



# Internet Technologies for Personalized Care

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## 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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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.

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## 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]	<ul style="list-style-type: none"> <li>• Offers features to lose weight</li> <li>• Tracks food intake and activity</li> <li>• Tracks calories for food consumed and exercises performed</li> <li>• Offers customized weight loss plans by recommending diet and exercise</li> <li>• Supports flexible diets such as the South Beach Diet, the Zone, Atkins, and others</li> <li>• Maintains a food diary with the help of a food database of over 300 million records</li> <li>• Users can add their food and recipes</li> <li>• Offers discussion board for community support in the form of making friends, sharing, and receiving tips and motivation</li> </ul>
Runkeeper [5]	<ul style="list-style-type: none"> <li>• Tracks runs, walks, and other physical activities</li> <li>• Offers training guidance and community support</li> <li>• Facilitates the goals of losing weight, training for race, or maintaining a certain pace</li> <li>• Offers a dashboard for customized training plans</li> <li>• Asks a series of questions to develop the training schedule</li> <li>• Uses GPS to track, save, and discover new routes</li> <li>• Offers rewards for workouts</li> <li>• Provides options to share progress with friends</li> </ul>
Strava [6]	<ul style="list-style-type: none"> <li>• Developed on the concept of social training</li> <li>• Works on the concept of developing a global team of athletes</li> <li>• Tracks key statistics including speed, pace, elevation gained, distance covered, and calories burnt</li> <li>• Displays an interactive map</li> <li>• Connects millions of runners, cyclists, and adventurers and offers an insight into their training patterns</li> <li>• Allows the user to compare performance against others</li> <li>• Offers leaderboard to design friendly competitions for continuous motivation</li> </ul>
Yoga Studio [7]	<ul style="list-style-type: none"> <li>• Yoga app</li> <li>• 70 ready-made exercises for yoga and meditation</li> <li>• Customized level with activity duration ranging from 15 to 60 min</li> <li>• Classes can be customized based on the requirement of gaining each balance, flexibility, strength, relaxation, or all of these</li> <li>• Provides easy-to-follow commentary for instructions to do a pose and how to seamlessly move between poses</li> <li>• Offers step-by-step instructions for 280 poses along with the benefits, modifications, variations, and cautions for each</li> <li>• Offers synchronizing of the classes with calendar for schedule assistance</li> </ul>
Sworakit [8]	<ul style="list-style-type: none"> <li>• Customizable workout app</li> <li>• Offers workout dashboard with numerous exercises for yoga, strength, and cardio trainings</li> <li>• Offers customized dashboard to compile individual exercise plan</li> <li>• Workout plans to become fitter, leaner, or stronger</li> <li>• Custom plans for high interval intensity training (HIIT) and Tabata</li> </ul>

(continued)

**Table 1** (continued)

App name	Features
JEFIT [9]	<ul style="list-style-type: none"> <li>• App for maintaining workout logs of gyms</li> <li>• Offers gym plans with more than 60 routines</li> <li>• Offers thousands of plans contributed by community</li> <li>• Displays 1300 weight-lifting and cardio exercises</li> <li>• Offers visual step-by-step instructions on how to complete exercise</li> <li>• Community support from millions of users</li> <li>• Logs the repetitions and weight on each gym machine with a single click</li> <li>• Provides graphical visualizations and logs based on the information of active and resting time</li> </ul>

## 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

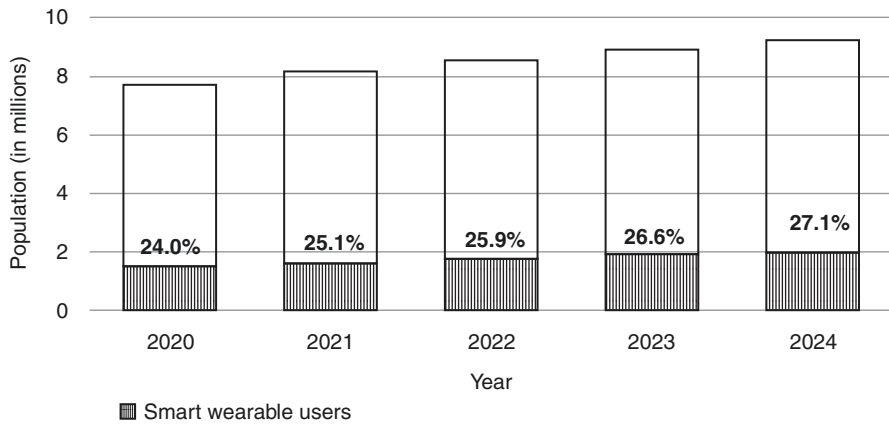
App name	Features
Medisafe [11]	<ul style="list-style-type: none"> <li>• Medication management app</li> <li>• Offers information sharing with friends and pharmacists</li> <li>• Links with the pharmaceutical companies to offer timely refill services to patients</li> <li>• Offers cloud-based links with clinical support</li> </ul>
Mango Health [12]	<ul style="list-style-type: none"> <li>• Offers reminders for medicines. Offers reward points for taking medicines on time which can later be redeemed as gift cards of charities</li> <li>• Alerts for refills</li> <li>• Informs about possible reactions when certain medications are taken together</li> </ul>
GOLD COPD Strategy [13]	<ul style="list-style-type: none"> <li>• COPD management app</li> <li>• Follows the Global Initiative for Chronic Obstructive Lung Diseases (GOLD) standards</li> <li>• Allows the doctors to track patient's symptoms</li> <li>• Connects community of patients, public health officials, and healthcare professionals worldwide</li> </ul>
mySugr Junior [14]	<ul style="list-style-type: none"> <li>• Juvenile (type 1) diabetes management app for kids</li> <li>• Offers fun ways to users to measure and log the blood glucose levels</li> <li>• Offers an interactive game character that recommends insulin dosage for patients</li> <li>• Kids can tame their online game character by eating healthy</li> <li>• Connects with blood glucose meters for automated data entry</li> <li>• Connects patients with the caregivers or parents, if opted for</li> <li>• Provides graphs to track patient's record</li> <li>• Provides estimates for HbA1c and clear reports</li> </ul>
SmartBP [15]	<ul style="list-style-type: none"> <li>• Blood pressure (BP) management app</li> <li>• Allows patients to record, track, and analyze their BP data</li> <li>• Offers color codes to guide the patients about their risk levels</li> <li>• Offers option for sharing information with family and caregivers</li> <li>• Tracks relationship of diets and medication with the BP status</li> <li>• Offers a chance to upload ECG and provides analysis</li> <li>• Creates multiple users</li> <li>• Connects with Apple Watch</li> <li>• Offers sharing and printing of PDF reports</li> </ul>
MyPainDiary [16]	<ul style="list-style-type: none"> <li>• Pain management app</li> <li>• Tracks over 60 chronic health conditions including fibromyalgia, Crohn's disease, migraines, rheumatoid arthritis, back pain, depression, etc.</li> <li>• Offers patients to log their pain throughout the day using a customized scale</li> <li>• Provides a color-coded calendar to view the pain progress at a quick glance</li> <li>• Allows the patients to share pain information with the doctors</li> <li>• Offers calendar for managing appointments</li> <li>• Allows to take pictures to log symptoms and to set reminders for logging regular entries</li> <li>• Tracks weather changes and offers an insight on how pain changes in relation to weather</li> <li>• Creates interactive graphs presenting pain symptoms and helps to identify the major source of pain</li> </ul>

**Table 3** Smartphone apps for mental health management

App name	Features
Moodfit [18]	<ul style="list-style-type: none"> <li>• Customized for users</li> <li>• Suggests daily mental workout goals for remaining fit</li> <li>• Maintains a mood journal</li> <li>• Maintains a gratitude journal to encourage positive thinking</li> <li>• Offers cognitive behavioral therapy (CBT) for managing issues such as personalizing, overgeneralizing, or overthinking</li> <li>• Offers standard assessments for mental health such as GAD-7 and PHQ-9</li> <li>• Offers meditation and breathing exercises</li> <li>• Suggests sleep and lifestyle routines</li> <li>• Connects with the most appropriate therapist or coach</li> <li>• Tracks activity and its impact on mood</li> <li>• Conducts data analysis and offers summarized, customized reports</li> </ul>
eMoods [19]	<ul style="list-style-type: none"> <li>• Tracks issues related to disorders of anxiety, PTSD, depression, and bipolar I and II</li> <li>• Helps to identify the triggers and patterns related to stress with the help of rich visualizations</li> <li>• Integrates with the weather updates to evaluate the impact on mood</li> <li>• Provides reminders for logging in the details, taking medications, etc.</li> <li>• Maintains mood and symptom diary including details about sleep and medications</li> <li>• Provides configurable graphs</li> <li>• Offers detailed reports to the doctors via email every month</li> <li>• Offers access to a dedicated member-only forum where patients can interact with other community members with similar mental health issues</li> </ul>
Bearable [20]	<ul style="list-style-type: none"> <li>• Tracks patient-reported outcomes</li> <li>• Keeps track of daily activities, mood, symptoms, medication, exercise, and food intake</li> <li>• Can synch with physical parameter monitoring such as number of steps, blood pressure, heart rate, and weight</li> <li>• Customized interface</li> <li>• Offers unique insights into the factors which affect mood</li> <li>• Develops reports comprising graphs and key health statistics. Sets reminders. Works ensuring security and encryption of data</li> </ul>
Shine [21]	<ul style="list-style-type: none"> <li>• Offers guidelines for personalized self-care</li> <li>• Provides daily tips for meditations based on weekly intention and daily mood</li> <li>• Offers a library of over 1000 meditation exercises</li> <li>• Offers community support from other users and mental health experts</li> </ul>
MY3 [22]	<ul style="list-style-type: none"> <li>• Suicide prevention app</li> <li>• Provides customized safety plans</li> <li>• Tracks warning signs and timely offers coping strategies to deal with the situation</li> <li>• Connects to the community and helpful resources</li> <li>• Connects to three people in case of developing suicidal thoughts</li> <li>• Connects to a direct contact from National Suicide Prevention Lifeline and 911</li> </ul>

**Table 3** (continued)

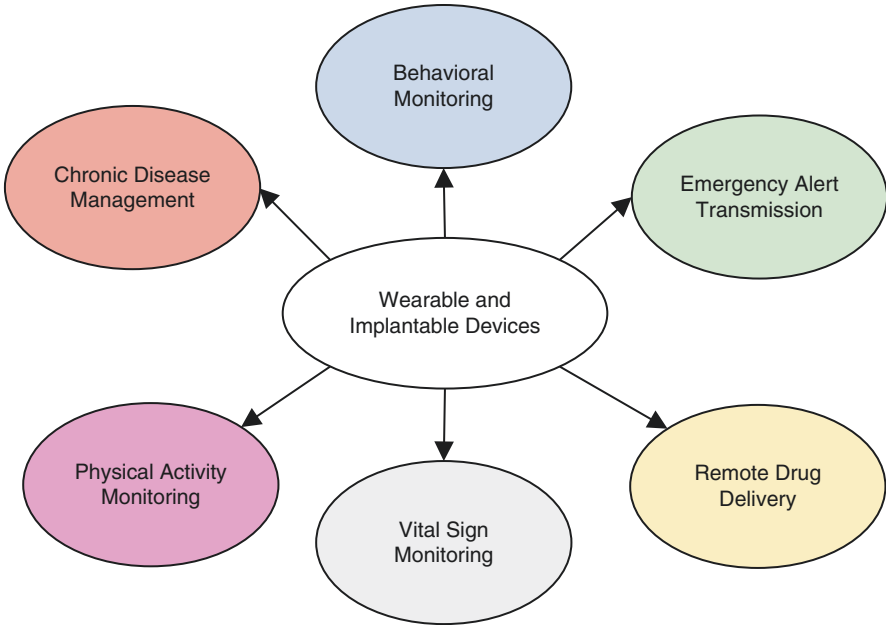
App name	Features
What's Up [23]	<ul style="list-style-type: none"> <li>• Manages anxiety, anger, depression, and stress using therapies of CBT and acceptance commitment therapy (ACT)</li> <li>• Tracks mood throughout the day and evaluates any historical patterns</li> <li>• Tracks positive and negative habits and recommends the coping strategies</li> <li>• Maintains a diary where users can maintain their feelings, thoughts, and mood ratings</li> <li>• Provides well-being awareness and encourages the users to set goals</li> <li>• Provides “Get Grounded” to gauge the exact feelings of users</li> <li>• Provides “Thinking Patterns” to avoid negative internal monologues</li> <li>• Connects to local and national mental and well-being professionals and provides direct messaging feature</li> <li>• Provides daily motivational and inspirational quotes</li> <li>• Facilitates mental health and well-being management at the workplace</li> <li>• Users may show concern and identify risks for colleagues</li> </ul>



**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

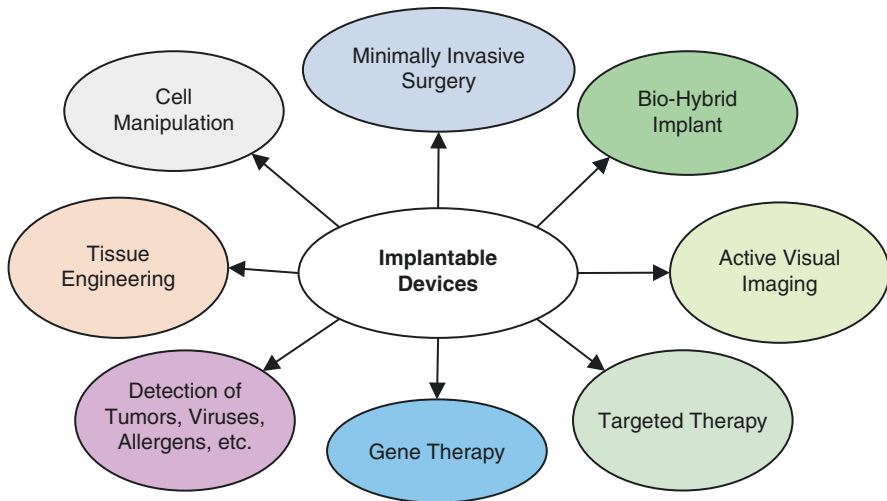
The use of wearable devices has been increasing over the past decade, and the trend is expected to continue in the future. Figure 1 shows an estimate of the number of smart wearable users during the period 2020–2024 in the US adult population. Use of wearable devices provides a sense of better control 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.

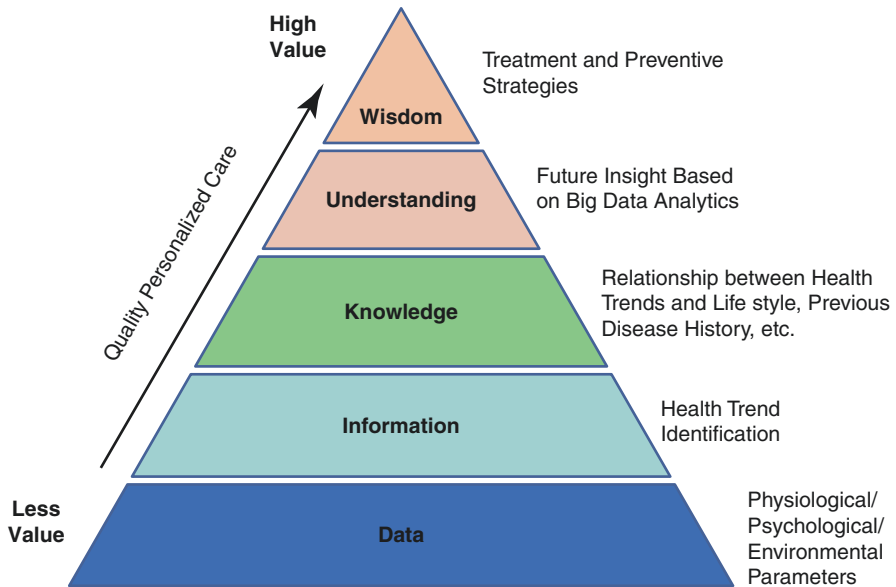
The adaptation of value cycles to address the rapid changes in customer expectations requires agile digital platforms with dynamic software ecosystem interacting with multiple actors that can be enabled through the IoT networks. Agile digital platforms can provide tailored services to particular requirements 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 heterogeneous 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.

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## 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.

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## 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.

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