# Use of the Wearable Device in Telehealth during Covid-19

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

| *Systematic Review* |
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## ABSTRACT

The purpose of the review is to find out the extend of wearable devices in the field of telehealth and other technologies used to implement telehealth, as this was the immediate solution to the COVID-19 pandemic for maintaining the social distance and also to treat the patients for disease or consult them, without the physical presence. In the research systematic literature review is being followed. Various databases like pubmed, medline and Google scholar is used to extract information for the list of papers downloaded. Screening based on filters was done removing papers other than English language and included only research papers, excluding articles editorial, etc. Also, some papers were added by snowballing technique while going further with the research. The review helps find some great telehealth technological findings, like wearable technologies and data accumulation. The research has been followed by 28 papers and focuses on the enablers of telehealth and the implication of wearable technologies in times of COVID-19. Originality: The independent search on telehealth and wearable technologies has been combined with reviewing this study and building the framework and the existing studies have been used for the review.

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## 1. INTRODUCTION

All over the world, treatment centres has taken a step back while treating a COVID-19 patient as the staff, and other patients are at risk. Due to the rising situation of COVID-19, the planed or scheduled surgeries did not take place, and pain or infections among the patients increased, and examining them was not possible. Consequently, the concept of virtual treatment is accepted for managing pain in the world with the help of telehealth [1]. Telehealth is not new as it was previously used for treatment in rural areas, though the purpose has changed. Still, healthcare facilities are being provided as a step of safety measure or the acceptance of the digital tools and technologies in the healthcare sector like telemedicine, virtual treatment in the form of treatment from a distance through the digital medium or ICT medium [2].

There is a scope for wearable technologies with telehealth implementation as these devices help treat from a distance. There has been a drastic improvement in the healthcare sector. An ample number of technologies like robotic operations, telemedicine for rural or remote areas, AI-based monitoring system, and more are being used in the health care sector [3]. The wearable devices produce large amounts of data that require processing, which can be done with various technologies like artificial intelligence, machine learning, etc [4]. Despite such safety measures, there are risks involved, like a patient waiting in a clinic waiting area can get infected or spread infection. Apart from the healthcare workers, they can also get malignant disease apart from COVID. Some solutions that could be useful were proposed and have been accepted to some extent in the market [5]. Some of them are the wearable device which records patients' condition through various sensors, telehealth where patients can get remote treatment. This technological advancement in the healthcare sector of remote monitoring and wearable device can be useful in two ways, one being safe for healthcare workers, and second, it uses the data recorded for analysis [6].

### 1.1 Research Gap

The sudden outbreak of COVID-19 has made it difficult for people to reach health care professionals, for which the concept of telehealth came into the limelight. With that, the role of wearable was also under study. The existing literature review has a theoretical study about telehealth and wearable device. The review's main aim is to find out the enablers of telehealth and the role of wearable. If there are any limitations which are attached with the wearable technology being implemented in this field.

### 1.2 Research Questions

The analysis of the gap leads to develop question which reflects the review:

RQ1: What are the enablers of telehealth?
RQ2: What are the outcomes of implementing and adopting telehealth and wearable devices?

### 1.3 Research Objective

The questions stated help to review and find out the main objective of the study to be:

RO1: To identify the enablers of telehealth.
RO2: To find out the outcomes of the adoption and implementations of telehealth and wearable device.

## 2. LITERATURE REVIEW

Pain recovery around the globe has bolted their entryways. In light of the Covid-19 pandemic, health care facilities change the delivery of their health services at a snap to protect one's staff and patients [7]. Bubonic plague; yellow fever, Spanish flu, and now COVID-19 were jointly responsible for globe-wide fatalities. Unlike previous pandemics, the COVID-19 pandemic's healthcare management will rely on preventive devices, initial development of symptoms, isolating them self, quarantining themselves, and eventually returning to social contact [8].

The low adoption of telehealth services is largely due to the reluctance of physicians to accept telehealth. A timely response to emergencies such as the COVID-19 outbreak requires a professional health workforce to switch delivery modes as needed. Telehealth acceptance by clinicians depends on them perceiving telehealth as effective, healthy, and average. Clinicians may not be trained and conscious of telehealth, which is not surprising considering minimal telehealth training in pre-registration curricula for medical, nursing, and allied health [9]. A survey

on similar lines showed that live video visit users had been trained, working, and predominantly urban-focused. These were less likely to provide primary care compared to non-users, and many unsuccessfully received in-person care. The closer integration would help both telehealth and primary care, but significant hurdles remain, and few effective models exist [10]. Successful application of digital health technologies, capable of freeing staff resources, improving quality of care, and having a beneficial impact on recruitment and retention of workers.

Various technologies have been used in telehealth and wearable devices. SWH devices incorporate into the Healthcare Information Systems by using RFID, biometrics, sensors, actuators, and metering devices capable of monitoring and controlling the real world's data. The traditional healthcare system has become smarter and personalized by introducing numerous wearable devices and smartphones that use IoT-based technology [11]. Different types of accessories that have been made out of wearable healthcare technology are integrated into the user's bodies, referred to as smart electronic devices [12]. The wearable sensors, smart textiles, and body-worn garments become cheaper and more accessible to the consumer. They are expected to be in routine usage and for various other purposes also. The development of wearable health data collection systems provides features for user interaction and chronic disease self-management. Also, these devices are capable of collecting data that can be used further [13].

When combined with telehealth, wearable devices and unobtrusive sensing can monitor COVID-19 symptoms and notify the user and enable the health care workers to monitor patients remotely to allow face-to-face communication to be further decreased and will be possible to manage early detection and monitoring of coronavirus symptoms. Health care authorities are made aware of the data transmitted through the secured cloud platforms, so they can put patients under quarantine, moving them from homecare facilities or handling the high-risk patients in their homes [14]. Mobile health innovations also provide an ability to scale up physiological monitoring experiments and discover new applications of healthcare wearable's. Data processing approaches, including machine learning, show the potential to use wearable devices in clinical applications in various ranges from acute health issues like

inflammation or infection to chronicle tracking of disease and treatments like diabetes or heart disease [15].

The data collected from various sources are used to predict various aspects of the disease. Computer-assisted diagnosis decreases the risk of conflict and helps us understand the data. For future research, technologies like deep learning and big data can be strong alternatives. Telemedicine allows a patient to examine their health. It also helps inform patients about changes and signs in physical examination that may trigger a conversation with their physicians. Also, data stored from this patient's examination can be used in the future during reconciling [16]. Various transformations have taken place in the healthcare sector in some of the proposed ideas, remotely monitoring the patients in the ICU wards and COVID ward. The Duke institute have almost >600 patients per day via video, and there is an increase in telephonic visits also, the total turns around 1000 patient's telehealth visit per day. Wearable devices have been successful in detecting the emerging patterns for the outburst of the disease. Also, smart thermometers have provided a novel source of knowledge for influenza tracking and prediction [2]. One of the emerging software technology blockchain was suggested to support COVID-19 diagnosis. Self-testing and monitoring is AI technology-based application and Low-cost blockchain applications in countries with low-income for COVID-19 and other emerging infectious diseases. The AI-coupled blockchain-based proposed application is designed, developed, and deployed against COVID-19. Before opening pre-testing instructions, a personal identification of the user is requested by the app. Once the user uploads the result into the application, it enables the blockchain and AI program to precede the results to notify the outbreak monitoring [17].

Also, various researches have been done to determine the use and acceptance of telemedicine and healthcare by patients and healthcare workers [18]. Despite the drawbacks attached to it, studies show that there is a positive response towards telemedicine. Many studies and surveys have shown that telemedicine has a positive acceptance by patients and healthcare workers [19]. Also, telemedicine has prospered in the wearable device field; many prototypes have been proposed to monitor patient at a distance and record data [20]. For instance, an IoT band

**Table 1. Terms used for the development of telehealth**

| Term | Definition |
| --- | --- |
| Telehealth and Telemedicine | To provide health care to patients using technology who are separated geographically. |
| Remote Patient Monitoring | Connecting to the patient remotely that is with a device and come up with a report. |
| Wearable Device | A device that records various data of the user in terms of health. |
| Virtual Reality | usage of 2-3-dimensional technology to communicate to the patient virtually without the physical presence |
| Augmented Reality | Artificially or digitally involving an object into the real world with the help of technology. |
| | Machines demonstrate Artificial Intelligence. Sometimes called machine learning. |

tracks the patient's geographical presence, so that patients can be monitored with the wearable device [21]. The only digital traces left behind were historical evidence regarding an individual's interaction with health and welfare services. Digital traces of human behaviour patterns have accumulated at a breath-taking pace with the rise of new ICT innovations. Today, we have many different ways and data sources to measure and trace individuals and their health-related behaviour digitally.

The data collected from various studies and data collected can be used for forecasting and prediction. AI-driven algorithms can make predictions and readings more precise in the future via increased data sharing. Increased data sharing in the urban health sector must be enforced while respecting the dimensions of privacy and security due to the sensitive nature of information in this industry. In this regard, AI processes based on Smart Data Sources and Smart cities science and their related technical principles, coupled with wearable technologies, can and must be encouraged, as they can allow larger data sets and thus more accurate predictions and detections [22].

Primary care organizations also provide recommendations to encourage health management and preventive healthcare principles to increase public awareness of the PHR program [12]. The more data sources are available for access, the predictive analytics can also be used for various other purposes like privacy challenges and security purposes. The sensitivity of such data is high; hence high importance is given to such data. Recommendations to form a uniform policy for tele healthcare have been made [13]. Multiple solutions are suggested to cater to the problem of sensitivity of the data, such as enabling Data Tracker-driven action-oriented policy initiatives is an interactive policy informatics platform monitoring the spread of COVID⬜19 outbreaks and global policy decisions [18], helping scientists and policymakers tackle technical and ethical complexity, we present the typology of the currently in use key digital public health applications. Namely: proximity and touch mapping, tracking of symptoms, regulation of quarantine, and modelling of flows [10], the conceptual framework for exchanging real, continuous dynamic health data using technology like blockchain extended by the cloud storage technology to have transparency in health-related information. Table 1 shows the Terms used for the development of telehealth.

## 3. METHODOLOGY

For the systematic search, we developed a strategy to identify relevant literature. We used the database Scholar.google.com, pubmed and medline to search for literature. We searched for terms like telehealth, COVID, wearable device, and also a combination of some of them. The span of the search was until 2020. It consists of a literature review, articles, and research reports, published in English.

The selection was done based on PRISMA methodology. The majority of the paper is mapped towards COVID-19, telehealth, and wearable technology. The research narrowed down to the research area of remote patient monitoring, security and policy for data, and the implementation of various technologies available in the health sector market.

The initial search was for the keyword "Wearable" and "telehealth," with the filter of
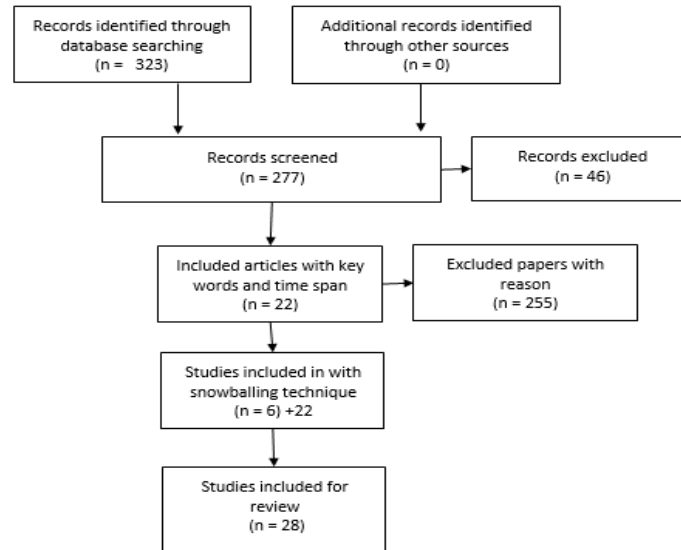
**Fig. 1. Prisma flowchart for literature search**

period 2015 to 2020 and keyword in the paper title, which resulted in around 323 papers. Additionally, added COVID-19 to the title, which resulted in 277 papers. Further applying filter for systematic review papers and English language with 54 papers. Twenty-two papers were selected after excluding papers with other formats like an article, book journal chapters, editorial, etc. Further, with snowball methodology, six papers were cross-referenced and added because of relevancy. The total paper included for review is 28.

The study is based on original research articles, review papers, and the paper is analyzed deeply to ensure the relevance and quality of the academic literature included in the review process. Data extraction was done based on the originality of the papers and literature, span from 2015-2020, and wearable devices' relevancy. Fig. 1 shows the Prisma flowchart for the research survey.

## 4. FRAMEWORK

### 4.1 Enabler of Telehealth

Telehealth as a concept is not new but has become a need in the breakdown of COVID-19. The use of telehealth and various technologies depend on various factors, but the key reason for the adoption and acceptance is the need. Parallels, technologies and factors enable telehealth during the pandemic. Also, without the pandemic, some technologies like IoT devices, AI, VR, etc., are required for proper functioning

and telehealth [1]. As it is helpful in maintain distance for breaking the chain of COVID-19, it is a useful concept. But what make it useful are the enablers of telehealth. Technologies play a major role in it. Table 1 discussed about development of telehealth

Technology like IoT is used to implement sensors that sense and collect data from the user (here patients). To implement this IoT, a device is needed. This device can use IoT and record data and give real-time monitoring of the patient said to be a Smart Wearable device [16]. Along with this, implementing all these technologies integrating them was important, and for that, a common platform was required for telehealth like an online platform [4].

### 4.2 Characteristics of Telehealth

With the implementation of the various technologies and integrating them, tele health's concept grew to wider aspects, and telehealth started on different gadgets and formats like e-health, m-health, Tele-imaging, Tele-ICU [6]. As a result, the wearable device could capture data, and health care professionals could remotely monitor the patients. Also, the Patient was able to initiate messages using the platform and remotely connect to the healthcare professionals. Telephonic Visits, E-consultancy, video consultancy, and other forms were implemented in telehealth and monitored by wearable devices. Algorithm for Processing data with the help of Machine learning, Deep Learning, and Big data analysis was done for future prediction.
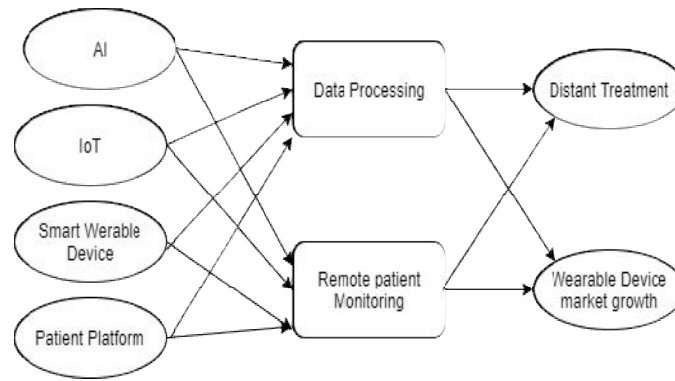
**Fig. 2. Research framework**

## 4.3 Outcomes

Implementing various technologies, machine learning, and big data analysis will help make a prediction, which will help prevent any disease from spreading, and precautionary steps can be taken for the same. Predictions for a malignant disease like COVID-19 can also be predicted and precautionary steps can be taken.

Also, telehealth and other e-health technologies have been beneficial to the healthcare workers and other general patients and resulted in flattening the infection curve not completely but have made the process slow [14]. Growth for marketers in wearable's makes consumers communicate about the benefits of wearable devices [5]. Fig. 2 shows the framework for the research process.

## 5. RESULTS

### 5.1 Telehealth Care Adoptions

The phase of COVID-19 started in china and then gradually started spreading all over the world. The healthcare sector was on its toes, but somehow not all medical facilities were capable of providing the facility the COVID-19 infected person required. The safety of the healthcare workers and the patients already being treated for other disease become a risk when such disease is treated on the same premise [9]. Besides implementing telehealth to be an effective solution for emergency service in the health sector, it must be a daily used system in the clinical sector [22]. With telehealth implementation, implementing different technologies that can store data collected from this telehealth system and then utilizing this data for analysis. Further, this data-driven technology

can predict the occurrence of any infectious or malignant disease like COVID-19 [2]. Also, as Meshari F. Alwashmi states, the lessons from the disease must be taken into account and made further use of the relevant data.

Studies have been carried out for the technological implementation of AI to detect COVID-19 [11]. Results vary according to a survey conducted in 2017 for acceptance of telemedicine 59% of the people had no prior experience and considered telemedicine to be a future thing [19]. Another survey conducted in 2018 showed result of 73% of people preferring to visit a health professional in person. The survey was conducted with users and non-users of the telehealth facility [15]. But with the change in scenario, the acceptance of telemedicine and telehealth has increased due to the pandemic. The users have readiness for acceptance of telehealth due to the situation. But the healthcare workers, like the nursing staff, are not as much used to the technologies. The lack of knowledge of digital health technologies in the staff can lead to tele health's slow acceptance. Hence a survey conducted in 2020 concludes to a result of conducting training programs for healthcare staff. The telehealth overall process is not complexes as it is considered to be, concluded by hypothesis study [20].

### 5.2 Role of Wearable Devices

With telehealth implementation, new technologies like Artificial intelligence, Virtual reality, Machine learning, etc. have to be a part of it. But apart from that, the wearable device has played a major role as a physical device. The Wearable device is already being used outside the healthcare sector. Still, the implication of wearable devices inside the healthcare sector

has been a revolutionizing phase as it enables access to telehealth and digital treatment with such devices [8]. The wearable device used here records the entire device's data when worn by the patient or user. This data is in huge amount and storing it and processing it is a big challenge. Data accumulated cannot be utilized without the technologies like IoT, Big data Analysis, and Machine Learning. This technology will take the data as an input and process it according to IoT and AI processes and give output such as prediction analysis, forecasting the data, and trend analysis [3]. With wearable technologies in the telehealth sector, multiple technologies have increased in the field, acceptance, and adoption of technologies like telerobotic for treating from a distance, Tele imaging for real-time analysis of patients and report generation, Tele-ICU, etc. are seen [6]. Apart from that prototype of a wearable device specifically for the need of COVID-19 quarantine patients has also been proposed [21].

### 5.3 Data and Policy

These systems implementing the wearable device are a solution for maintaining social distancing. The wearable device as an outcome produces an ample amount of data. This data has to be processed and stored, which is a tedious task. For this, technological advancements like IoT, blockchain, Artificial Intelligence, etc., are used [1]. And this data is further processed and utilized for forecasting, trend analysis, and prediction of any disease with the help of applications of Machine Learning, Deep Learning, Big data analysis, etc [10]. But the use of the data should be done concerning the privacy of the data and security of one's personal health care data. The Advantage of having this data is that any healthcare worker will easily have access to the data of the patient and all kinds of undergone treatments and diseases and will help treat the patient further [18].

But along with pros, there are cons which imply the security aspect of the health care data, the health data of any person is considered to be very important and crucial at the same time hence privacy of the data is at most important with this technology, as telehealth with use of remote monitoring and real-time data takes information from the patient like biometric scans which can be further misused [13]. So meeting the security needs while using telehealth for correct usage of data, the policy for the ethical practices should be in place. With the use of this

data, it can be possible to establish an effective healthcare management system for which the system has to be in place. The public should be made aware of the same, for which the medical institutes and medical care centres can make the general public aware about the same; along with this the security aspect of the data can be explained [12].

The use of telehealth and wearable has increased due to the COVID-19 pandemic, and so the implication for ethical use should be made and hence the policymakers should work upon implementation of policy for the correct and ethical use of data collected [10]. One of the solutions to personal health care data storage suggested by a group of authors (Xiaochen Zheng, Raghava Rao Mukkamala, Ravi Vatrapu, Joaquin Ordieres-Mere) was to implement a blockchain cloud-based storage system, as blockchain is a secured concept and can be used by the patient to have ownership of data and share data according to the need. Only authentic users can have access to it or the one with whom it is shared.

### 5.4 Managerial Implication for Wearable Technology

A study suggests that there are high implications for developers and marketers of wearable technology using which promotion of the products can be done better. There is a considerate and significant amount of influence on the adoption of the wearable device. Also, the data's accuracy from the wearable device plays a significant role; health beliefs also play an important role here. So, the developers should make sure that the accuracy should be maintained to engage a customer. Besides this, the customer should be made aware of the health benefits associated with the wearable device. Features like sleep quality messaging, heart rate, step count, the intensity of a workout, etc., should be highlighted while engaging the customers and making them aware of the wearable devices [5]. Now with the pandemic situation, people are getting concerned about healthcare; hence there can be a varied scope in terms of health care. Apart from this, wearable in the clinical side is also a new scope in the market. The healthcare industry accepts concepts like Tele-ICU, Tele-robotics, Tele-imaging, etc., for distant treatment and staff safety [6]. So, a potential market can be seen in the healthcare sector's wearable technology acceptance.
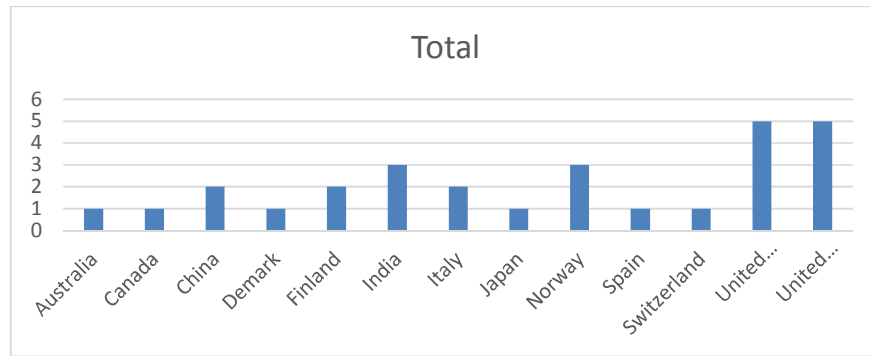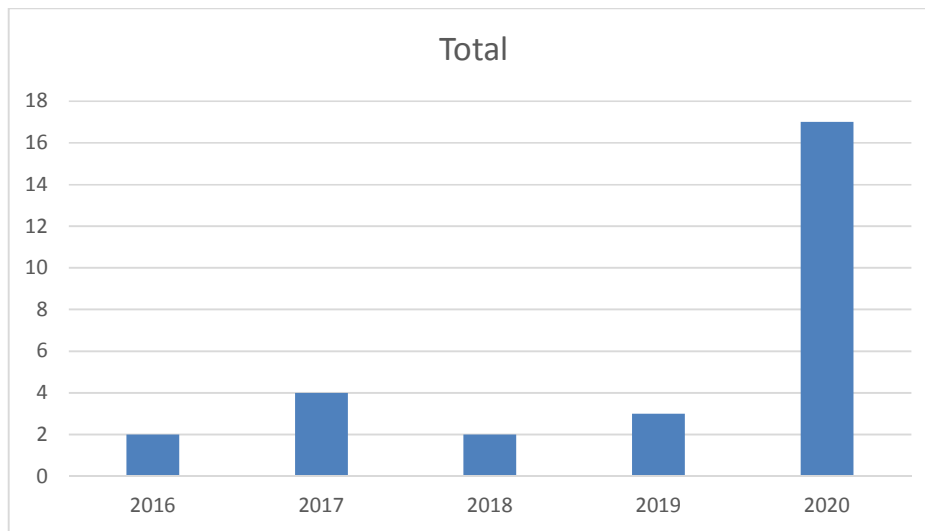
**Fig. 3. Country-wise publication**



**Fig. 4. Year-wise publication**

## 6. DISCUSSION

### 6.1 Contribution by the Countries

The papers selected were affiliated from various countries were being extracted for the review. Out of the selected papers, the research dominance in the United Kingdom's and the United States of America is seen as high in Fig. 3 based on the country-wise publications.

### 6.2 Year-wise Publication

The selection criteria for the year were 2015 to 2020. There is a drastic increase in the year 2020. The count of papers published in the year 2020 is 17 out of 28. And the reason for the increase is simply the pandemic occurring due to COVID-19. Fig. 4 shows the publication-based years.

## 7. CONCLUSION

The wearable device, an intelligent gadget, is an important step towards the future, helping to analyse human capabilities. Further, this technology with various use cases can now amalgamate into a robust framework and lay its foundation towards augmented reality and even augmented humans. This invention can become a revolution for human beings. Besides this, international standards and guidelines are important as far as privacy, security, and global access are concerned with these technologies being used as ethical issues related to such technologies tend to increase.Telemedicine is not a new concept as it was initially used in rural areas to provide remote treatments. Still, with the need for a situation like COVID-19, telehealth has been accepted overall with a satisfying result. Due to the pandemic, telehealth got rapidly implemented in the healthcare sector.

The wearable device has prospered well in the telehealth sector. Wearable Devices have proved to help treat from a distance and be a safer option for patients and healthcare workers as far as treatment is concerned. As a by-product, an ample amount of public health record data is generated. This is sensitive, which brings the record of patients in a vulnerable state. Further suggestions have been made to implement a unified law for the use of telemedicine.

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## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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