

Wearables in the Pharmaceutical Industry

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Abstract:

A wearable device is any device that is worn comfortably on the body and enables user interaction. It is typically integrated into the clothing or attached to the body of a person to enhance human performance. The use of wearable technologies has skyrocketed in recent years. Although wearable technology has touched multiple areas, healthcare has been the major benefiter of this technology. Pharmaceutical companies are now already integrating wearable pharmaceuticals into their marketing strategies. They are able to use wearable technology to drive innovation and analytics and speed up the drug development process without compromising efficacy or safety. This paper examines the various uses of wearables in the pharmaceutical industry.

Keywords: wearables, wearable devices, pharmaceutical industry, pharma.

INTRODUCTION

Wearables and hearables are everywhere. They have become an inherent part of our daily lives. Wearable devices or systems are usually lightweight, miniature electronic or digital devices. They are worn on the wrist, in clothing such as vests, footwear, headwear, earwear, and eyewear. A wearable computer is computer-powered device that is never-sleeping ever-present network-connected electronic system that can be used at anytime and anywhere and does not in any way disturb the user's interaction with the real world. It should be worn, much as eyeglasses or clothing are worn, and interact with the user [1]. It includes all manner of technology that is on or in the body such as fitness trackers, smartwatches, smart clothing, smart rings, smart glasses, wearable mobile sensors, smart jewelry, and smart ECG (electrocardiogram) monitors. There has been a proliferation of wearables from consumer gadgets to medical devices that are approved by the Food

and Drug Administration (FDA). Typical wearable devices are shown in Figure 1 [2]. Wearables bring about a new digitized and connected economy, where people and organizations collaborate in different and more profound ways, devices communicate with other devices, and customers choose what they want and need without physical constraints.

The pharmaceutical industry is undergoing a shift from legacy modalities. The pharmaceutical world is changing, both in how new drugs are discovered and how they are manufactured. Many companies have realized that their legacy systems no longer suffice in the move toward more personalized medicine. What has become clear is that the integration of people and advanced technologies is required for companies to survive and thrive in this new competitive landscape.

BACKGROUND ON WEARABLES

A wearable device is any device that is worn comfortably on the body and enables user interaction. It is typically integrated into the clothing or attached to the body of a person to enhance human performance. It often includes smart devices that can be worn on the body or attached to clothes. Wearable devices have been around for centuries. The first one was introduced in the 1660s by the Qing Dynasty. Since then the popularity of wearables has shifted from royalty to the healthcare industry. Wearable computing is a natural evolution of the smartphone technology that has become so ubiquitous and indispensable in education, business, and medicine. We wear wrist watches to know the time. Perhaps the most crucial bit of wearable tech accessible today is Google Glass. There has been a proliferation of wearables from consumer gadgets to medical devices that are approved by the Food and Drug Administration (FDA).

Wearable devices or systems are usually lightweight, miniature electronic or digital devices that are worn by a user, including clothing, watches, glasses, shoes, and similar items. A wearable computer is computer-powered device that is never-sleeping ever-present network-connected electronic system that can be used at anytime and anywhere and does not in any way disturb the user's interaction with the real world. It should be worn, much as eyeglasses or clothing are worn, and interact with the user [3]. It includes all manner of technology that is on or in the body such as fitness trackers, smartwatches, smart clothing, smart rings, smart glasses, wearable mobile sensors, smart jewelry, and smart ECG (electrocardiogram) monitors.

Wearables are always ready, unrestrictive, not monopolizing of user attention, observable and controllable by the user, attentive to the environment, useful as a communication tool, and personal devices [4]. Wearables are being used across healthcare, insurance, interactive systems, safety critical settings, wearable cameras, baby and pregnancy monitors, entertainment, fitness and sports, emergency responders, and military. Some of these applications are illustrated in Figure 2 [5]. Due to its wide range of applications, international corporations such as Google, Apple, and Intel are investing heavily on wearable technology research and development [6]. As with any new technology, one must exercise caution when using a wearable device.

A wearable device essentially consists of two different components: wearable and body sensors. It incorporates sensors, memory, solar cells, and batteries. It stays in contact with the body for extended periods of time. Traditional materials for wearables are mostly metals and semiconductors with relatively poor mechanical flexibility. Modern wearable technologies are characterized by body-worn devices, as smart clothing, e-textiles, and accessories [7]. Wearable devices can be used to collect various data to support a series of innovative applications. Today, wearable devices have numerous applications due to their integration with artificial intelligence. Wearable devices can be attached to shoes, eyeglasses, earrings, clothing, gloves, and wrist watches [8].

DIFFERENT TYPES OF WEARABLE DEVICES

As illustrated in Figure 3, AI Is making wearables smarter [9]. Wearable devices are used for many purposes such as fitness, monitoring, sleeping disorder, etc. Different types of wearable devices are discussed as follows [10],

- *Smart Phones:* People usually carry their smart phones around in their pockets. Smart phones have many sensors embedded, which collect data about the movements of users.
- *Smart Watches and Wristbands:* These have various built-in sensors that monitor users' daily activity, calorie consumption and heart rate, as well as the quality of sleep, etc. Wristbands have recently become a widely used health management tool, with large numbers of people wearing them daily.
- *Smart Glasses:* Smart glasses will not become a threat to privacy, but a practical life assistant and medical tool.
- *Smart Clothes:* Smart clothes collect body data from users, which can be used to monitor users' exercise data and heat consumption. There are also smart baby clothes for infants to monitor their physical condition.
- *Smart Shoes:* Smart sneakers collect users' sports data to help them improve their sports performance.
- *Smart Earphones:* These allow users to operate the equipment more conveniently using voice commands.

There are also smart gloves of manufacturing settings and smart suits for military and space.

WEARABLE PHARMACEUTICALS

Digital technology departments within pharma companies are becoming common, with the responsibility to stay on top of the latest digital health trends and devices, as well as understand how to use the data provided. The departments oversee preclinical testing of various devices, which has become a more prominent and required step prior to clinical trial initiation.

Wearable technologies are essentially sensors and/or software applications on smartphones and tablets that can collect health-related data remotely, i.e., outside of the healthcare provider's office. They include smartwatches, wristbands, hearing aids, electronic/optical tattoos, head-mounted displays, subcutaneous sensors, electronic footwear, and electronic textiles. Wearable devices need to be able to function with an independent operating system offering low power consumption and user friendliness without being paired to smartphones.

Fitness bands, smart watches, Google glass, etc. are new forms of wearable technologies that have made it big in the consumer market already. Wearable devices in the sports and fitness sector have become so commonplace that it is no surprise to see them making their way into the pharmaceutical industry. A wearable appropriate for the pharmaceutical industry is a clean-room-ready, industrial-strength assisted reality device that connects frontline workers within labs and factories. The pharmaceutical industry is now able to use wearable technology to drive innovation and analytics, e.g. to capture a diverse array of data remotely and speed up the drug development process without compromising efficacy or safety.

APPLICATIONS OF WEARABLES IN PHARMACEUTICAL

Wearable technology, also known as “wearables,” are electronic devices designed to be worn on the user's body. Wearables are typically used to collect data and track health information, but they can also monitor environmental conditions and social factors. These wearables also include biomedical devices which provide diagnostics, monitoring, and treatment services. Wearable technology is set

to change the way we live and change it for the better. Application areas include the following [11,12]:

- *Healthcare:* Wearable medical devices have transformed healthcare. Wearable technology in healthcare is growing rapidly with several advanced features which are expected to offer significant advantages for pharma enterprises. Rising costs of healthcare are of immense concern and the possibility of healthcare virtualization via digital devices has been heralded by relentless hype. Wearable pharmaceuticals allow both healthcare providers and patients to benefit from better treatment outcomes. Medical devices have to be approved/cleared by the FDA before they can be released to the market. Wearables make it much more accessible than ever to get biological measurements from people during a study. The latest wearable medical devices are transforming clinical research processes and outcomes by enabling clinicians to collect a wealth of data remotely. The newest crop of wearable devices is optimized to capture a variety of distinct patient health indicators that can provide a clear snapshot of a person's health status. For example, a person undergoing heart rate monitoring can wear a device and collect data while they go about the course of their regular day in their own environment. There have been several advancements in sensor technology helping to drive the demand for wearables in healthcare. Figure 4 shows wearable technology in healthcare [13].
- *Clinical Trials:* Wearables have been used in clinical trials for years, but technology has advanced so quickly that they have become more accessible and affordable for people to buy themselves. Wearables are also revolutionizing clinical trials by making drug development faster and more effective. Wearables can reduce costs in clinical trials and have shown success in treating mental health disorders. It has been predicted that by 2025, the majority of clinical trials will use wearable technology such as biosensors. Clinical trials can be an expensive and time-consuming process, but the use of wearables has the potential to reduce costs associated with management. Wearables in clinical trials are displayed in Figure 5 [14].
- *Augmented Reality:* Wearable devices have the potential to offer features such as augmented, virtual, and mixed reality, artificial intelligence, and pattern recognition. Some companies in the industry have attempted to implement augmented reality solutions, which overlay a computer-generated image on top of a user's view of the real world. Many startups are integrating virtual reality (VR) and augmented reality (AR) to improve patient engagement through immersive and interactive experiences. VR has been utilized as a pain distraction technology for wound care and physical therapy procedures of burn patients, where pain medications are inadequate.
- *Medication Adherence:* Some patients suffering from hypertension, diabetes, psychosis, and other conditions are non-adherent to the prescribed medications, mostly due to forgetfulness. Non-adherence to prescription drugs leads to more hospital readmissions and clinical complications. Medication adherence is a big area of concern in multiple therapeutic areas. The reasons behind nonadherence are multifaceted and include socioeconomic factors, access to health care, communication means with healthcare professionals, patients' education, and understanding of the impact of nonadherence to the treatment outcome. Cell phone apps can provide data to monitor medication adherence and help with timely intervention by medical personnel and caregivers.
- *Aided Living:* Hearing impairment is the major reason of disability among old patients. One of the early examples of the use of wearable devices in medicine was to treat hearing loss. Hearing aids can be wirelessly connected to smartphones or tablet computers to directly tune the volume or the bass of the sound. These wireless hearing aids can communicate with one another to adjust the audio properties simultaneously. Such devices offer FM listening devices with wireless microphones that can be used by a partner.

- *Hearables:* Hearables or smart hearing devices enable bloodless bio-signal accumulation and vital sign monitoring based on audio and voice interactions. People with hearing disabilities can use digital hearing aids that convert sound waves into digital signals and produce precise sound duplication. The computer chips embedded in the digital hearing aids can analyze speech and other sounds in the environment. Digital hearing aids have substantial flexibility in hearing aid programming, so that sound they produce can be matched to the specific hearing loss pattern. Doctors, clinicians, and eHealth platforms utilize hearables for sleep monitoring as well as anxiety and depression diagnosis using speech analysis.
- *Sleep monitoring:* Healthcare wearables provide a non-intrusive method for sleep analysis and management. Wearable devices can measure and provide recommendations for improving your sleep. One of such wearables is Beddit. It measures sleep time, heart rate, breathing, humidity, and room temperature. Users can set up sleep time goals and based on the sleep patterns the app can recommend how to achieve these goals with bedtime reminders and nudges. Figure 6 shows a sleeping wearable [14].
- *Drug Delivery:* There are applications of wearable devices in drug delivery. A wearable device containing a microgel depot has been developed to release drug loaded nanoparticles based on tensile strain triggering of an elastomer membrane. Pharmaceutical companies are able to use wearable technology to drive innovation and analytics and speed up the drug development process without compromising efficacy or safety. Wearable technologies are promising and have the potential to fundamentally change healthcare and drug development by changing the means of collecting, processing, and visualizing health data.
- *Telemedicine:* Innovations in wearable devices and the Internet of things (IoT) increase precision in remote diagnosis and disease prediction. Remote patient monitoring predominantly relies on wearables to monitor and relay patient data to healthcare providers for analysis, interpretation, and intervention. This decreases hospital visits and mitigates rehospitalizations, thereby reducing the burden on the healthcare infrastructure. Wearables also streamline virtual doctor consultations to provide personalized health advice and automate patient data collection.
- *Fitness Wearables:* Smart wearable devices are helping people in making their resolution a success, with some striving for personal satisfaction while some for competitiveness. Fitness wearables such as Fitness trackers help in monitoring or tracking fitness-related metrics such as distance walked or run, calorie consumption, and in some cases heartbeat and quality of sleep. Such trackers are mainly used by sports or fitness freaks, or overweight people, which help them monitor physical activities or a guided weight loss program. Figure 7 shows a fitness wearable [15].
- *Close-Contact Wearables:* Conformable mounting of a wearable device on the human skin requires compatibility between the mechanical properties of the compliant wearable device substrate and the stiff surface. Wearable piezoelectric tattoos have been fabricated to measure soft tissue viscoelasticity over epidermis. Tattoo-based wearables integrating optical sensors have been utilized as indicators for UV radiation exposure. A wearable tattoo-based sensor was developed to monitor alcohol in sweat. Noninvasively monitoring a patient's health status at the molecular level is the key in advancing the applications of wearables.

BENEFITS

The ability of wearable pharmaceuticals and biomedical devices to track and record data makes them a powerful tool for physicians. Wearable devices present opportunities for medical professionals. Wearables are changing the treatment process in significant ways. Wearable devices can monitor vital signs such as blood pressure, heart rate, and temperature. Time, convenience, and cost savings are big potential benefits of wearable devices, although currently development and

adoption costs are militating against such savings. The growing demand for wearable therapeutics is underpinned by the appetite of consumers to take control of their health and circumvent rising costs and staff shortages within traditional healthcare. Wearable technology offers drug-free solutions for pain relief, nausea, and neurological disorders. Other benefits include [16]:

- *Personalized Care:* Patients are not one-size-fits all. To improve health outcomes overall, personalized medicine and individual approaches are the way of the future. Wearable devices can enable monitoring at risk patients, intervening diseases at an earlier stage, and reducing healthcare expenditures by means of prediction and prevention of disease. Wearable devices integrated with electronic and optical biosensors can provide real-time data about the electrophysiological or biochemical status of a patient at point-of-care settings or in the clinic.
- *Clinical Trial Participation:* By enabling the monitoring to be done from home, wearables can also make it much easier for people to participate in studies. While traditional medical equipment can be cumbersome or overwhelming to use, most wearables are comfortable and familiar. A lot of people in the US already have some type of smart watch and are tracking some data.
- *Empowering Patients:* Beyond tracking details in the name of medical research or patient monitoring, there are lots of other insights patients can glean for themselves using a smart watch or other fitness tracking device. People have data about their health right on their wrist, and it can alert them to potential issues.
- *Access to Care:* Wearables can also increase access to care in some cases. For example, clinicians can send out wearable devices to people who live in more rural parts of the country where they may have to travel long distances to access specialty care. This can make it possible to not only collect data, but also to share key data with clinicians in other locations, thus improving access to high-quality care. The goal is to shift to more personalized care that empowers patients to be engaged in self-care and helps caregivers better support their loved ones.

Some of these benefits are displayed in Figure 8 [13].

CHALLENGES

Challenges presented by adoption of wearable technologies are significant. They include data ownership and sharing, consent requirements, privacy, security, and substantial geographical differences in approaches to addressing these challenges. Key implementation challenges are patient and provider engagement, connectivity and device communication, and clinical validation. The sheer volume of wearables, especially in the consumer-grade market, also poses an obstacle. Although a bit costly at present, the wearable technology market will soon be consumed like the clothes and other mass market products. Other challenges include the following:

- *Regulation:* Pharmaceutical manufacturers are held to a higher set of regulatory standards and cybersecurity protocols by the FDA and other international regulatory bodies in the kinds of technology they can deploy. Many wearable device companies have been working on medical solutions for years, but regulatory approvals followed by physician acceptance takes time. US and European legislation seems headed in different directions concerning scope, consent, data sharing, and processing. Wearable devices are regulated in the same way as any other medical device based on medical use intent. These regulations are in place to ensure that wearables do not harm patients during device use or result in the long-term effects.
- *Patient Safety:* Patient safety is of utmost concern in setting up a clinical trial. While wearables can help improve trial safety overall through increased patient monitoring, pharma companies must ensure the selected device(s) themselves are safe and provide reliable data.

- **Data Safety:** The protection of the personal information and patient data in wearables is a significant concern. The ownership of the data from wearable devices is debatable. Currently third party companies sell patient information (age, sex, height, weight, location, contact details) and global positioning-tracked activities. Wearable devices can be hacked by accessing the communication channel between the wearable device and smartphones. Wearable device manufacturers and IT infrastructure should protect medically relevant data by providing tamper protection, authentication, data encryption, or end-to-end data integrity.
- **Data Security:** In the practical consideration of privacy, security, and compliance with respect to medical devices, it can be helpful to separate compliance from privacy and security, as compliance tends to be retrospective in nature, but ensuring privacy and security must be proactive and forward-looking. Focusing specifically on wearable sensors and devices, it is essential that all personally identifiable information (PII) and all personal health information (PHI) must be protected, and that the devices themselves be protected from any form of outside interference.
- **Data Privacy:** Patient data privacy is a major concern with wearable devices as they collect and transmit sensitive health data. If not properly secured, this data could be vulnerable to hacking, theft, or misuse. But developments in encrypted data transmission, user authentication, and more secure data storage are constantly evolving, with new improvements being made all the time to protect data privacy and security.

CONCLUSION

Although wearables are still in development, they will become the world's best-selling consumer electronics product after smartphones. With highly targeted technology like wearables, the sky is the limit for what companies might be able to create, uncover, simplify, prevent, and repair in the future.

Wearable devices can collect data on a 24/7 basis in natural settings as people go through their daily routines at home and work. The promising potential of wearable devices has attracted enormous attention in the pharmaceutical industry. The future means we will be wearing our technology on the outside, and, perhaps one day, on the inside, too. More information about wearables in pharmaceutical can be found in the related journal: *Clinical Pharmacology & Therapeutics*.

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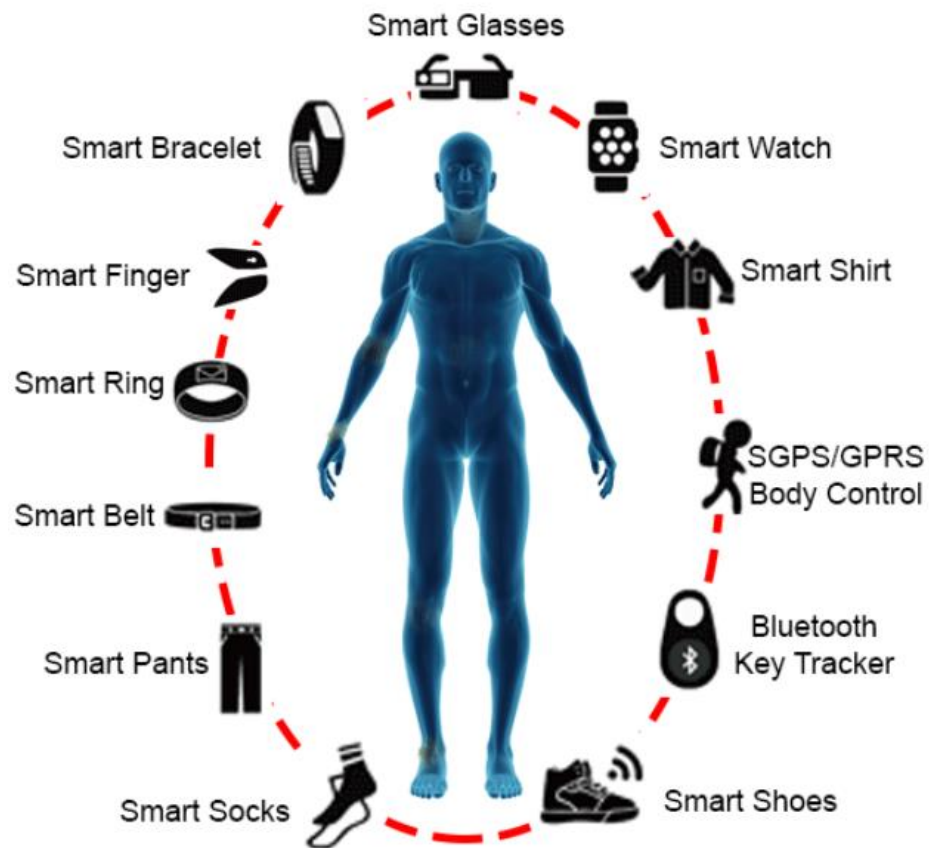


Figure 1 Different types of wearable devices on human body [2].



Figure 2 Different applications of wearable technology [5].

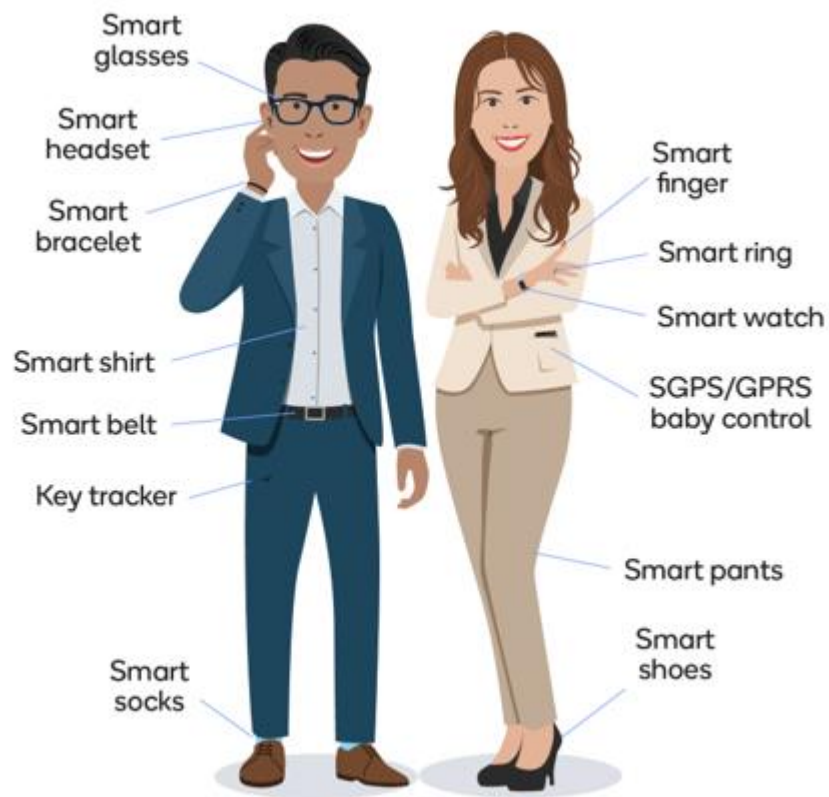


Figure 3 Examples of smart wearables [9].



Figure 4 Wearable technology in healthcare [13].



Figure 5 Wearables in clinical trials [14].



Figure 6 A sleeping wearable [14].



Figure 7 A fitness wearable [15].

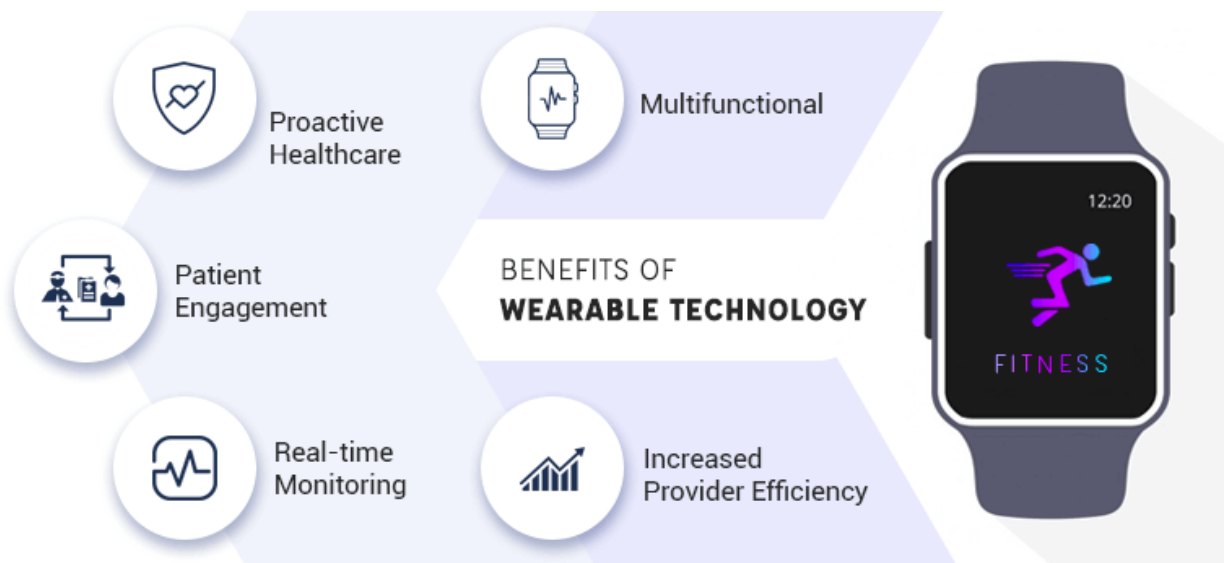


Figure 8 some of the benefits of wearables [13].