology, and psychophysical research [14]. Multichannel EEG capture is required for several hours to monitor sleep EEG and detect infection leading to epileptic seizures. Needle electrodes, nasopharyngeal electrodes, electrocardiogram (ECOG) recording from the exposed area of the cortex, and intracerebral electrodes are some specialized EEG techniques. Early recording at rest (opening of the eyes, closing of the eyes), hyperventilation (2–4 min after 20 breaths per minute), photostimulation (with light at 1–50 flashes per second), loud clicks, and listening to some pharmaceuticals or medications are more advanced techniques for arousal, sleep (various stages), and EEG recording.

3.6 Electrogastrogram (EGG)

An electrogastrogram (EGG) is a graphic created by an electrogastrograph that captures and controls electrical signals flowing through the abdominal muscles. An electrogastrogram (also known as a gastroenterogram) is an equal treatment that

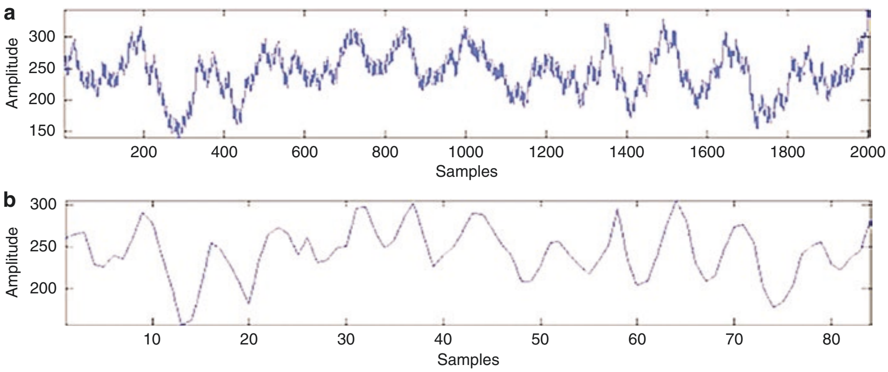

Fig. 7 Eight channels of the EGG of a subject depicting alpha rhythm

records electrical impulses from the stomach and intestines. These names are composed of several parts: electro, which refers to electrical activity; gastro, which in Greek means "stomach"; entro, which is Greek; and gram for intestines, which is derived from the Greek word "write." Electrogastrogram and gastroenterograms are sensors on the skin that act as an electrocardiogram (ECG) that detects electrical impulses that indicate muscle activity in the body (Fig. 7).

The electrogastrogram detects the wavelike contractions of the stomach, whereas the ECG measures muscular activity in various parts of the heart (peristalsis). In 1921–1922, Walter C. Alvarez pioneered electrogastrography research [15]. The stomach was restrained utilizing a 5 MHz ultrasound transducer exhibit with the subject motionless and prone. The direction of the distal stomach was set apart on the abdominal surface. The stomach's electrical activity consists of cyclic depolarization and repolarization of the stomach's constituent smooth muscle cells [16]. In humans, the action starts in the mid-corpus of the stomach and lasts for about 20 s. The activity waves are constantly present and have nothing to do with stomach contractions' spatial and temporal structure [17]. The electrogastrogram signal can be recorded using external (cutaneous) electrodes (EGG). The following protocols were used by Chen et al. to record cutaneous EGG signals: The stomach was located by utilizing ultrasound while the person was in the supine position and motionless. Three live electrodes were put on the abdomen along the antral axis of the stomach with an inter-cathode distance of 3.5 cm [18]. A standard reference terminal was put 6 cm away in the upper right quadrant. Three bipolar signs were acquired from the three active anodes concerning the standard reference electrode. The signals were amplified and filtered to a bandwidth of 0.02–0.3 Hz with 6 dB/octave transition bands and sampled at 2 Ha. It is believed that the surface EGG shows the entirety of the electrical activity in the stomach, which also includes both electrical control and electronic responses [19]. Thus, an EGG can be used to diagnose stomach dysrhythmia or arrhythmia. Other researchers claim that the signal's diagnostic potential has yet to be determined [20]. The insertion of electrodes within the stomach is required for accurate and reliable measurement of its electrical activity, which restricts its practical applicability.

3.7 The Phonocardiogram (PCG)

A phonocardiogram (or PCG) is a compilation of high-fidelity recordings of heartbeat and sighing using a phonocardiograph device. Therefore, recording all the sounds from the heart during the heart cycle is known as phonocardiography. The heartbeat is produced by vibrations caused by the closing of the heart valves. The first (S1) occurs when the tricuspid and mitral atrioventricular valves close at the start of systole, and the second (S2) happens when the aorta and pulmonary valves (half-month valves) close at the end of systole [21]. Phonocardiography is a method of finding and recording mysterious sounds and complaints in the heart. On the other hand, the stethoscope does not always capture all of these sounds or moans, nor does it trace your recurrence. The ability to measure the sound produced by the heart provides information that is not available through the most advanced tests and is essential in understanding the effects of certain drugs on the heart.

Discrete and packet wavelet transformation: Discrete wavelet change (DWT) is better at filtering cardiac murmurs without damaging S1 or S2. Packet wavelet change has a far more significant effect on the internal structure of components than DWT [22].

A stethoscope is a portable instrument used by doctors to indicate that the heart rate signal is probably the most common biological indication. PCG is a vibration or sound signal that refers to the recording of a heart sound signal and is related to the contractile function of the cardiogenic system (heart and blood together) [23]. A transducer, such as a microphone, pressure transducer, or accelerometer, must be placed on the chest to convert the vibration or audio signal into an electronic signal to record the PCG signal. Normal heart sounds give you an idea of how rhythmic your heart is. Additional changes or sounds and complaints caused by cardiovascular disease and abnormalities may benefit your diagnosis. The origin of heart sounds is as follows: Recorded heart sounds are now driven by the vibration of the entire circulatory system due to a decrease in pressure, rather than by motion of the valves, as previously thought. The cardiogenic system can be compared to a liquid-filled balloon that is completely absorbed when activated.

On the other hand, portions of the heart sound better outside from time to time [24]. The cardiogenic system can be compared to a fluid-filled balloon, which vibrates when excited anywhere. Externally, however, some heartbeat segments sound better in some chest locations, leading to the concept of secondary sources in the chest. The mitral area is near the upper heart, and the aortic part is to the right of the sternum, in the second right intercostal space. The tricuspid region is located near the right border in the fourth intercostal region. The lung region is located in the second or third left intercostal region in the left parasternal line [25].

The first heart sound (SI) and the second heart sound (S2) are the two powerful sounds in the normal cardiac cycle (S2). It shows ECG and carotid pulse tracing and an average PCG signal. S1 is related to the QRS complex in the ECG signal throughout time and begins at ventricular contraction. When the initial infarction in the ventricles forces blood into the atria, the atrioventricular valves (AV-mitral and tricuspid) close, and the first tremor occurs in S1. The second part of S1 is caused by blood loss due to the sudden tightening of the closed AV valve. The semilunar valves (aorta and lungs) open, allowing blood to drain. A third of S1 may be caused by blood oscillations between the root of the aorta and the walls of the ventricles. Next comes a quarter of S1, which may be caused by tremors caused by rapid disruption of blood flow through the ascending aorta and pulmonary artery.

3.8 Galvanic Skin Response

Variation in sweating of the physical body causes conduction. GSR analysis is based on the idea that skin resistance varies based on the position of sweat within the skin. The body's sweating is controlled by the autonomic nervous system (ANS). If the autonomic nervous system's sympathetic branch (SNS) is greatly stimulated, sudoriferous gland activity also increases, which progressively increases skin conductance and vice versa. Thus, skin conductance is a commonly used assay for the sympathetic nervous system's neuronal reactions.

A mechanism like this is intimately involved in human emotional behavior regulation. Additional research has revealed a link between the GSR signal and mental states like tension, tiredness, and closeness. The recording of the GSR signal is straightforward: typically, only two electrodes are inserted on the second and third fingers of one hand. As a measure of EDA, the low-voltage-applied current fluctuation between the two electrodes is used [26]. Galvanic skin response (GSR), also known as electrodermal activity (EDA) and skin conductance (SC), is reflective of the continuous variation in the electrical characteristics of the skin, such as conductivity, as a result of body sweating. The working principle behind GSR analysis is the variation of dermal resistance depending on where the sweat glands are located within the skin. The autonomic nervous system regulates sweating in the body (ANS). If the sympathetic branch of the autonomic nervous system (SNS) is significantly excited, sudoriferous gland activity increases, increasing skin conductance and vice versa. Human sympathetic system neural responses are frequently measured using skin conductance. A mechanism like this plays a significant role in human emotional behavior regulation. Additional research has revealed a link between the GSR signal and mental states like tension, tiredness, and attachment. A GSR signal can quickly be recorded by using just two electrodes positioned on the second and third fingers of the subject's hand. The fluctuation characteristics of a low-voltage-applied current between the two electrodes can measure EDA. This has enabled the development of increasingly wearable, convenient, and usage-friendly healthcare equipment in recent years [25].

There is an increase in the activity of the sudoriferous endocrine gland on seeing actions that are painful, threatening, joyful, etc. The GSR measures changes in electrical activity that, thanks to changes in sudoriferous gland activity, can lead to an increase in sudoriferous gland activity due to positive ("pleasant") and negative ("scary") events. Hence, the GSR signal does not represent the emotion type. The hands have a high density of sensitive sweat glands. Thus, GSR data is collected from the finger, wrist, or palm. A well-known application of GSR may be the lie detection test.

From the outset, it is clear that both EEG and MEG can be used to detect brain disorders, but MEG is the preferred method. The ECG is used to detect irregularities in the heart, whereas EMG and MMG are commonly used diagnostic tools for muscular defects, with MMG being the most preferred diagnostic tool. EOG can be used to assess attention deficit and shifting. GSR measures electrical activity in the skin, which can be initiated by changes in the body's moisture levels due to sweating. This crucial information aids in the diagnosis of numerous bodily disorders.

Furthermore, different and specific indicators are grouped to address a particular health concern. Therefore, the same signal may be incapable of producing the requisite results for other maladies. EDA, also known as skin conductance or galvanic skin response (GSR), is a method of ascertaining the skin's electrical conductivity, which varies with its moisture content. Since the sympathetic nervous system controls the sweat gland activity, skin conduction can be used as an assay to detect psychological or physiological changes. Measurements of galvanic skin response (GSR) analyze sweating changes to identify electrical conductivity fluctuations in cognitive load studies in three different ways to explore the viability of utilizing GSR to live mental stress. With varying levels of task complexity, three alternate control interfaces are used. To complete the tasks, the test subjects have to use multimodal (speech and gesture) or unimodal (either speech or gesture) interfaces.

According to a preliminary analysis of five participants' knowledge, multimodal interfaces had the lowest mean response levels, followed by speech and gesture interfaces. The overall response increased with task complexity [27]. This was interpreted as providing evidence of the usefulness of GSR to indicate cognitive load. Analysis of specific recordings found that GSR peaks correlated with stressful or frustrating events, with responses decreasing over time. The peaks were also related to cognitively challenging critical event, including reading instructions and competitive tasks [28].

Stress is more accurately described as a heightened counteraction to events. It is how our bodies prepare to meet challenging situations with focus, strength, and increased alertness [29].

When the subject is faced with a threatening situation, the nervous system secretes many stress hormones, including adrenaline and cortisol. These hormones help acclimatize the body for action in an emergency. A study showed the production of a device to harness these biosignals to detect stress, based on the changes in the conductance characteristics of the skin using a GSR-based array [30]. Like the generally used GSR devices, it has two electrodes meant to be placed on the fingers, serving as two terminals of a single resistance [31]. This device uses ZigBee to provide individual data to a coordinator while also updating the same remotely to a coordinating server. The final goal is to integrate this GSR into a medical device control program. The tension sensor can be used anywhere in the home in a 10-m range [32]. When using a wireless communication system, the user can control the device up to a certain amount. The control center offers various options to help a person de-stress. As a result, the coordination center may employ other systems to assist the individual in unwinding [33]. It uses very little energy and can link up to 255 nodes. As can be seen, this mode of communication has been employed in healthcare in the past. A few studies have been conducted to validate these stress sensors with test subjects, and it was revealed that despite the variations of stress levels in different individuals, using the same critical threshold led to satisfactory results [34, 35]. Some other aspects, like the posture and position of the patient and the sensors, and the effort put in by the subject to maintain stance, may affect the variations in the results, which is why hardware-related characteristics must not be ignored.

3.9 Mechanomyogram (MMG)

The total of the activities of single motor units (detected at the muscle surface as MMG by accelerometers, piezoelectric contact sensors, or other transducers) constitutes a surface mechanomyogram (MMG) (MUs). The pressure wave generated by active muscle fibers is related to each MU contribution [36]. The first section of this review will summarize the findings of our research team, which looked into the impact of motor unit recruitment and firing rate in determining MMG properties during stimulated and voluntary contractions. The MMG and EMG in fresh and fatigued biceps will be investigated in the second part of this review during a short isometric force ramp from 0 to 90% MVC. The goal is to see if changes in motor unit activation strategy in voluntary tired muscles are reflected in the MMG's temporal and frequency domain parameters. MMG-RMS vs. percent MVC: The MMG-RMS did not show the notable increase with increasing effort level, followed by a distinct drop at near-maximal contraction levels at fatigue. MMG-MF vs. percent MVC: Compared to fresh muscle, fatigued biceps brachii had a substantially lower MF trend, with no steeper MF increment from 65% to 85% MVC. The inability to recruit rapid, but more fatigable MUs, as well as the reduction of global MU firing during the short isometric force ramp studied, appears to be related to the change in MMG and EMG parameters vs. percent MVC correlations at exhaustion. The mechanomyogram (MMG) is the mechanical signal visible on the muscle's surface when it is contracted. At the initiation of muscular contraction, gross muscle form fluctuations may trigger heightened peak formation in the MMG [37].

Oscillations in myofibrils at the muscle's resonant frequency cause the following vibrations.

Phonogram, acoustic myogram, sound myogram, vibromyogram, or muscle sound are all names for the mechanomyogram. The MMG is a low-frequency vibration that can be detected using appropriate measuring techniques when a muscle is contracted. An accelerometer or a microphone put on the skin over the muscle belly can be used to measure it. The acoustic myogram is a measurement made with a microphone. For measuring muscle activity, the MMG could be a good alternative to the electromyogram (EMG). Because it has a greater signal-to-noise ratio than surface EMG, it can be utilized to monitor muscle activity in deeper muscles without the use of invasive monitoring techniques. It is presently the topic of research on prosthetic control and disabled assistive technology. The surface mechanomyogram (MMG) is the sum of the activity of single motor units (detected at the muscle surface as MMG by accelerometers, piezoelectric contact sensors, or other transducers) (MUs). The pressure waves generated by active muscle fibers are related to each MU contribution.

4 Recent Application of Biosignal Interpretation

Wearable gadgets for monitoring health during sports activities are speedily gaining popularity. A very common application of these devices can be the dynamic monitoring of the vitals and other physical performance parameters of athletes, enabling coaches to perform regular assessments and collect data from the sportsmen during strenuous performance. Furthermore, unique methods have been proposed to perform real-time monitoring assays (like heart rate monitoring, pulse oximetry, and AHRS) in scenarios like swimming, where the field of activity is water, i.e., hostile to the usage of regular monitoring devices [38]. These systems have been tested thoroughly, using haptic, tactile, or wearable devices, and employing machine learning algorithms in real-time dynamic data-collecting mode. These tests have yielded excellent results, even enabling frequently updated performance feedbacks [39]. With the recent advancements in IoT-based devices, and the booming popularity of smartphones and other smart devices, health-monitoring gadgets are becoming increasingly indispensable. Furthermore, wearables are now advancing to such stages that many features in the alleged "smart" devices are becoming smarter by learning from the sheer immensity of data generated all the time by the users [40]. The market for wearable gadgets is expected to reach $12 billion by 2018, according to the research firm BI Intelligence. A "wearable device" is a compact electronic gadget that may be worn on the body and used freely even when the user is moving. This category includes Google Glass, Samsung Galaxy Gear, and Sony Smart Watch. Furthermore, even sportswear firms like Nike and Adidas have recently entered the wearable gadget market with innovative goods and services. The Internet of Things (IoT) is a relatively new technology that collects and transmits data via sensors while also providing a communication capability to every object. With a 21.8% annual growth rate, the IoT industry was valued at $203.1 billion in 2013 and is expected to grow up to $1 trillion by 2022.

The market for mobile apps is constantly rising in line with the adoption of smartphones and gadgets. The term "cross-platform development" refers to software development for multiple systems. Developers in the early stages of application development must build spaces for a specific field, use different programming languages, and hold links to support programs needed for the advent of smartphones and the availability of multiple platforms (APIs) [41].

Contributions and Challenges in Research Cross-platform development is a feature that helps create Web applications using hypertext markup language 5 (HTML5), cascading style sheets (CSS), or JavaScript [42].

Its most important value is that it provides a single application source that can work on multiple mobile devices, speeding up development [43]. However, because Cordova and Titanium are in their early stages of development, the range of APIs is insufficient, especially concerning allowing portable and IoT devices. Because the platform's development alone is not enough for the app's development, developers will be forced to make good use of the native language supported by the appropriate device platform and start tracking the development. In addition, Bluetooth technology is supported by in-device and IoT devices between devices [44]. Bluetooth is a short-term communication technology that makes it impossible to communicate with portable/IoT devices over a particular range. In this context, we propose a "network application agent" forum, which covers the development of mobile devices with IP-based connections and innovative network development software, because it is based on the Apache Cordova platform and uses the Cordova API and native API to enable I/O on smartphones and accessories [45].

References

1. Escabí MA. Biosignal processing. Introd to Biomed Eng. 2005:549–625. https://doi.org/10.1016/B978-0-12-238662-6.50012-4.
2. Naït-Ali A. Advanced biosignal processing. Berlin Heidelberg: Springer; 2009.
3. Ortiz M, Coghlan N, Jaimovich J, Knapp RB. Biosignal-driven art: beyond biofeedback. Ideas Sonicas/Sonic Ideas. 2011;3(2):43–52.
4. Rangayyan RM. Biomedical signal analysis: a case-study approach. Wiley-IEEE Press.
5. Palaniappan R. Biological signal analysis. Studentia Ventus Publishing. 2011;
6. Biomedical signal and image processing HST582J/6.555J/16.456J biomedical signal and image processing spring 2007; 2007.
7. Zibula A, Majchrzak TA. Cross-platform development using HTML5, jQuery mobile, and PhoneGap: realizing a smart meter application. Lect Notes Bus Inf Process. 2013;140 LNBIP:16–33. https://doi.org/10.1007/978-3-642-36608-6_2.
8. Zhang, B, Xu, TG, Wang W, Jia X. Research and implementation of cross-platform development of mobile widget. 2011 IEEE 3rd Int. Conf. Commun. Softw. Networks, ICCSN 2011, pp. 146–150; 2011, https://doi.org/10.1109/ICCSN.2011.6014238.
9. Lipa BM, Han JJ. Electrodiagnosis in neuromuscular disease. Phys Med Rehabil Clin N Am. 2012;23(3):565–87. https://doi.org/10.1016/j.pmr.2012.06.007.
10. The biomedical engineering handbook. 4th Ed. Medical Devices and Human Engineering.
11. Tafash HT, et al. Study of some factors that affect ECG device. IOP Conf Ser Mater Sci Eng. 2020;757(1) https://doi.org/10.1088/1757-899X/757/1/012032.
12. Goyal LM, et al. Improved ECG watermarking technique using curvelet transform. Sensors. 2020;20(10):2941.
13. Klass DW, Westmoreland BF. Nonepileptogenic epileptiform electroencephalographic activity. Ann Neurol. 1985;18:627–35.
14. رازی. ز. ا. م., *No title*1384; الحاوی جلد بیستم.
15. T. H. E. Electrogastrogram. The electrogastrogram and what Hitherto, physiologists have often been hampered by the visceral paralysis, Vol. 493; 2013.
16. Simonian HP, et al. Multichannel Electrogastrography (EGG) in normal subjects: a multicenter study. Dig Dis Sci. 2004;49(4):594–601. https://doi.org/10.1023/B:DDAS.0000026304.83214.50.
17. Mintchev MP, Bowes KL. Extracting quantitative information from digital electrogastrograms. Med Biol Eng Comput. 1996;34(3):244–8. https://doi.org/10.1007/BF02520081.

18. Tompkins WJ, editor. Biomedical digital signal processing C-language examples and laboratory experiments for the IBM ® PC; 2000.
19. De J, Chen Z, Stewart WR, McCallum RW. Spectral analysis of episodic rhythmic variations in the cutaneous electrogastrogram. IEEE Trans Biomed Eng. 1993;40(2):128–35. https://doi.org/10.1109/10.212066.
20. Sanmiguel CP, Mintchev MP, Bowes KL. Dynamics of level of randomness of electrogastrograms can be indicative of gastric electrical uncoupling in dogs. Dig Dis Sci. 1999;44(3):523–8. https://doi.org/10.1023/A:1026697021756.
21. Cherif LH, Debbal SM, Bereksi-Reguig F. Choice of the wavelet analyzing in the phonocardiogram signal analysis using the discrete and the packet wavelet transform. Expert Syst Appl. 2010;37(2):913–8. https://doi.org/10.1016/j.eswa.2009.09.036.
22. Meldrum SJ. Introduction to biomedical engineering. Physiol Meas. 2000;21(2):341. https://doi.org/10.1088/0967-3334/21/2/701.
23. Prakash R. The first heart sound. Circulation. 1978;57(1):202–3. https://doi.org/10.1161/01.CIR.57.1.202.
24. Sudhakar Reddy P, Salerni R, Shaver JA. Normal and abnormal heart sounds in cardiac diagnosis: Part II. Diastolic sounds. Curr Probl Cardiol. 1985;10(4) https://doi.org/10.1016/0146-2806(85)90027-1.
25. Lazar J, Feng JH, Hochheiser H. Research methods in human-computer interaction. Cambridge: Elsevier; 2017.
26. Benovoy M, Cooperstock JR, Deitcher J. Biosignals analysis and its application in a performance setting - towards the development of an emotional-imaging generator. In Proceedings of the first international conference on bio-inspired systems and signal processing. BIOSIGNALS, (BIOSTEC 2008). 2008;1:253–8. https://doi.org/10.5220/0001063402530258. ISBN 978-989-8111-18-0; ISSN 2184-4305.
27. Sarobin MVR, Rukmani P, Jasmine SG, Harini S. Application of data analytics for IoT based healthcare system. Int J Eng Technol. 2018;7(3.8 Special Issue 8):169–72.
28. Shih AY. Stress: a brief history, C. L. Cooper and P. Dewe, Blackwell publishing, Oxford, 2004, 144 pp.(paperback). ISBN 1-405-10745-6. Stress Heal. 2004;20(4):240. https://doi.org/10.1002/smi.1027.
29. Handri S, Yajima K, Nomura S, Ogawa N, Kurosawa Y, Fukumura Y. Evaluation of student's physiological response towards e-learning courses material by using GSR sensor. Proc.—9th IEEE/ACIS Int. Conf. Comput. Inf. Sci. ICIS 2010, pp. 805–810; 2010, https://doi.org/10.1109/ICIS.2010.92.
30. Ragavi R, Srinithi B, Sofia A. Data mining issues and challenges: a review. Ijarcce. 2018;7(11):118–21. https://doi.org/10.17148/ijarcce.2018.71125.
31. Massot B, Baltenneck N, Gehin C, Dittmar A, McAdams E. EmoSense: an ambulatory device for the assessment of ANS activity-application in the objective evaluation of stress with the blind. IEEE Sensors J. 2012;12(3):543–51. https://doi.org/10.1109/JSEN.2011.2132703.
32. Ye S, Feng S, Huang L, Bian S. Recent progress in wearable biosensors: from healthcare monitoring to sports analytics. Biosensors. 2020;10(12):1–34. https://doi.org/10.3390/bios10120205.
33. Mittal M, Tanwar S, Agarwal B, Goyal LM. "Energy conservation for IoT devices," Concepts, Paradig Solut Stud Syst Decis Control Prep. Singapore: Springer Nature Singapore Pte Ltd.; 2019. p. 1–356.
34. Beck TW, et al. Mechanomyographic amplitude and frequency responses during dynamic muscle actions: a comprehensive review. Biomed Eng Online. 2005;4:1–27. https://doi.org/10.1186/1475-925X-4-67.
35. Kaur P, Sharma M, Mittal M. Big data and machine learning based secure healthcare framework. Procedia Comput Sci. 2018;132:1049–59.
36. Born M. Annalen der Physik Annalen der Physik. Ann Phys. 1901;11:433.
37. Fryer G. The Royal Society is collaborating with JSTOR to digitize, preserve, and extend access to Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. ® www.jstor.org. Society. 1985;308(795):379–430.

38. Ganzevles S, Vullings R, Beek PJ, Daanen H, Truijens M. Using tri-axial accelerometry in daily elite swim training practice. Sensors (Switzerland). 2017;17(5) https://doi.org/10.3390/s17050990.
39. Silva AS, Salazar AJ, Borges CM, Correia MV. Wearable monitoring unit for swimming performance analysis. Commun Comput Inf Sci. 2011;273:80–93. https://doi.org/10.1007/978-3-642-29752-6.
40. Félix ER, da Silva HP, Olstad BH, Cabri J, Correia PL. Swimbit: a novel approach to stroke analysis during swim training based on attitude and heading reference system (ahrs). Sports. 2019;7(11):1–11. https://doi.org/10.3390/sports7110238.
41. Kim H, Ahn M, Hong S, Lee S, Lee S. Wearable device control platform technology for network application development. Mob Inf Syst. 2016;2016 https://doi.org/10.1155/2016/3038515.
42. Oh K. Eight key areas of ICT development in Korea and three high priority initiatives in Abu Dhabi's ICT. Development. 2011;
43. Study B, Telekom D, Sonera T. Vodafone takes top spot in Machina Research's 2012 M2M CSP Benchmarking Study, no. January, pp. 1–3; 2012.
44. Fakan F, Chlumská A, Krijt J, Kočová L. Cytoplasmic liver cell inclusions—a typical feature of porphyria cutanea tarda—are absent in porphyria-related hepatic neoplasias. Neoplasma. 1998;45(2):102–6.
45. Somerset VS. Intelligent and biosensors. InTech; 2010.

Safeguarding Senior Citizens Using ICT

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and Mayank Gupta

1 Introduction

People are a nation's greatest resource, which makes it extremely important to safeguard and empower them. Safeguarding involves ensuring people's safety, protection from abuse and neglect, encouragement to give informed consent, and providing sufficient amount of care to improve their health, quality of life, and emotional well-being. According to a report by the National Statistical Office (NSO), the lower death rate has caused a steady rise in the elderly population of India since 1961, and it is set to rise by 41% over a decade (by 2031) as shown in Fig. 1 [1].

It has been indicated by a study that nearly 73% of elderly people have faced abuse during pandemic lockdowns and amidst second wave in India. There are many other vulnerabilities faced by the senior citizens due to rapid changes in the lifestyle caused by pandemic such as greater mortality risk, severe illness, deprivation, and exploitation. A survey has showed that 82% of the elderly people have witnessed adverse effects in their life due to ongoing pandemic. Furthermore, digitalization, industry4.0, urbanization, and globalization have also made the lives of senior citizens challenging. Therefore, it is necessary and obligatory to take measures to safeguard and empower senior citizens so that they can contribute to the development of the nation.

The Ministry of Social Justice and Empowerment, being the Nodal Ministry for the welfare of senior citizens, has announced various schemes for the welfare of the elderly from time to time. One such recent scheme is the National Action Plan for

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_14

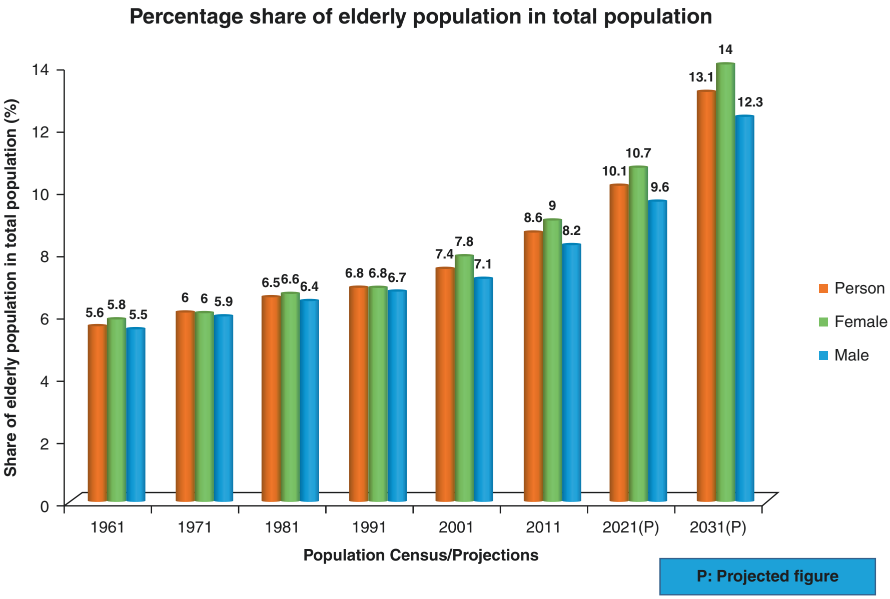

Fig. 1 Elderly population statistics as per the NSO

the Welfare of Senior Citizens, which consists of four sub-schemes to ensure the welfare and empowerment of senior citizens through various services such as food, shelter, care, mobile medicare units, physiotherapy clinics, and training centers.

With the advent and progress of information and communication technology (ICT), the output and benefits of various government schemes meant for the senior citizens can be increased multifold. This book chapter discusses the issues and challenges faced by senior citizens and the role of ICT to safeguard, empower, and caress them.

2 Role of ICT in Safeguarding Senior Citizens: Various Approaches and Application Areas

ICT is an umbrella term which allows individuals to store, access, process, and transmit information through different media. The advancements in Internet technology have increased the overall benefits of ICT, and it has become a convenient means to provide different services to people such as telemedicine, e-Health, m-Health, and eLearning to facilitate them. The applications of ICT are being explored and enhanced to safeguard and empower senior citizens. This section discusses such application areas and approaches, which are meant to improve the quality of life of senior citizens.

(i) **Smartphone-Based Human Activity Recognition:** Research in building safeguarding application using technologies and sensors for healthcare

Table 1 Motion sensors involved in our scheme

Sensor	Unit	Description
Accelerometer	m/s^2	Acceleration along the three axes (x, y, z)
Gyroscope	rad/s	Angular velocity around the three axes (x, y, z)
Magnetometer	μT	Geomagnetic field intensity along the three axes (x, y, z)
Gravity accelerometer	m/s^2	Gravitational acceleration along the three axes (x, y, z)
Linear accelerometer	m/s^2	Linear acceleration without gravity along the three axes (x, y, z)

systems specially for senior citizens has been gaining momentum in recent years. Applications for safety monitoring, fitness tracking, disease prediction, etc. are attracting the focus of researchers and developers across the globe. With the deep penetration of smartphones, loaded with motion sensors and adequate processing power, they have become a convenient option for collecting data and processing data to generate meaningful outcomes.

Researchers in [2] propose the use of smartphones to collect data for human activity recognition. Table 1 demonstrates various sensors used to collect data in [2]. Data collected is preprocessed to remove the influence of phone orientation and subsequently used in machine learning for activity identification. In the absence of sufficient training data (for unseen activities), a self-learning mechanism is proposed to identify a patient's activity.

(ii) **Fall Detection and Prevention:** According to the Centers for Disease Control and Prevention (2017), 3 million seniors are treated in emergency departments for fall injuries each year, and over 800,000 patients are hospitalized due to head and hip injuries. Falls are not an inevitable part of aging, and there are proven ways to reduce falls. Products and technology for fall detection are advancing day by day due to high demand and active research in this direction. Figure 2 categorizes the approaches and methods of fall detection and approaches.

Lucy et al. [4] have proposed an IoT-based fall prevention and detection method. The authors suggest the use of an accelerometer algorithm, which triggers an alarm based on a preset threshold value to detect fall. They also propose a fall prevention solution, which requires identification of fall-prone zones in home, office, or hospital environment as danger zone. A BLE module implemented in a wearable then alerts the subject as soon as the subject reaches in close proximity of a danger zone. A typical fall detection process based on image processing has been shown in Fig. 3.

Camera-based inactivity detection can also play an important role in fall detection as fall will end with inactivity for some time on the floor. 3D image captured at that time can analyze the body area and identify orientation to provide requisite information. Video signals may also be processed using image processing to detect fall by scene analysis and interpretation. Detection of abrupt movements can be done using vector analysis [5].

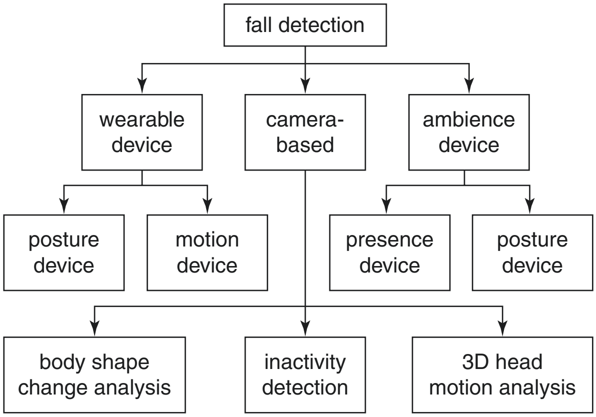

Fig. 2 Hierarchy of fall detection methods and approaches [3]

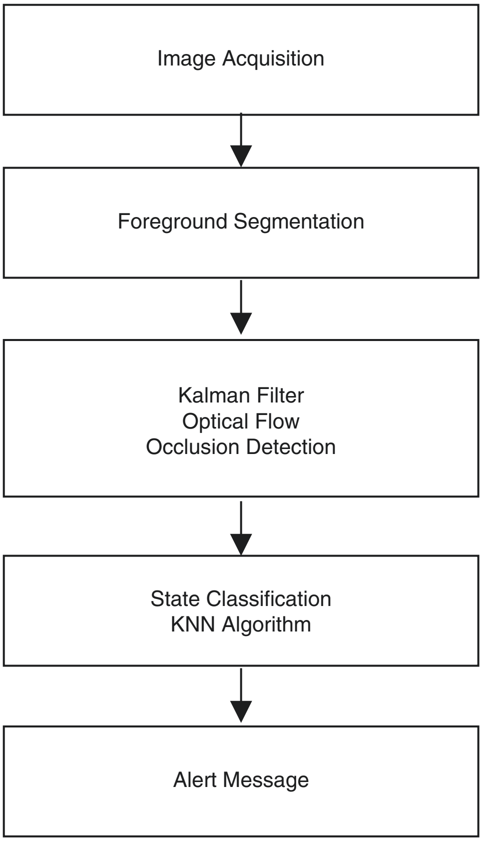

Fig. 3 Image processing-based fall detection process

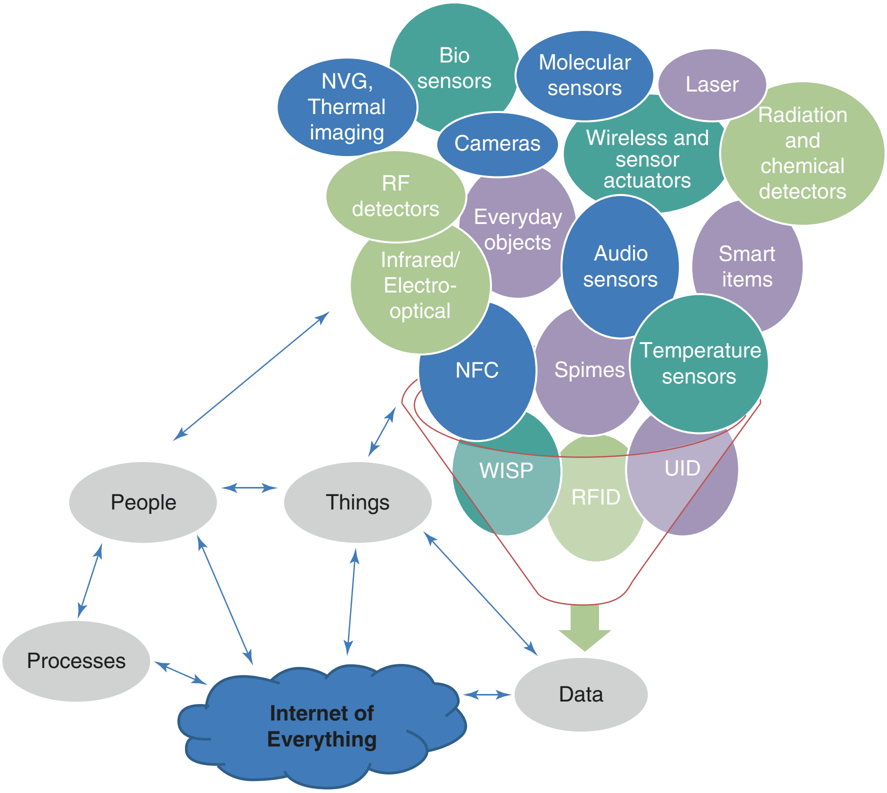

Fig. 4 IoT paradigm

(iii) **Internet of Things for Healthcare of Elderly:** The convergence of Internet with the radio-frequency identification devices (RFID), smart devices, and sensors is defined as the Internet of Things (IoT) as shown in Fig. 4. The IoT connects people, processes, data, and things together and provides services on demand anywhere to everywhere. The paradigm of the IoT is being widely exploited by the healthcare industry because of its many benefits and capability to provide integrated services.

An IoT-based e-Health and sleep apnea monitoring system (IEHSAM) has been prototyped by Moon et al. [6]. The system has an Arduino module, which collects real-time data of elder patient from different sensors like temperature sensor, pulse oximeter sensor, accelerometer, and GSR sensor. Data is further relayed to server for further processing and anomaly detection. The system allows caretakers and medical aides to do a technology-enabled real-time tracking from remote location.

(iv) **Sensors and Wearable Devices:** Sensors and wearable devices facilitate people by allowing the implementation of IoT-enabled services. Mostly used sensors include accelerometers, oximeters, temperature sensor, humidity sensors, GSR sensors, proximity sensors, etc. Wearable devices include multi-sensor smart belts, smart watches, movement trackers, reminders, e-Health monitors, etc.

A research [7] study has been done to design a multilayer system, which is able to detect the movement of residents inside house, specifically in bedroom, living room, and restroom. Due to migration of young population to cities and limited availability of health services in rural areas, it becomes difficult to take care of elder residents by care workers. The proposed system collects data of daily routine of the resident using motion sensors, hence ensuring privacy. The experiments show that since restroom is frequently visited by an elder during daytime, it promises effective location for placing of other sensors and anomaly detection. The authors also propose the use of IoT-enabled chips in shoes of the subject for detecting anomalies in outdoor setting for sending alerts to caretakers, hospitals, etc. in proximity.

(v) **Social Networking and Internet Usage:** Finland is a country which is considered to be possessing societies with economic and social equality [8, 9]. According to a study done by Finnish researchers, elderly have become more active online to access various services such as online shopping, emails, and e-banking. Acquaintance with social networking and Internet usage can help senior citizens avoid hassle and access various services on a single click. They need not go and stand in long queues for basic facilities. They may share their experiences with the world by using blog feature.

One research study has illustrated the use of tourism apps by senior citizens in order to visit various cultural heritage sites. Leisure and recreational activities via social networking and online platforms engage the elderly and help avoid mental stress and loneliness. Therefore, social networking and Internet can induce lifelong learning in the elderly population. Participatory technology assessment may help with future research directions. Future research directions should focus on the implications and the role of the Internet in the everyday life of the aging elderly citizens.

(vi) **Elderly and the Pandemic:** Elderly population, being the most vulnerable during the pandemic, must be protected and safeguarded by leveraging latest technologies. The lockdowns and safety protocols led to a rise in mental health issues, irrespective of the age. But senior citizens are at more risk due to additional illnesses and diseases. Social distancing further caused lifestyle disruptions among the elderly population who used to enjoy sitting in parks together as a routine and were suddenly made to self-isolate.

It is very difficult to convince the elderly to do what the governments tell to. Therefore, the use of ICT can be explored to protect and safeguard the elderly during the pandemic by providing them means to take care of their health and engage themselves in activities online during isolation or quarantine times. Ensuring safe and natural environment by regular garbage collection based on the IoT concept and sustainable solutions for other daily life challenges also makes a huge impact on assisting the elderly to handle the pandemic situations.

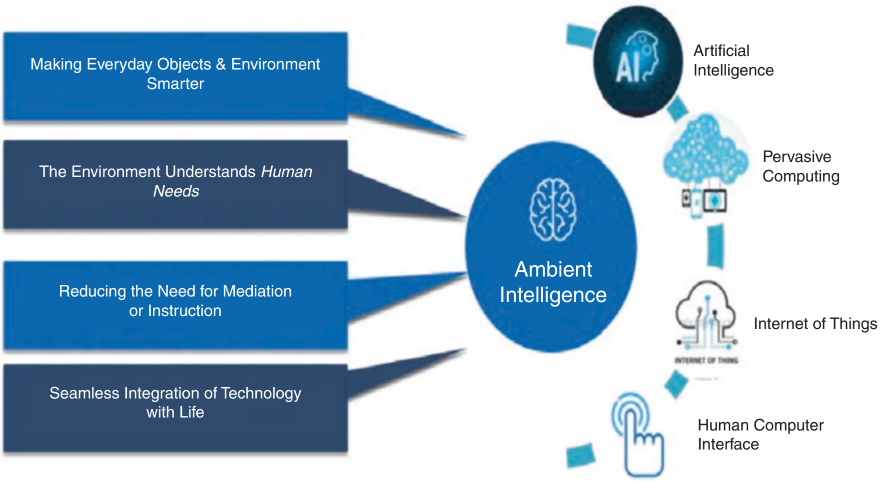

Fig. 5 Ambient intelligence description [Source: https://www.infosys.com/insights/ai-automation/ambient-intelligence.html]

(vii) **Ambient Intelligence:** Ambient intelligence is an area of pervasive computing, which makes our surrounding environment sensitive to us and helps in better interaction. Ambient intelligence [10] can assist and facilitate the elderly in daily life and emergency situations, such as automatic recognition of critical situations. However, the related concerns like privacy, social stigma, and security need to be addressed while designing solutions using such computing technologies (Fig. 5).

(viii) **Smart Homes:** With the rise of connected devices, large number of smart devices are getting installed in commercial/residential buildings and vehicles and on street. Applications and protocols are getting developed where these devices can connect and communicate to accomplish bigger tasks. Human activity recognition (HAR) in a smart home/building setting can be performed using data collected from sensor-based smart devices [11]. Figure 6 shows typical components of a smart home setup. Researchers in [11] proposed deep learning method for HAR over data collected using smart devices. Since conventional machine learning method requires feature engineering, use of deep learning method eliminates the need of feature selection. The experiments using four-layer CNN-LSTM model show a high accuracy rate of 99.39%. Authors in [12] have also used deep learning methods namely CNN-LSTM and gated recurrent units (GRU) for human activity recognition. The result shows an accuracy of 98.00% and 96.83% over standard WISDM and UCI-HAR datasets, respectively.

(ix) **Smart Cities:** As per reports [13], by 2050, nearly 70% of the total world population will be living in cities. This inflow of people has ignited the transformation of urban areas into smart cities. There are a variety of urban issues which need better, sustainable, and efficient solutions and management. Such

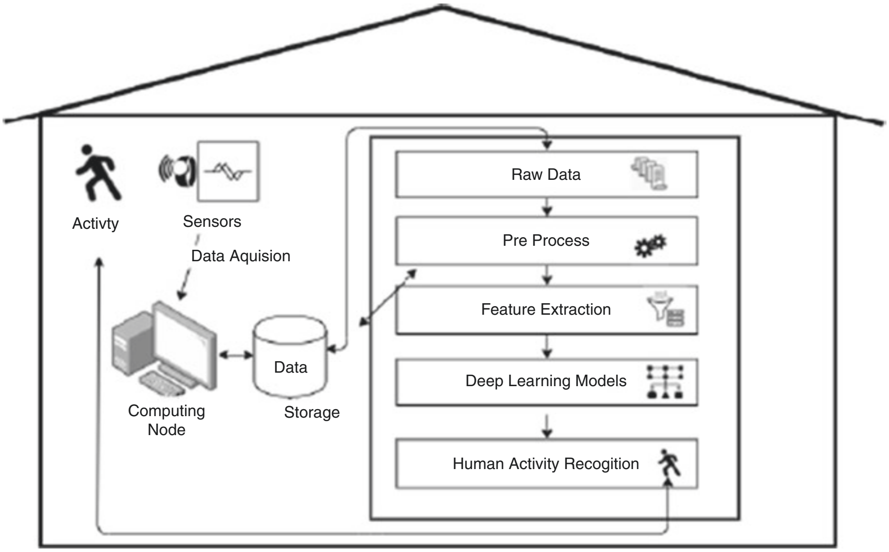

Fig. 6 Deep learning methods for human activity recognition in smart home setting [12]

social issues comprise waste management, energy management, water management, public transportation, healthcare, security, and education, to name a few. In the present pandemic situation, it is even more important to digitalize everything in order to facilitate people living in quarantine zones. But digitalization should not make the life of senior citizens challenging. Rather, it should ease their lives, and technological solutions should be assistive to the elderly. Various components of smart cities have been displayed in Fig. 7, whereby elderly population must be considered.

(x) **E-Government Services:** Rapidly growing populations all around the world have made the aging phenomenon prominent. Ubiquitous computing and information technology is being seen in many areas to facilitate people and processes. E-government refers to the umbrella term which includes providing a wide variety of services to the citizens with convenient access and privacy. ICT plays the most significant role in the provision of such services (Fig. 8).

3 Case Studies

This section discusses various case studies to illustrate the implementation of ICT-based technological solutions for elderly care.

1. Smart Homes for Elderly [14]

   The increase in the elderly population affects the socioeconomic growth of nations, which calls for the development of individual-based welfare models. In

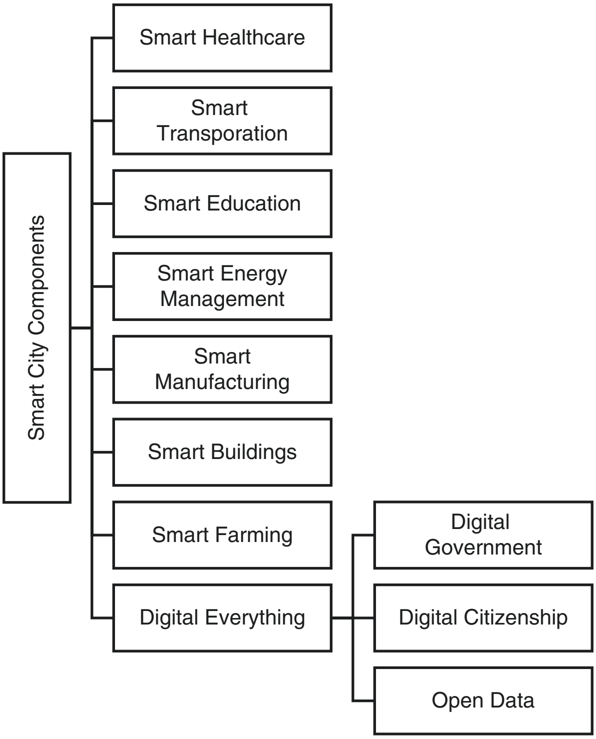

Fig. 7 Smart city components

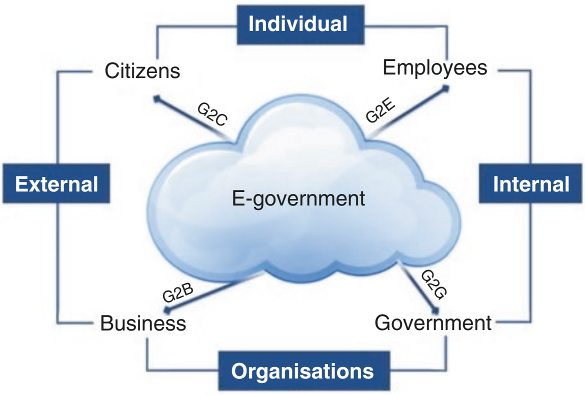

Fig. 8 E-government model [Source: https://www.researchgate.net/figure/Types-of-e-government_fig1_307892702]

the world of Industry4.0, the technology revolution involving paradigms of big data, IoT, cloud computing, and ICT has made it possible to develop smart cities. Smart home is one component of smart cities which focuses on the individual's basic needs such as independence, security, safety, privacy, health, and assistance. The initial proposal of a smart home was given by the American

Table 2 Smart home nomenclature

Country name	Nomenclature	Services
UK, USA, China	Smart home for elderly Smart home for seniors	Safety Health monitoring Equipment with modern technology
Sweden	e-Home care	Application of ICT to home care Monitoring, reminders, social networking
Germany	Ambient assisted living	Intelligent appliances Scalable intelligent technology Modern transmission devices

Association of Builders in 1984, referring to houses equipped with intelligent interactive technology [15]. The country-wise nomenclature for smart homes is shown in Table 2.

Smart home leverages the potential of various technology paradigms and incorporates that into a number of devices (Table 3), which can provide assistance to senior citizens to improve their quality of life and meet their basic requirements without hassle [16–18].

Apart from the abovementioned smart devices and systems, there are many smart home solutions already in practice globally to ensure safety and well-being of senior citizens. Some of these solutions are as follows [16]:

(a) Walabot Home

It is a solution designed to be placed on the wall of the bathroom, and it scans continuously for the movements of the elderly. If any fall is detected, it generates alarm and sends information to trusted contacts of the senior citizens. With this solution, there is no requirement of pressing any button in case of emergency situation. It will automatically assess the emergency situation and share information with the required people for assistance and help. The technologies being used by Walabot home are sensors and radio waves to detect movements and falls.

(b) Sense

It is an energy-monitoring device which is installed in the electrical panel of the home of the elderly. It monitors all the devices and tracks energy usage. It also gives information about which devices are on and which are off, so that it becomes easy to remotely access them.

(c) June Oven

It is a one-in-all oven, which provides various features such as toaster, convection, air frying, and slow cooking. It has an inbuilt camera, and the elderly can monitor their food without leaving their place at the click of a button and they get alerts when food is ready to eat.

Such simple solutions can make the life of elderly easier than ever, provided that they are well acquainted with the use of such devices.

2. E-Health for the Elderly

Healthcare is the most vital component of any welfare model designed for the elderly population. In terms of ICT, e-Health has emerged as a boon for various

Table 3 Smart home devices and systems

Device/systems	Features
Mesh Wi-Fi systems	– Mesh Wi-Fi uses multiple routers to provide Internet and high-power connectivity – Reliable solution that enables connectivity anywhere in your home
Smart security systems	– Provide safety from trespassers and adversities like floods, fires, and smoke – Door, windows, motion monitoring to trigger alarms – Involves sensors—smoke sensors, temperature sensors, flood sensors – Remote controlled using mobile apps
Voice-activated virtual assistants	– Amazon's Alexa is a powerful example of artificial intelligence – Act as digital companion
Routine monitoring smart sensors	– Capturing daily patterns to flag anomalies – Making the environment responsive to needs of elderly – Alert generation in case of inactivity, patient forgetting to take medicine or falls
Remote access systems	– Remote access to thermostat, air conditioner, television, security systems, etc.
Biomedical monitoring system	– Wearable implantable devices for continuous monitoring – Storage of medical history on a single chip
Alarms and reminders	– Linking devices together and generating alarms about things seniors forget to do such as locking the car – Reminders to take medication from time to time
Smart locks, doorbells	– Automatic monitoring of in and out movements and taking action accordingly to lock and unlock the doors – Visual and audio controls
Automated lighting and thermostats	– Temperature regulation using voice-controlled or remote-controlled systems – Energy management by automatic switching of lights
Smart pill dispenser	– Medication stored and dispensed according to prescription – Locking mechanisms to prevent overdoses and theft
Fall detection sensors	– Detecting slips, trips, and falls – Communicating and alerting the close contacts during emergency
Robotic vacuum	– Autonomous navigation and floor cleaning to protect the elderly from dust and dirt
Smart pet feeder	– Automatic food and water distribution to pets – Consistent feeding schedule
Smart light bulbs	– Wi-Fi-enabled LED lights – Automatic control via smartphone – Quick access, control, and efficiency
Smart outlets	– Extensions of normal outlets to switch on and off – Controlling devices through remote access
Smart garage door controller	– Ensures safety of vehicle by ensuring that the garage is closed during night or while seniors have gone on vacation
Smart kitchen appliances	– Wirelessly controlled ovens – Integration with smart home hubs and voice-enabled assistants
Smart clothes washer and dryer	– Tracking wash/dry cycles – Easy-to-manage laundry loads by senior citizens

(continued)

Table 3 (continued)

Device/systems	Features
Smart air filter monitor	– Generation of alerts when heating and cooling systems are at risk of clogging – Alerts sent via SMS and email
Smart leak detector	– Placed in pipe systems to detect changes in water pressure, risks of leakage, etc. – Alerts generated in view of running heater for long duration or running toilet
Smart water heater	– Remote management of water temperature – Monitoring energy usage and management

segments of the society. Provision of videoconferencing-based medicine prescriptions, telemedicine, smart assisting devices, e-marketplace for medicine, and other solutions has started to showcase its potential to safeguard the elderly from various prominent diseases. Various kinds of services in terms of e-Health include the following:

(a) SMS/email reminders to visit the hospital for the scheduled appointments
(b) Ordering prescription-based medicines through the Internet
(c) Consulting a doctor virtually
(d) Storage of medical health records and health-related other information
(e) Personalization in e-Health devices to assist the target user base efficiently
(f) Getting medical test reports and results on smartphone or emails
(g) Simple medical recommendations received over email/SMS
(h) Remote health monitoring using specialized device
(i) Ubiquitous computing and personalized algorithms helping to maintain healthy attitudes and behavior
(j) Promoting and maintaining mental health issues using mobile applications and various digital assistants
(k) Elderly specific care ensured by integrated health framework
(l) Up-to-date health information stored at one place and easier accessibility to predict or detect diseases at early stages

In order to provide the abovementioned services, various e-Health technologies have been listed in Table 4 [19].

Other technologies and devices to implement e-Health include e-Watches for activity and movement tracking, GPS systems to monitor outdoor locations of the individual, GSM for generating alerts, and RFID for location tracking and finding. The amalgam of all such technologies is progressing effectively to assist the elderly population in their daily lives.

4 Challenges Faced by Senior Citizens While Using ICT

Digital inclusion initiatives have made it possible for most of the senior citizens to keep up with the pace of modern technologies. However, the use of smart devices and digital technologies is not failproof. The developers and technologists need to

Table 4 e-Health technologies

Name of the technology	Description
Assistive technologies	• Overall management of routine activities using various kinds of devices, products, tools, and equipment • Examples: – Devices for environmental management – Systems embedded with sensors – Videophone network
Safety and social technologies	• Security technologies networked with other services • Examples: – Health TV – Safety bracelets – Smart floors – Integrated sensors – Bed occupancy sensors
Health technologies	• Self-monitoring and self-care • Examples: – Blood pressure monitors – e-Health portals
Self-activation and personal Development technologies	• Technologies to focus on self-development • Examples: – Pedometers – Activity bracelets – Smart sport watches – Accelerometers
Ambient assisted living (AAL)	• Design-for-all concept is used to ensure equality • Examples: – Sliding door – Robots – Medication optimization devices – Wearable technologies
Gerontechnology	• Includes all the above-listed technologies • Aims to develop age-friendly technologies • Promotes independence and ensures well-being
Hospital and EHR systems	• Data integration and monitoring the health • Electronic records of patients maintained

address the associated troubles with ICT and psychological issues encountered by senior citizens while learning these new technologies. The mobile applications need to be available in the native languages of the users so that they can acquaint themselves better with those apps. These kinds of issues impact the interest level of senior citizens to keep using these modern technologies and imbibe a spirit of change within themselves. The major challenges faced by senior citizens have been listed below:

- Lack of a suitable environment to develop technology skills and active participation in the resolution of societal issues.
- Lack of participatory management while developing the technological solutions.
- Rate of acceptance of modern technologies by senior citizens is quite low.

- Privacy concerns while adoption of e-government [20].
- Digital divide and the generation gap.
- Mental and psychological issues faced while using assistive technologies due to past failures.
- Ambiguity issues in the design and development of interactive digital technology for senior citizens by avoiding stigma [21].
- Family influences which might cause hindrances while using technologies [22].
- Rapid socioeconomic changes affect the lifestyle of elderly, especially caused by the pandemic.
- Lack of physical infrastructure to ensure safety and security has made the lives of senior citizens challenging.
- Poor accessibility, affordability, and ability to use the technological solutions due to financial status of the elderly.
- Lack of initiatives to inculcate digital literacy.

Apart from the above-listed challenges, there are more issues such as inability to use touchscreens due to leathery fingers, reduction in mobility, low income, social isolation, lack of companionship, and illiteracy. Therefore, individual specific models need to be thought of while developing technological solutions so as to bridge the digital divide as well as generation gap and allow the citizens to make the maximum use of such systems to improve their quality of life and ensure safety, security, independence, and well-being.

5 Conclusion

The benefits of ICT technology are numerous, which can be leveraged to design welfare models for the elderly population. The senior citizens are an important aspect of the progress of the nations and therefore require to be safeguarded from all kinds of issues. However, the challenges faced by the elderly have become a hurdle in the effective implementation of the technological solutions designed using ICT. Therefore, strong measures need to be taken to ensure the acceptance of the designed models for the well-being of the senior citizens. Careful consideration of the issues such as digital divide, generation gap, illiteracy, and digital inclusion needs to be done while developing platforms for usage by the elderly. This chapter discussed the role of ICT in safeguarding the senior citizens by integrating and incorporating details of existing solutions, techniques, technologies, products, and devices, which have been designed for the well-being of the subject population. Few case studies have been discussed to support the potential of ICT for designing efficient solutions for the senior citizens to safeguard and protect them. The challenges faced by the elderly while using ICT have also been discussed to ponder upon for the future research directions.

References

1. "Elderly in India", Available: http://mospi.nic.in/sites/default/files/publication_reports/Elderly%20in%20India%202021.pdf
2. Mittal M, Battineni G, Singh D, Nagarwal T, Yadav P. Web-based chatbot for frequently asked queries (FAQ) in hospitals. J Taibah Univ Med Sci. 2021;16(5):740–6. https://doi.org/10.1016/j.jtumed.2021.06.002.
3. Yu X. Approaches and principles of fall detection for elderly and patient. In HealthCom 2008-10th international conference on e-health networking, applications and services; 2008, July, pp. 42–47. IEEE.
4. Sumi L, Longchar I, Dey S. IoT-based fall prevention and detection for senior citizens, physically and intellectually disabled. In International conference on information technology; 2019.
5. Noury N, Fleury A, Rumeau P, Bourke AK, Laighin GO, Rialle V, Lundy JE. Fall detection-principles and methods. In 2007 29th annual international conference of the IEEE engineering in medicine and biology society;2007, August. pp. 1663–1666. IEEE.
6. Chowdhury M, Dey GK, Karim MR. IEHSAM: IoT based E-health and sleep apnea monitoring system. In Emerging Trends in Industry 4.0; 2021.
7. Shima K, Kawamura T, Yamaguchi M, Yoshida T, Otsuka T. Implementation and layout optimization of motion sensor for anomaly detection in daily life of elderly persons. In International conference on information & communication technology and system (ICTS); 2021.
8. Esping-Andersen G. The three worlds of welfare capitalism. Oxford: Polity Press; 1990.
9. Ferrera M. The "southern model" of social welfare in Europe. J Eur Soc Policy. 1996;6(1):17–37.
10. Kirchbuchner F, Grosse-Puppendahl T, Hastall MR, Distler M, Kuijper A. Ambient intelligence from senior citizens' perspectives: understanding privacy concerns, technology acceptance, and expectations. In: European conference on ambient intelligence. Cham: Springer; 2015, November. p. 48–59.
11. Shih CS, Chou JJ, Lin KJ. WuKong: secure run-time environment and data-driven IoT applications for smart cities and smart buildings. J Internet Serv Inf Secur. 2018;8(2):1–17.
12. Kolkar R, Geetha V. Human activity recognition in smart home using deep learning techniques. In 2021 13th International conference on information & communication technology and system (ICTS); 2021, pp. 230–234, https://doi.org/10.1109/ICTS52701.2021.9609044.
13. Bhushan B, Khamparia A, Sagayam KM, Sharma SK, Ahad MA, Debnath NC. Blockchain for smart cities: a review of architectures, integration trends and future research directions. Sustain Cities Soc. 2020;61:102360.
14. Zhang Q, Li M, Wu Y. Smart home for elderly care: development and challenges in China. BMC Geriatr. 2020;20:318. https://doi.org/10.1186/s12877-020-01737-y.
15. Harper R. Inside the smart home. London: Springer; 2003.
16. 9 Smart home devices for aging in place. https://www.dwell.com/article/9-smart-home-devices-for-aging-in-place-5528881a
17. 8 ways smart homes are perfect for seniors. https://www.caringseniorservice.com/blog/smart-home-for-seniors
18. Smart home senior safety. https://www.housecallpro.com/learn/smart-home-senior-safety/
19. Battineni G, Chintalapudi N, Amenta F. AI Chatbot design during an epidemic like the novel coronavirus. Healthcare (Basel). 2020;8(2):154. https://doi.org/10.3390/healthcare8020154.
20. Phang CW, Li Y, Sutanto J, Kankanhalli A. Senior citizens' adoption of e-government: in quest of the antecedents of perceived usefulness. In Proceedings of the 38th annual Hawaii international conference on system sciences, IEEE; 2005, pp. 130a.
21. Sokoler T, Svensson MS. Embracing ambiguity in the design of non-stigmatizing digital technology for social interaction among senior citizens. Behav Inform Technol. 2007;26(4):297–307.
22. Tan KS, Chan CM. Unequal access: applying Bourdieu's practice theory to illuminate the challenges of ICT use among senior citizens in Singapore. J Aging Stud. 2018;47:123–31.

Insights on Applying Teledentistry Principles in Managing the Emergency Endodontic Conditions During the COVID-19 Pandemic

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1 Introduction

The outbreak of the novel coronavirus strain (COVID-19) is the current threat faced globally [1]. This chapter enlightens the role of endodontists explicitly in the present situation and discusses the current protocol for endodontic intervention and the change in performing endodontic procedures, based on applying the teledentistry principles in endodontics.

In the current-day scenario, teledentistry is a possible mode to symptomatically manage and deliver the oral therapeutic protocols, across the distance [2]. High-speed access to mobile data and the Internet has led to building strong and effective communication between patients and dentists. It is possible to render teledentistry with the usage of various software, video conferences, smartphones, iPads, and laptops. Nowadays, face-to-face interaction is reduced, modifying the traditional method of consulting the patients in dentistry.

Teledentistry is a field, where telecommunication principles are applied. Remote consultations and treatment planning are done by exchanging clinical images and information [3]. In endodontics, a real-time consultation and store and forward are the two applicable modes of teledentistry. An endodontist and a patient can have a

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_15

video conference in real-time consultations, where a patient can see, hear, and communicate with the doctor using high-speed Internet connection with advanced telecommunication devices. The static information and the clinical images stored are used for remote consultation and treatment planning in cases of the store-and-forward mode. It is usually done by exchanging the data using telecommunication equipment. A dentist can either collect the intraoral images of the patients and radiographs and refer them to a concerned endodontist or the collected information can be transferred to another specialist for an expert opinion.

2 Role of Teledentistry in Endodontics

Endodontics is a field where complex root canal anatomy is dealt with in a simplified way. The role of an endodontist is to treat the diseases of neurovascular tissues encased three-dimensionally in hard tooth structure, which barely has a collateral supply. So, most of the time, patients usually present with severe pain requiring emergency management, and treatment options include the excising of the tissue from the root canal space and alleviating the patient's pain. So, the role of an endodontist is to perform an emergency neurovascular surgery, by extirpating the pulp. A recent study on the emergency endodontic procedures performed in Wuhan, China, revealed that most of the emergency endodontic managements in a COVID-19 high-risk area concentrated on treating symptomatic irreversible pulpitis cases [4].

A recently published survey on dentists revealed that currently, emergency endodontic treatments are the most performed procedures, especially by specialists and consultants [5]. The threat of infection transmission is higher among endodontists due to airborne aerosol transmission. So, when performing the treatments in patients with COVID-19, endodontists are highly prone to the aerosol transmission of disease [6].

As the hospitals and dental setups serve as a source of cross infection, for transmitting community infections, it is recommended to avoid direct visits often to the clinics. A recent study revealed the anxious state and fear faced globally by dental practitioners, and many of them have either closed down practices for an uncertain period or modified their services to emergency treatment only [7]. So, the endodontists are defending the threat of transmission and performing emergency endodontic therapies at higher risk in the present situation. Hence, new modes of consultation are encouraged to minimize the contact with patients, especially with infected individuals with a higher risk of transmission.

3 Currently Formulated Protocols to Prevent the Infection Transmission During Endodontic Therapy

In the present situation, the formulated therapeutic protocols and the approach towards treatment aspects have changed enormously. Now the potential routes of COVID-19 transmission are clear, claiming to transmit through droplets and aerosol clinical procedures. Although classical symptoms are quite evident in infected individuals, chances of infection transmission are also higher with asymptomatic individuals too. So, various protocols have been formulated to prevent disease transmission among dentists [8, 9].

- Prior telescreens and triaging are considered the most appropriate options in the present situation. The valuable options that can be considered during the telescreens are based on emergency severity assessment, a decision-making tool [9], and others based on the true emergency questionnaire [8].
- The major reason for assessing the patient using these tools is to categorize the conditions under the level of emergency and the specific intervention needed for a certain level.
- The level of emergencies was categorized as emergency care, urgent care, and scheduled/elective care.
- Emergency care: Only conditions like uncontrolled bleeding, life-threatening airway obstructions due to intra- or extraoral swellings, or severe traumatic injuries are categorized under emergency care and have to be addressed immediately with no appointments.
- Urgent care: All other dental conditions including symptomatic irreversible pulpitis, primary or secondary symptomatic apical periodontitis, and soft-tissue trauma as a result of tooth fracture or pain and avulsion injuries are categorized under urgent care. Therapeutic strategies in such situations include pharmacological management with constant follow-ups, and in case of worsening of symptoms, patients should be scheduled for physical appointments.
- Scheduled/elective care: Loss of restorations with no pain, asymptomatic fractures involving enamel or dentin, and asymptomatic pulpal infections requiring endodontic therapy are categorized under elective care. Such patients are advised for telescreens until the regular dental services are restored.
- Patients categorized under emergency or urgent care requiring therapeutic intervention through physical appointments have to be managed specifically through patient evaluation and cohorting. A detailed assessment of medical history and COVID-19 screening questionnaire has to be done prior to therapeutic intervention [8].
- Based on the COVID-19 risk assessment chart [9], which includes (a) stage of disease spread (details on particular geographic location/state/country), (b) history of exposure (positive COVID-19 suspect), and (c) contributing respiratory illness and symptoms (fever, cough, and dyspnea), patients can be categorized under high or low risk. These risk assessments can be better done prior to the scheduling of appointments. In the present situation, it is better to consider all patients as potential asymptomatic carriers and better to have appointment timings as short as practically possible.

3.1 Treatment Guidelines to Be Followed During This Pandemic Situation

- Once it is confirmed that urgent or emergency care is required for a patient, a physical appointment has to be planned accordingly. The treatment guidelines differ when treating a COVID-positive or high-risk patient versus a low-risk patient [8, 9].
- Guidelines for performing dental procedures remain almost similar in both high- and low-risk patients. General guidelines include the standard contact and airborne precautions including the appropriate use of personal protective equipment and hand hygiene practices, by minimizing aerosol-generating procedures, avoiding the intraoral radiographs, and 1% hydrogen peroxide or 0.2% povidone-iodine pre-procedural mouth rinse. Chlorhexidine has been tested ineffective against SARS-CoV-2 [9, 10].
- The emergency management of high-risk individuals is barely different from treating a noninfected individual. The treatment procedures can be categorized as nonaerosol-generating procedures and aerosol-generating procedures.

4 Protocol for Nonaerosol-Generating Procedures

- Cases such as carious tooth presenting with symptomatic irreversible pulpitis or symptomatic apical periodontitis can be managed using alternative procedures to aerosol generation. Four-handed dentistry with adequate local anesthetic techniques remains the same. Isolation can be carried out using a dental dam with high-volume saliva ejectors. It is preferable to avoid a three-way syringe [9].
- Alternative caries removal procedures such as chemo-mechanical caries excavation can be done using a spoon excavator or a slow-speed handpiece without water spray until the pulp is exposed. Partial or complete pulpotomy [8, 9] can be done followed by arresting the bleeding using cotton pellet soaked in 3% sodium hypochlorite under slight pressure, followed by providing a temporary seal. An arsenic-free pulp devitalization can be used in cases of uncontrolled bleeding. Postoperative pain management can be pharmacological using NSAIDs.
- Cases of acute apical abscess presenting with intraoral and extraoral swelling can be managed immediately by supplementation of a long-acting anesthetic, 0.5% bupivacaine for immediate pain relief, followed by incision and drainage of intraoral swellings and analgesic prescription as and when required and antibiotic course for 5 days, and call an oral and maxillofacial surgeon for further instructions or a possible referral [8].
- Cases of avulsion/luxation can be immediately replanted following the IADT guidelines if not implanted at the site of the accident, followed by pain management using first-line analgesics for initial pharmacological management [8].
- Cases of tooth fractures exposing pulp resulting in pain can be managed by vital pulp therapy, followed by pharmacological pain management.

- All other traumatic conditions involving the facial bones and cellulitis or diffuse intra- or extraoral swellings potentially compromising the airway can be immediately referred to an oral and maxillofacial surgeon [8].

5 Protocol for Aerosol-Generating Procedures

- Endodontic emergencies, necessitating the use of an airotor, can be adequately managed under a rubber dam with four-handed dentistry using high-volume saliva ejectors, minimizing the aerosol production and reducing the airborne particles 3-foot diameter to the operational field [9].
- In cases of treating the suspected or confirmed COVID-19 patients in dental setups, a negative-pressure or AIIR treatment room allows complete disinfection, thereby preventing cross-contamination. If the operator is not prepared, then the patient should be directed towards the local authorities for assessment and management [8, 9].

Disinfection of the Clinic Settings

- For all nonaerosol-generating procedures, frequent cleaning and disinfection of general areas such as door handles, chairs, and desks can be done using disinfectants such as isopropyl alcohol and 1% sodium hypochlorite. Reusable instruments can be pretreated, cleaned, sterilized, and properly stored [8, 9].
- In case of performing any aerosol-generating procedures, it is advisable to fix the appointment as the last case followed by fumigation and ventilation of the clinic [9]. An indoor portable air cleaning system with HEPA filter and UV light may be used. In a recent study, it was concluded that the use of UVC irradiation using novel UVC assembly could reduce the cross-contamination in dental offices [11].
- Marking of medical and domestic waste is done adequately and disposed of by following biomedical waste management and handling rules [9].

5.1 Precautionary Measures After Management of Suspected High-Risk or COVID-19-Positive Cases

- There are no currently recommended additional precautions rather than regular measures as discussed earlier, for healthcare practitioners after the management of COVID-19 cases. However, there is insufficient evidence on the optional personal practices such as removing any clothing worn during delivery of healthcare, taking off shoes, washing clothing, and immediate showering [12].
- The dental clinics or hospitals can be separated into various color-coded zones, which include a yellow room for the waiting area, and triage staff wear a disposable surgical mask, cap, and work clothes [13].
- Orange room is for a general dental clinic, and staff are provided with PPE, including disposable N95 masks, gloves, gowns, cap, shoe cover, and goggles or face shield [13].

- Red room is considered as isolation room designed for COVID-suspected patients, patients recovering from COVID-19, or dental procedures producing droplets or aerosols. Green room is a resting area for staff only.
- Healthcare workers are advised to wear PPE at all times while on duty and undergo thermal screenings regularly. The buddy system is employed for persons working in the institutions associated with the active COVID-positive cases. Buddy system employs a team, where the hospital staff share the responsibility of appropriate donning and doffing of PPE and taking requisite steps on observing the breach of PPE [14].
- Standard operating procedure needs to be followed after every high-risk exposure of healthcare worker. Accidental direct exposure to the body fluids or face-to-face contact with COVID-positive cases and performing aerosol-generating procedures without appropriate PPE or a possible breach in the PPE are categorized under high-risk exposures of healthcare workers.
- In the case of high-risk exposure, healthcare workers who are tested negative and asymptomatic are quarantined for 14 days, monitored for the development of active symptoms, and allowed to work after a complete quarantine period [14].
- Positive-tested asymptomatic healthcare workers or those with manifesting mild signs and symptoms are home quarantined for 14 days. Moderate and severe cases are managed at dedicated COVID healthcare centers and hospitals [14].
- Currently, there is no FDA-approved post-exposure prophylaxis for patients and healthcare workers who may have been exposed to COVID-19 [12]. Hence, to prevent disease transmission to the healthcare workers, standardized infection control and appropriate sanitization protocols are to be undertaken.

6 Conclusion

In this chapter, we would like to emphasize the threat of the current situation on the dentists and endodontists. We would like to emphasize the strict application of teledentistry principles in endodontics to prevent infection transmission.

References

1. Battineni G, Chintalapudi N, Amenta F. Forecasting of COVID-19 epidemic size in four high hitting nations (USA, Brazil, India and Russia) by Fb-Prophet machine learning model. Appl Comput Inform. 2020; https://doi.org/10.1108/ACI-09-2020-0059.
2. Mahdi SS, Allana R, Battineni G, Khalid T, Agha D, Khawaja M, Amenta F. The promise of telemedicine in Pakistan: a systematic review. Health Sci Rep. 2022;5(1):e438. https://doi.org/10.1002/hsr2.438.
3. Yoshinaga L. The use of teledentistry for remote learning applications. Pract Procedures Aestehtic Dentistry. 2001;13(4):327–8.
4. Yu J, Zhang T, Zhao D, Haapasalo M, Shen Y. Characteristics of endodontic emergencies during coronavirus disease 2019 outbreak in Wuhan. J Endod. 2020;46:730. https://doi.org/10.1016/j.joen.2020.04.001.

5. Teja KV, Vasundhara KVA, Gummuluri S. Knowledge, awareness, and practice of dentists in preventing- novel corona virus (COVID-19) transmission - a questionnaire based cross-sectional survey. Braz Dent Sci. 2020;23 https://doi.org/10.14295/bds.2020.v23i2.2287.
6. The workers who face the greatest coronavirus risk [WWW Document]; n.d. https://www.nytimes.com/interactive/2020/03/15/business/economy/coronavirus-worker-risk.html. Accessed 23 Mar 2020.
7. Ahmed MA, Jouhar R, Ahmed N, Adnan S, Aftab M, Zafar MS, Khurshid Z. Fear and practice modifications among dentists to combat novel coronavirus disease (COVID-19) outbreak. Int J Environ Res Public Health. 2020;17:2821. https://doi.org/10.3390/ijerph17082821.
8. Ather A, Patel B, Ruparel NB, Diogenes A, Hargreaves KM. Coronavirus disease 19 (COVID-19): implications for clinical dental care. J Endod. 2020;46:584–95. https://doi.org/10.1016/j.joen.2020.03.008.
9. Krithikadatta J, Nawal RR, Amalavathy K, McLean W, Gopikrishna V. Endodontic and dental practice during COVID-19 pandemic: position statement from the Indian endodontic society, Indian dental association, and International Federation of Endodontic Associations. Endodontology. 2020;32:55. https://doi.org/10.4103/endo.endo_61_20.
10. CDC. Coronavirus disease 2019 (COVID-19) [Internet]. Centers for Disease Control and Prevention; 2020. https://www.cdc.gov/coronavirus/2019-ncov/infection-control/index.html
11. Botta SB, de Sá Teixeira F, Hanashiro FS, de Araújo WWR, Cassoni A, da Silveira Salvadori MCB. Ultraviolet-C decontamination of a dental clinic setting: required amount of UV light. Braz Dent Sci. 2020;23:10. https://doi.org/10.14295/bds.2020.v23i2.2275.
12. CDC. Coronavirus disease 2019 (COVID-19) [WWW document]. Centers for Disease Control and Prevention; 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/faq.html. Accessed 22 June 2020.
13. Chakraborty T, Jamal RF, Battineni G, Teja KV, Marto CM, Spagnuolo G. A review of prolonged post-COVID-19 symptoms and their implications on dental management. Int J Environ Res Public Health. 2021;18(10):5131. https://doi.org/10.3390/ijerph18105131.
14. WHO. Health workers [WWW Document]. WHO; n.d.. https://www.who.int/occupational_health/topics/hcworkers/en/. Accessed 22 June 2020.

EMD Inspired by Wavelet Thresholding for Correction of Blink Artifacts from Single-Channel Cerebral Signals

Vijayasankar Anumala and Venkata Rao Dhulipalla

1 Introduction

As per the records of the WHO and the statistics of neurological disorders, 50 million people are affected by epilepsy globally and 24 million by Alzheimer's and other disorders. As a result of neurological disorders, around 6.8 million people lose their lives every year [1, 2]. Physicians suggest continuous brain monitoring to diagnose the diseases like Alzheimer's, epilepsy, and other neurological disorders.

There are several methods to acquire the cerebral activity: magnetoencephalography (MEG), functional magnetic resonance imaging (FMRI), near-infrared spectroscopy (NIRS), computed tomography (CT), electroencephalogram (EEG), etc. Though these methods can provide good spatial resolution, EEG is the powerful and frequently used tool in modern medical field and academia due to affordable price along with acceptable temporal resolution [3].

Of late, EEG-based home care systems such as Neuro Monitor and OPTIMI are being used rapidly to monitor the condition of individuals, particularly in care related to elderly, where minimal instrumentation and less computational resources are required [4, 5]. Single-channel EEG contains few electrodes and ambulatory system embedded with signal processing to process the EEG signals, which makes it more popular. EEG signal can be produced with the excitation of neurons in brain. The magnitude of the EEG signal approximately varies between 10 μV–100 μV and 0–64 Hz, respectively. The sub-bands of typical EEG brain rhythms are delta, theta, alpha, and beta, respectively, from low to high frequencies which are shown in Fig. 1.

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M. Mittal, G. Battineni (eds.), *Information and Communication Technology (ICT) Frameworks in Telehealth*, TELe-Health,
https://doi.org/10.1007/978-3-031-05049-7_16

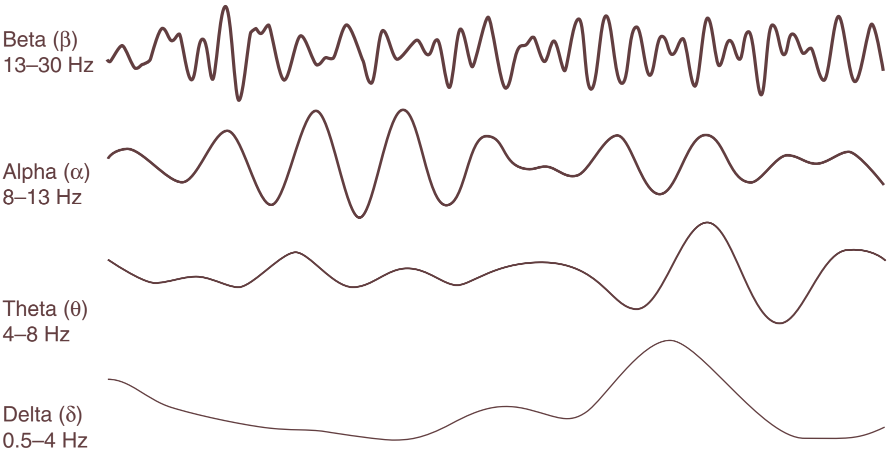

Fig. 1 Typical EEG brain rhythms

The extra-biological artifacts like line interference and electrode noise can be removed by filtering, due to spectral separation between extra-biological artifacts and electroencephalography signal. However, due to the fact that the heartbeat, movement of eyes, and muscles coexist in the frequency range as EEG signal, considerable attention must be paid to eliminate the biological artifacts. There exists a significant damage to the data of an EEG, if the procedure of artifact elimination is not methodical [6].

Several efforts have been made, and various methods have been developed till date for the removal of artifacts. However, each of them lags behind with some practical issues such as requirement of high computational resources and computational time, and there is no complete solution yet, which leads to the development of simple artifact removal techniques.

Several techniques were projected to correct BAs from recordings of EEG, among which wavelet transform (DWT and SWT) with thresholding methods is being widely used [7, 8]. Identification of mother wavelet also plays a major role in the system's overall performance.

Huang et al. developed EMD to evaluate nonstationary and nonlinear signals such as EEG [9, 10]. EMD decomposes the signal into several IMFs. The main advantage of EMD over WT is its ability to estimate suitable changes in the frequency of the signal. IMF interval thresholding is employed for correcting the artifacts resulting in a substantially cleaner EEG signal unlike using conventional EMD methods, which may result in loss of neural information at blink regions [11].

Frontal channels like F8, F7, FP2, and FP1 are likely to be dominant with respective to ocular artifacts. Thus, it is realistic to read the signals as corrupted or contaminated EEG signals from these electrodes. Figure 2 illustrates the blink artifacts of typical EEG signals. "eegmmidb" (EEG motor movement/imagery) dataset was used to carry the computations [12]. Comparison is made between the proposed method and the conventional EMD with concentration on considering standard metrics for performance like ARR, RMSE, ΔSNR, and CC.

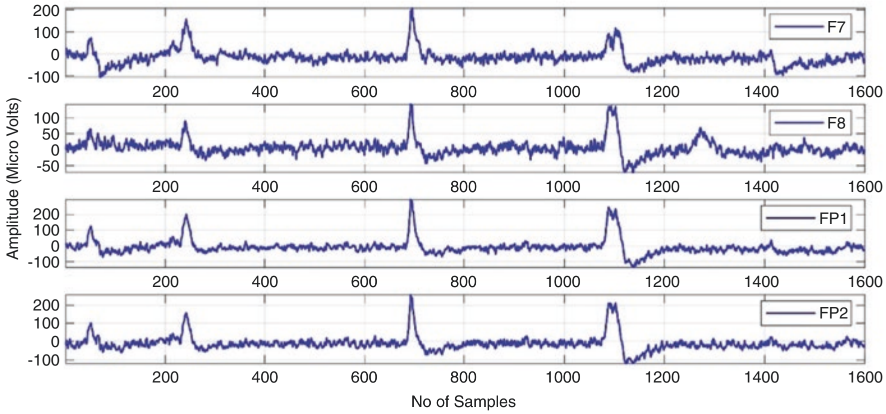

Fig. 2 Frontal electrode EEG signals with blink artifacts

The outline of this chapter is as narrated: A concise study of EMD algorithm is done in Sect. 2; Sect. 3 describes the identification of noisy IMFs and blink artifacts; the concepts of threshold function and IMF thresholding are discussed in Sect. 4; experimental verification and results of the proposed method are projected in Sect. 5; the conclusions are furnished in Sect. 6.

2 Empirical Mode Decomposition

EMD is an efficient approach for breaking down any complicated signal into finite intrinsic mode functions [13, 14]. The extremas and IMF zero crossings should be same or alter by one. The average of envelope stated by extrema must be zero at any point for each IMF. For a nonstationary signal $x(t)$, the detailed steps of EMD are the following:

(a) The maxima and minima points of the raw EEG signal are to be determined.
(b) Using cubic spline interpolation, the signals lower envelope (e_{lower}) and upper envelope (e_{upper}) are to be created.
(c) To generate the first IMF, the mean envelope should be deducted from the signal $x(t)$. $h_1(t) = x(t) - a(t)$, where $a(t)$ represents the average of the envelope, i.e., $a(t) = \frac{(e_{lower} + e_{upper})}{2}$.
(d) To get a new residual signal r_1(t), IMF1 is to be subtracted from $x(t)$, i.e., $r_1(t) = x(t) - h_1(t)$, and then $r_1(t)$ should be decomposed as done above to obtain the second IMF.
(e) All the steps are to be made recurrent till no IMFs are derived. Reconstruction of original signal can be from IMFs like $x(t) = \sum_{i=1}^{K} h_k(t) + r(t)$. Figure 3

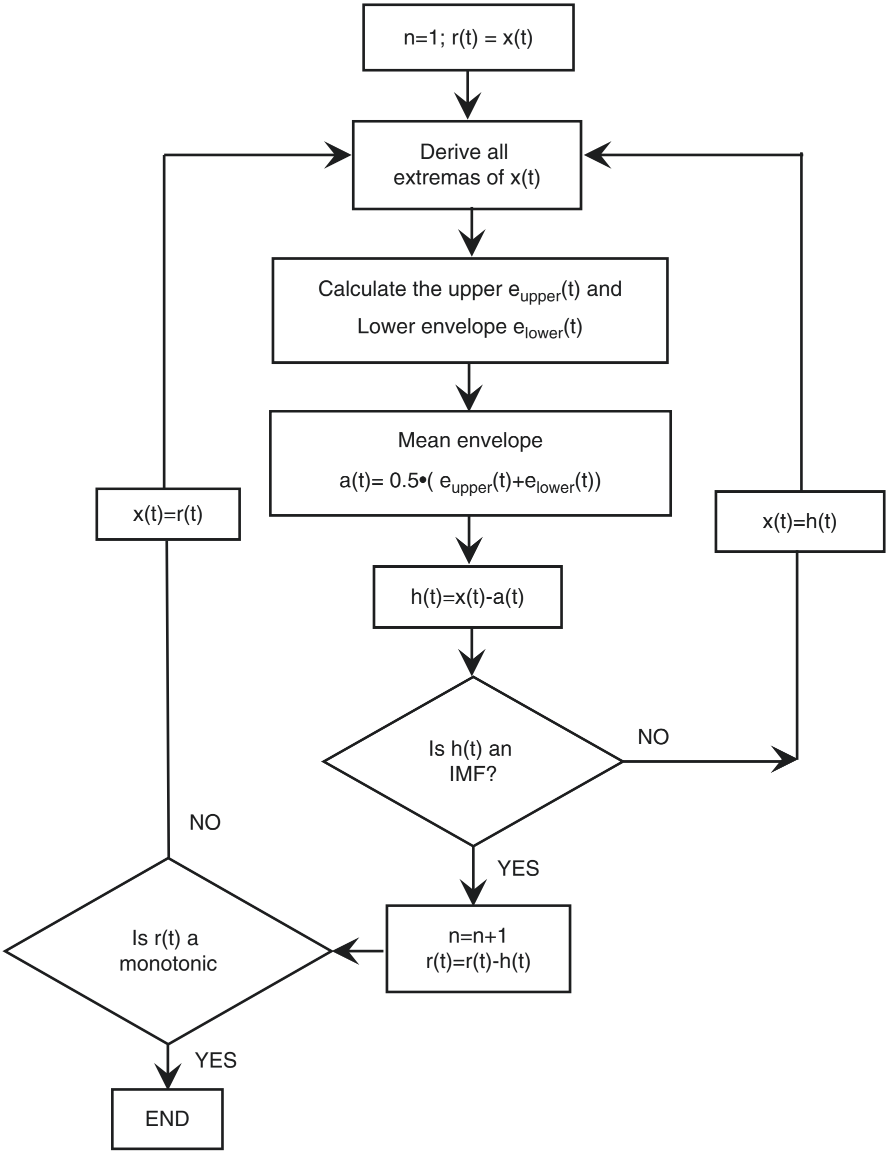

Fig. 3 Flowchart depicting the process of EMD

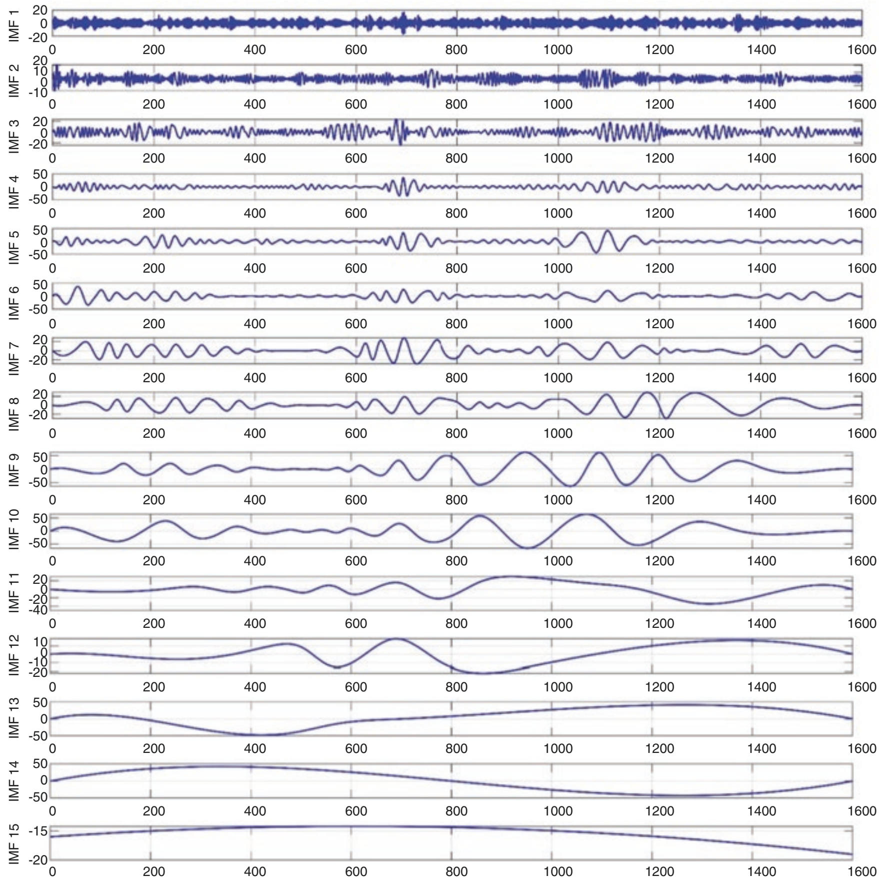

Fig. 4 IMFs 1–15 due to decomposition of FP2 EEG

illustrates the flowchart of the EMD process [15]. The resulting IMFs by applying EMD for the FP2 EEG signal are as shown in Fig. 4.

3 Identifications of Noisy IMFs and Blink Artifacts

3.1 Identification of Noisy IMFs

By performing thresholding to all IMFs, there may exist a loss of neural activity in the reconstructed signal [16]. Hence, it is necessary to identify the IMFs that belong to signal component or artifactual component and thresholding is performed to noisy IMFs that results in clearer EEG signal. The coefficients of correlation amid the IMFs and the raw EEG signal can be used to categorize the IMFs as either noise-dominant or signal-dominant modes. The magnitude and frequency of the EEG

Table 1 Correlation coefficient between raw EEG and IMFs

IMFs	1	2	3	4	5
CC	0.121	0.133	0.186	0.173	0.265
IMFs	6	7	8	9	10
CC	0.288	0.364	0.284	0.375	0.393
IMFs	11	12	13	14	15
CC	0.163	−0.045	−0.054	0.087	0.089

signal typically range from 10 μV to 100 μV and from 0 to 64 Hz, respectively, whereas ocular activity varies in the order of millivolts spread from 0 to 16 Hz subband. Hence, blink artifacts absolutely capture the neural signal with its occurrence, and mostly the EEG signal is noise dominant. So, the IMFs having the highest correlation coefficient with respect to raw EEG signal are considered to be dominant in noise, while the others are considered as signal dominant. However, if the signal contains a momentous noise, this method may cause some noise-dominant IMFs to be misjudged. Table 1 labels CC between the raw EEG and individual IMFs for FP2 EEG. Those IMFs with CC greater than 0.25, i.e., IMF5, IMF6, IMF7, IMF8, IMF9, and IMF10, are considered to be noise dominant.

Spectral analysis of modes is used to classify the IMFs in this study. Figure 5 illustrates the spectral comparison of raw EEG signal and its IMFs. The IMFs with substantial power at lower frequencies are considered as noisy IMFs. From this figure, IMFs 11–15 might not be considered as signal-dominant IMFs due to their spectral distribution at lower frequencies. To resolve the issue, EEG signal is preprocessed by stationary wavelet transform, and the CC between preprocessed signal and its IMFs is derived.

Raw EEG signal of sampling frequency 160 Hz is decomposed to four levels by stationary wavelet transform. Daubechies (db8) wavelet is chosen; hence, its shape resembles that of ocular activity. The approximation coefficients at fourth decomposition level that are at OA range are set to zero, and reconstruction is performed. The preprocessed EEG signal and its power spectrum are shown, respectively, in Figs. 6 and 7. As shown in Fig. 6, the spectral distribution of signal plus noise is minimum at 0–16 Hz. EMD is employed to the preprocessed signal for extracting IMFs. Correlation coefficient is carried out over the preprocessed signal and the extracted IMFs, from which noise-free IMFs are estimated and summarized in Table 2. On observing Table 1, it can be concluded that IMFs 1–4 are to be considered as signal dominant due to their mutual correlation with preprocessed signal. IMFs 11–15 are not correlated to the preprocessed signal and hence considered as noise dominant.

3.2 Identification of Blink Artifacts

Krishnaveni et al. developed a wavelet-based approach to identify slowly varying artifacts and performed denoising for the zones identified, which preserves the cerebral information at artifact-free zones. Haar wavelet is used to recognize rising and

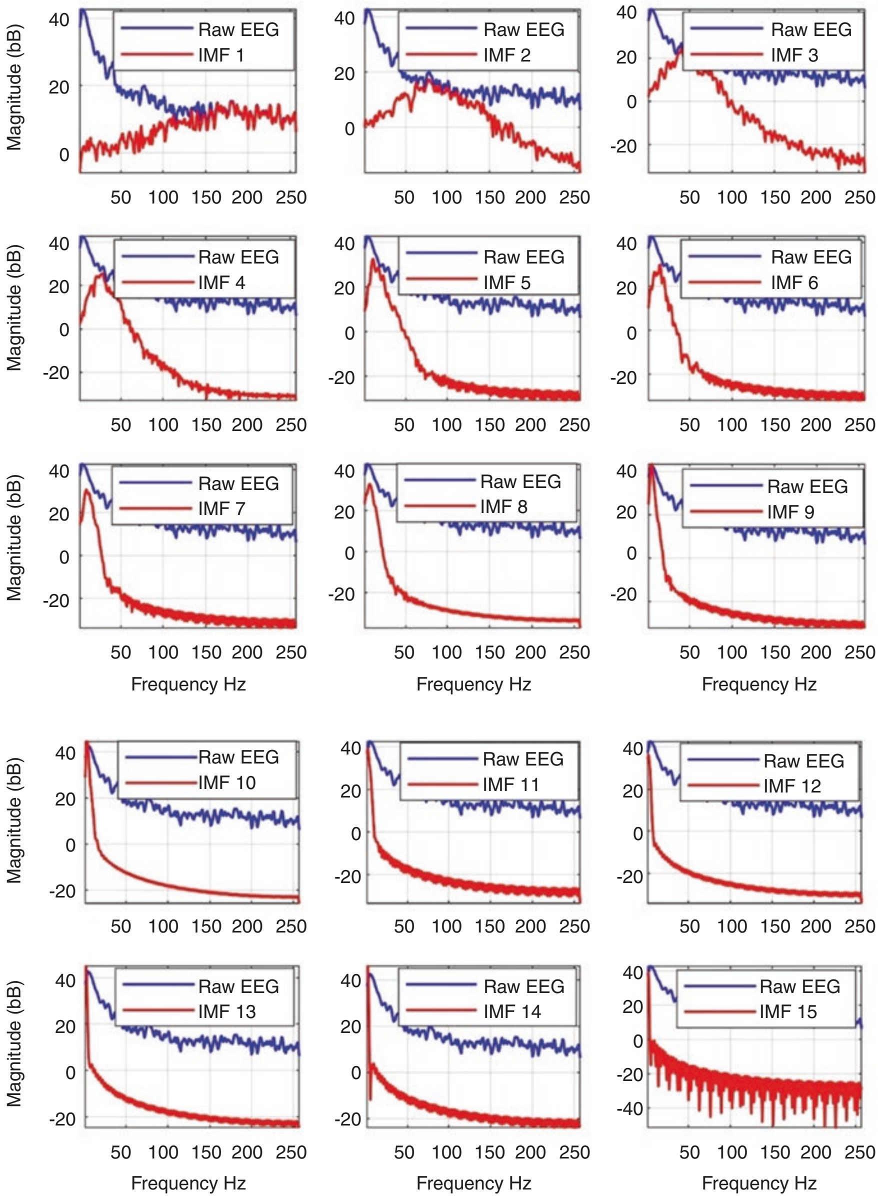

Fig. 5 Power spectral density plots of IMFs 1–15

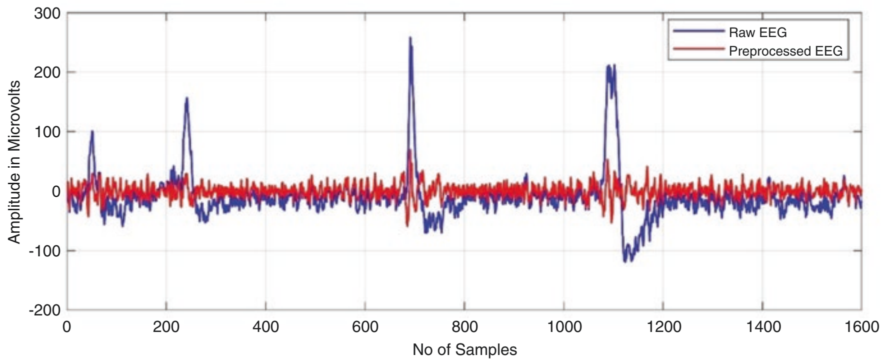

Fig. 6 Raw and preprocessed FP2 EEG signal by SWT

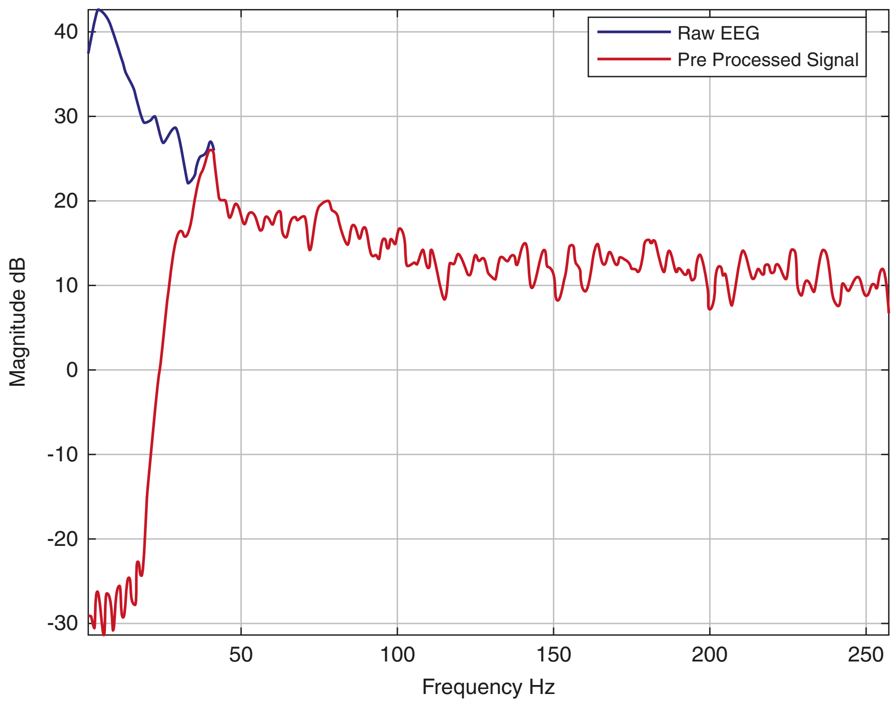

Fig. 7 Spectra of raw and preprocessed EEG signals

Table 2 Correlation coefficient between preprocessed EEG signals and its IMFs

IMFs	1	2	3	4	5
CC	0.533	0.529	0.549	0.337	0.063
IMFs	6	7	8	9	10
CC	0.004	2.05 × 10–4	−5 × 10–5	1.48 × 10–4	9.9 × 10–6
IMFs	11	12	13	14	15
CC	6.2 × 10–6	1.48 × 10–6	2.4 × 10–6	4 × 10–6	5.7 × 10–4

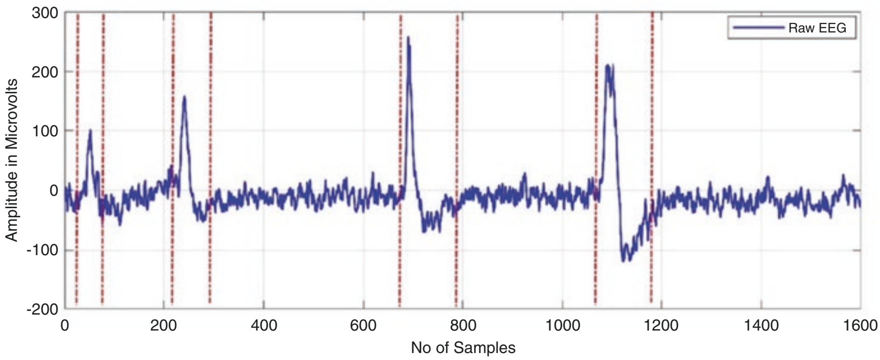

Fig. 8 Raw EEG with identified artifacts

falling edges of the blinks, i.e., artifact rising edge (ARE) and artifact falling edge (AFE); based on the location of ARE and AFE, blink zones are identified [17]. Figure 8 illustrates an EEG with identified artifacts.

4 Threshold Function and IMF Thresholding

Threshold function and thresholding methods play a critical role in artifact correction. Many threshold functions are available in literature such as universal threshold, statistical threshold, minimax threshold, and SURE threshold. But universal threshold is more popular and widely being used for artifact correction of biological signals.

4.1 Universal Threshold (UT)

UT is a function approved globally in which the threshold values for each IMF are estimated by Eq. (1):

$$\lambda_i = \sqrt{2E_i \ln N} \tag{1}$$

where E is energy and N is number of samples [18].

The energy of each IMF resulting from white Gaussian noise follows an exponential relationship defined by

$$E_i = \frac{E_1^2}{\beta}\rho^{-\mathrm{i}} \qquad i = 2,3,\ldots \tag{2}$$

Here, E_1 is the first IMF energy expressed by Eq. (3), and ρ and β are the parameters to be analyzed with a huge quantity of noise realizations and IMFs as 2.01 and 0.719, respectively [19]:

$$E_1 = \left[\frac{\text{Median}\left|h_1(n) - \overline{h_1(n)}\right|}{0.6745}\right]^2 \tag{3}$$

$h_1(n)$ replicates the first IMF coefficients. For additive white Gaussian noise, the denominator value of 0.6745 is found to be a more suitable estimator.

4.2 IMF Thresholding

The development of EMD decomposed the signal to numerous IMFs. The IMFs with higher order contain noise at low frequencies and vice versa. Typically, ocular artifacts are disseminated at 0–16 Hz. Hence, in conventional EMD, denoising of the denoised signal is attained by excluding the higher order low-frequency IMFs while combining the lower order high-frequency IMFs. However, selection of noisy IMF plays a critical role in artifact removal process; moreover, excluding the IMF completely yields loss of neural activity in artifact-free zones.

In EMD-DT (EMD direct thresholding), the signal is reconstructed after performing thresholding to the noisy IMFs. Direct wavelet thresholding performed on IMFs results in the construction of EMD-DT. The signal reconstructed with modified IMFs can be denoted as

$$x(t) = \sum_{i=M_1}^{M_2}\tilde{h}_i(t) + \sum_{i=M_2+1}^{L}h_i(t) + r(t) \tag{4}$$

where

$$\tilde{h}_i(t) = \begin{cases} h_i(t) & |h_i(t)| > \lambda_i \\ 0 & |h_i(t)| \le \lambda_i \end{cases} \tag{5}$$

for hard thresholding

$$\tilde{h}_i(t) = \begin{cases} \text{sgn}(h_i(t))\left(|h_i(t)| - T_i\right) & |h_i(t)| > \lambda_i \\ 0 & |h_i(t)| \le \lambda_i \end{cases} \tag{6}$$

for soft thresholding.

M_2 and M_1, respectively, indicate the high-order, low-order IMFs. λ_i is the value of threshold at ith IMF. However, for the decomposition modes, directly applying the threshold can yield disastrous results to disturb the continuity of the signal reconstructed. Kopsinis and Mclanglin introduced and verified an innovative EMD-based denoising technique on different signals, where EMD-IT was studied [20–22]. Taking into note the two zero crossings (adjacent) $Z_j^{(i)} = \left[Z_j^{(i)}\, Z_j^{(i+1)} \right]$ in the ith IMF, hard and soft thresholding for the IMF coefficients can be described mathematically by Eqs. (7) and (8), respectively:

$$\tilde{h}_i\left(z_j^i\right) = \begin{cases} h_i\left(z_j^i\right) & \left|h_i\left(r_j^i\right)\right| > \lambda_i \\ 0 & \left|h_i\left(r_j^i\right)\right| \le \lambda_i \end{cases} \tag{7}$$

$$\tilde{h}_i\left(z_j^i\right) = \begin{cases} h_i\left(z_j^i\right) \dfrac{\left(\left|h_i\left(r_j^i\right)\right| - T_i\right)}{\left|h_i\left(r_j^i\right)\right|} & \left|h_i\left(r_j^i\right)\right| > \lambda_i \\ 0 & \left|h_i\left(r_j^i\right)\right| \le \lambda_i \end{cases} \tag{8}$$

where h_i is the IMF coefficient before decomposition, $\tilde{h}_i$ is the estimated IMF coefficient after thresholding, $h_i\left(z_j^i\right)$ indicates the samples from z_j^i to z_j^{i+1}, and $h_i\left(r_j^i\right)$ represents the maxima of the zero crossing interval. Hard thresholding is unstable and is sensitive to even minute modifications of the signal: i.e., the coefficients remain unchanged above the threshold and below are decreased to zero. The local properties of the signal are not modified by this method, but due to discontinuity, they lead to certain fluctuation in the reconstructed signal. Soft thresholding is more stable than hard thresholding, and the coefficients can be minimized towards zero. Hence, soft thresholding is selected throughout, for this study.

The modified IMF coefficients by direct and interval thresholding for IMF 5 are as shown in Fig. 9. T5 is the obtained threshold value of fifth IMF using universal threshold. The modified IMF coefficients are continued at zero crossing by direct

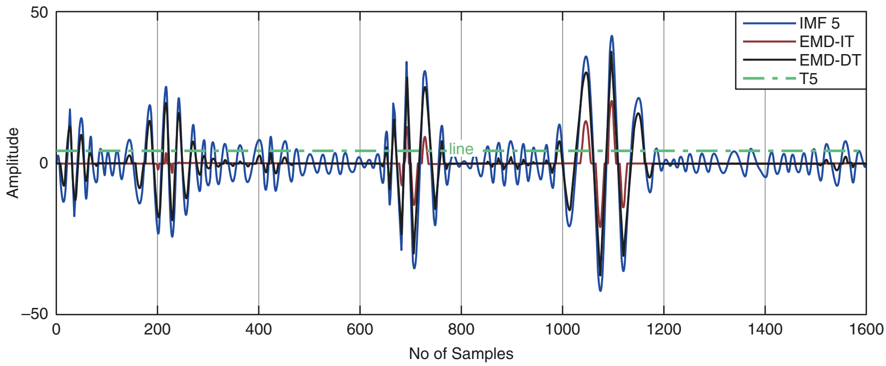

Fig. 9 Modified IMF coefficients by EMD-DT and EMD-IT techniques

thresholding, whereas those in the neighborhood of zero crossings are reduced to zero by interval thresholding, resulting in errors in the reconstructed signal. Hence, EMD direct thresholding is not a suitable choice for correcting artifacts of EEG signals.

4.3 Methodology

EMD is to be performed on the raw EEG signal for extracting the IMFs. The IMFs with higher order contain noise at low frequencies and vice versa; that is, the BAs are found to be distributed in the higher order IMFs.

The noisy IMFs are to be identified as explained in Sect. 3.1.

The threshold for each IMF should be calculated, and interval thresholding for the identified noisy IMFs is performed as described in Sect. 4.2.

Modified IMFs and the remaining signal IMFs are added for reconstructing the signal according to Eq. (4).

The metrics ARR, ΔSNR, RMSE, and CC amid clean and raw EEG signals are to be calculated. Figure 10 depicts the process of artifact correction.

5 Experimental Verification and Results

The quantitative metrics to evaluate the denoising techniques are defined by the following equations [23]:

$$\Delta\,\mathrm{SNR} = 10\log_{10}\left(\frac{\sigma_x^2}{\sigma_y^2}\right) \tag{9}$$

$$\mathrm{ARR} = \frac{\sum_{i=1}^{N}\left(x_i(n) - y_i(n)\right)^2}{\sum_{i=1}^{N} y_i^2(n)} \tag{10}$$

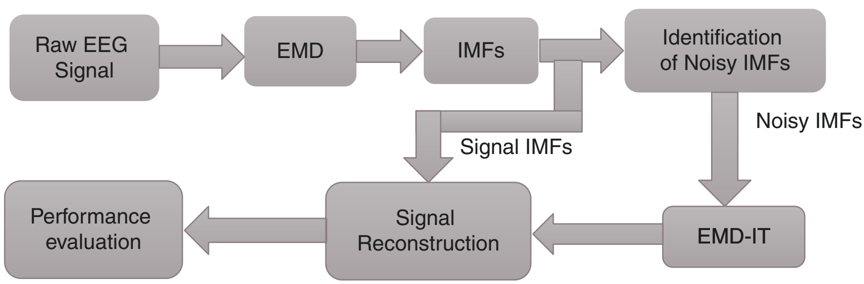

Fig. 10 Denoising approach based on EMD-IMF thresholding

$$\mathrm{CC} = \frac{\sum_{n=1}^{N}\left(x[n]-\overline{x[n]}\right)\left(y[n]-\overline{y[n]}\right)}{\sqrt{\sum_{n=1}^{N}\left(x[n]-\overline{x[n]}\right)^2 \sum_{n=1}^{N}\left(y[n]-\overline{y[n]}\right)^2}} \tag{11}$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(x[n]-y[n]\right)^2} \tag{12}$$

where $y(n)$ represents the clean EEG signal, $x(n)$ is the contaminated EEG, and σ_y^2 and σ_x^2 are the variance of the clean and raw EEG signals, respectively.

5.1 Results and Discussions

In the conventional EMD-based denoising method, the denoised signal is the sum of selected IMFs by excluding the IMFs which have artifactual components. However, in EMD direct thresholding (EMD-DT), the signal is reconstructed after performing thresholding to the noisy IMFs. Figure 11 exemplifies the raw and reconstructed FP2 EEG signal with EMD-DT and conventional EMD denoising method of artifact correction. Artifacts in blink region are not suppressed by EMD-DT method, which can be done by conventional EMD method. However, the cerebral activity at artifact-free zones might be affected. Table 3 represents the quantitative metrics between the contaminated and clean EEG signals, using conventional EMD and EMD-DT techniques for the frontal EEG signals at non-blink regions, which are separately discussed in Sect. 3.2, with an average CC and RMSE of 0.4175, 0.84 and 21.55, 0.443 by conventional EMD and EMD-DT methods, respectively, over non-blink regions. Artifacts are largely attenuated by the conventional EMD method, but the neural information is greatly affected based on CC and RMSE.

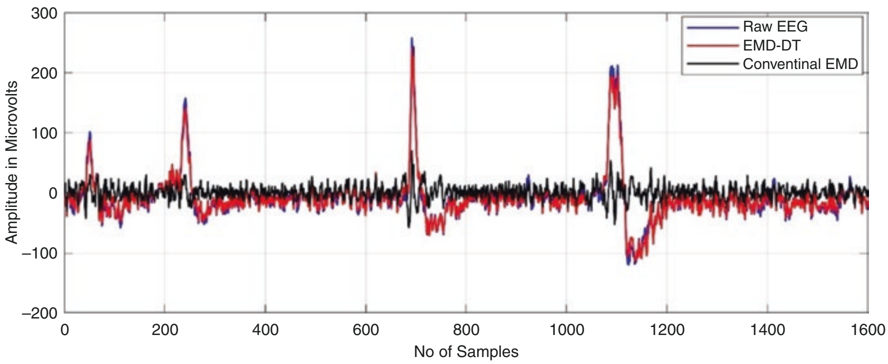

Fig. 11 Clean EEG signal by the conventional EMD method

Table 3 Quantitative metrics of artifact removal by Conv-EMD and EMD-DT

	Conv-EMD		EMD-DT	
Channel	CC	RMSE	CC	RMSE
F7	0.40	21.64	0.82	2.46
F8	0.36	16.87	0.84	2.43
FP1	0.44	26.86	0.86	3.24
FP2	0.47	20.86	0.85	3.16

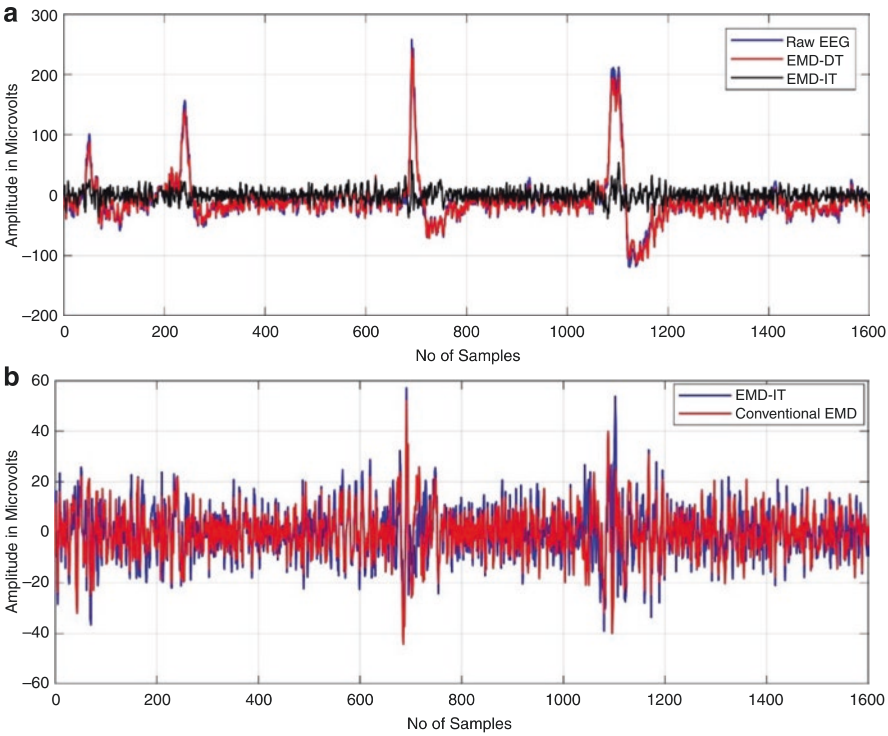

Fig. 12 (**a**) Clean EEG signal by EMD-IT and EMD-DT techniques. (**b**) Clean FP2 EEG signal by Conv-EMD and EMD-IT techniques

However, in the partial sum of IMFs, there might be the possibility of excluding high-frequency content in the signal or including the unwanted low-frequency oscillations of the signal. With this view to avoid any loss of data in the signal reconstructed, IMF interval thresholding is opted for artifact correction.

Figure 12 illustrates the time domain description of FP2 EEG signal before and after artifact removal by conventional EMD, EMD-DT, and EMD-IT methods.

Table 4 ΔSNR, ARR, CC, and RMSE by EMD-DT and EMD-IT methods

Channel	EMD-DT				EMD-IT			
	ΔSNR	ARR	CC	RMSE	ΔSNR	ARR	CC	RMSE
F7	1.12	1.24	0.82	2.46	19.24	8.26	0.64	28.22
F8	0.98	1.18	0.84	2.43	18.06	7.98	0.68	28.38
FP1	1.15	1.54	0.86	3.24	23.70	14.8	0.66	32.46
FP2	1.22	1.46	0.85	3.16	23.25	13.57	0.65	34.42

From this figure, it can be clearly understood that EMD-DT method is unable to reject the artifacts, whereas conventional EMD and EMD-IT methods minimize the artifacts to a greater extent.

Table 4 provides the average quantitative metrics between contaminated and reconstructed EEG signals using EMD-DT and EMD-IT techniques. The higher the values of ΔSNR and ARR, the better will be the rejection of artifacts, the higher the CC, and the lower the RMSE, which indicate that the neural information is protected. ΔSNR and ARR are estimated for the whole data, whereas CC and RMSE are estimated at non-blink regions. EMD-DT and EMD-IT methods have accounted for average ΔSNR, ARR, CC, and RMSE of 1.11, 1.35, 0.84, and 2.82 and 21.05, 11.15, 0.65, and 30.8, respectively, for the frontal EEG signals. According to ΔSNR and ARR, EMD-IT method has given better results than EMD-DT. Similarly, the performance of EMD-DT is found superior to EM-IT considering CC and RMSE. Universal threshold opted for DT was unable to shrink the IMF coefficients at each level, thereby being incapable to reject the artifacts. However, the same threshold function shrinks the coefficients better by the process of interval thresholding between zero crossings. CC and RMSE for EMD-IT are poor compared to EMD-DT but superior to conventional EMD method of artifact correction.

Blink artifacts were found dominant in EEG recording and occupy the low-frequency band from 0 to 16 Hz. Artifact removal algorithms should selectively reduce the spectral power in the lower frequency bands without distressing the high-frequency bands. Hence, spectral analysis was carried out for the EEG signal to estimate the artifact correction in the frequency domain, which is implemented in this study using Welch method (pwelch). Figure 13 illustrates power spectral density (PSD) of the raw and reconstructed EEG signals using EMD-DT and EMD-IT techniques. Unlike the spectrum of FP2 EEG signal, the power drop is found restricted to lower frequencies, and the neural information at higher frequencies is preserved by EMD-IT method.

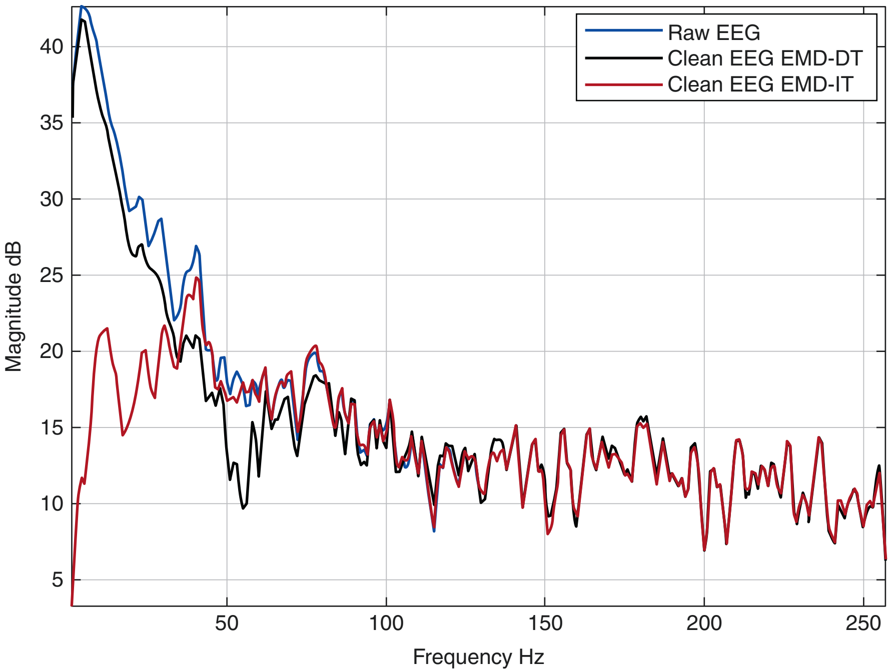

Fig. 13 Spectra of raw and clean EEG signals by EMD-DT and EMD-IT methods

6 Conclusion

In this chapter, IMF interval thresholding is proposed to correct blink artifacts of EEG signals. Noisy IMFs are detected based on CC and power spectral density estimate of the signals. Background data at artifact-free regions is conserved by performing thresholding to the noisy IMFs. Performance of the proposed method is compared with EMD-DT and conventional method of EMD denoising in terms of several standard metrics: ARR, ΔSNR, RMSE, and CC. Conventional EMD denoising method has shown extreme performance in artifact rejection, utterly affecting the neural activity. EMD-DT can preserve the neural information at artifact-free zones but is unable to correct the artifacts, whereas EMD-IT is good in correcting the artifacts while preserving the cerebral information at artifact-free regions. However, the neural information at non-blink regions is further improved by an optimized threshold function.

References

1. World Health Organization (WHO). Neurological disorders: public health challenges. Geneva: WHO; 2006.
2. Chin JH, Vora N. The global burden of neurologic diseases. Neurology. 2014;83(4):349–51.

3. Teplan M. Fundamentals of EEG measurement. Measur Sci Rev. 2002;2(2):1–11.
4. Peng H, Hu B, Shi Q, Ratcliffe M, Zhao Q, Qi Y, Gao G. Removal of ocular artifacts in EEG-an improved approach combining DWT and ANC for portable applications. IEEE J Biomed Health Inform. 2107;17(3):600–7.
5. Zhao Q, Hu B, Shi Y, Li Y, Moore P, Sun M. Automatic identification and removal of ocular artifacts in EEG-improved adaptive predictor filtering for portable applications. IEEE Trans Nano Biosci. 2014;13:109–17.
6. Savelainen A. An introduction to EEG artifacts. Aalto University School of Science: Systems Analysis Laboratory. 2010;20:1–22.
7. Sundararajan D. Discrete wavelet transform: a signal processing approach. Singapore: John Wiley & Sons; 2015.
8. Krishnaveni V, Jayaraman S. Automatic identification and removal of ocular artifacts from EEG using wavelet transform. Measur Sci Rev. 2006;6(4):45–57.
9. Huang NE, Shen Z, Long SR, Wu MC, Shih HH, Zheng Q, Yen N-C, Tung CC, Liu HH. The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. Proc Roy Soc A Math Phys Eng. 1998;454:903–95.
10. Boudraa AO, Cexus JC. EMD-based signal filtering. IEEE Trans Instrum Meas. 2007;56(6):2196–202.
11. Kopsinis Y, McLauglin S. Empirical mode decomposition based denoising techniques. In Proc. 1st IAPR Workshop Cogn. Inf. Process. (CIP), Santorini, Greece, Jun 2008, pp. 42–47.
12. Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PC, Mark RG, Mietus JE, Moody GB, Peng C-K, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: components of a new research resource for complex physiologic signals. Circulation. 2000;101:215–20.
13. Elouaham S, Latif R, Laaboubi A, Maoulainine FMR. Biomedical signals analysis using the empirical mode decomposition and parametric and non-parametric time -frequency techniques. Int J on Inform Technol. 2013;1:1–10.
14. Flandrin P, Rilling G, Goncalves P. Empirical mode decomposition as a filter bank. IEEE Signal Process Lett. 2004;11:112–4.
15. Khan Z, Keshava Murthy GN. Correction of ocular artifacts in EEG signal using empirical mode decomposition and cross-correlation. Res J Biotechnol. 2014;9(12):24–9.
16. Cheng J, Yu D. Research on the intrinsic mode function (IMF) criterion in EMD method. Mech Syst Signal Process. 2006;20(4):817–24.
17. Krishnaveni V, Jayaraman S, Aravind S, Hariharasudhan V, Ramadoss K. Automatic identification and removal of ocular artifacts from EEG using wavelet transform. Measur Sci Rev. 2006;6(4):45–57.
18. Donoho DL. Denoising by soft-thresholding. IEEE Tran Inf Theory. 1995;41:613–27.
19. Flandrin P, Rilling G, Gonçalvès P. EMD equivalent filter banks, from interpretation to applications. In: Hilbert-Huang transform and its applications. Singapore: World Scientific; 2005.
20. Kopsinis Y, McLaughlin S. Development of EMD-based Denoising methods inspired by wavelet thresholding. IEEE Trans Signal Process. 2009;57(4):1351–62.
21. Yang G, Liu Y, Wang Y, Zhu Z. EMD interval thresholding denoising based on similarity measure to select relevant modes. Signal Processing; 2014. p. 1–15.
22. Zhang M, Guo W. An integrated EMD adaptive threshold denoising method for reduction of noise in ECG. PLoS One. 2020:1–30.
23. Valipour S, Kulkarni GR, Shaligram AD. Study on performance metrics for consideration of efficiency of the ocular artifact removal algorithms for EEG signals. Indian J Sci Technol. 2015:1–6.