ISSN: 2288-7709 © 2020 KODISA & ICMA.
JEMM website: https://acoms.kisti.re.kr/jemm
doi: http://dx.doi.org/10.20482/jemm.2022.10.4.13

The Role of Wearable Devices for the Success of the Healthcare Business: Verification from PRISMA Approach

Ji-Hye KIM[1], Eungoo KANG[2]

Received: May 18, 2022. Revised: July 05, 2022. Accepted: August 05, 2022.

Abstract

Purpose: Although numerous research has covered content on trends in the adoption and use of wearable devices, their uses across several sectors such as healthcare, gaming, and fashion, there seems to be a considerable paucity with regard to empirical research focusing on the solutions for factors that undermine the effectiveness of wearable devices in healthcare. The present research aims to highlight what has been covered on wearable devices in healthcare while highlighting the limitations for future research. **Research design, data, and methodology** – The present authors conducted one of the most famous qualitative literature approach which has been called as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement. The selecting criteria for eligible prior studies was estimated by whether studies are suitable for the current research, identifying they are peer-reviewed and issued by notable publishers between 2017 and 2022. **Result** – Our results indicated that (1) Increasing the Affordability and User Education on Wearable Devices in Healthcare (2) Tackling the Technological Issues in Wearable Devices to Promote Healthcare Delivery (3) Solving Security and Privacy Issues Associated with Wearable Devices (4) Promoting Standards and Appropriate Regulations for Wearable Devices. **Conclusion** – To add, resolving the technological issues associated with wearable devices in healthcare will ensure that the new devices in the market will have longer battery life, multiple functions, and enhanced accuracy, thus ensuring that patients receive better care. Necessary interventions are taken on time to avoid any deleterious consequences such as proliferating mortality rates among the different patient groups.

Keywords: Wearable Devices, Healthcare Technology, Aging Senior, Qualitative Systematic Review

JEL Classification Code: L11, Z21, C35

1. Introduction

Following the rapid upsurge in the use of mobile technology since the last century, numerous researchers reveal that the usage of mobile devices has proliferated tremendously all over the globe. Recent research indicates that a significant percentage of the human population in the global north and the global south have access to mobile technology. The figures are expected to skyrocket in the next couple of years (Leliveld & Knorringa, 2018) further. The advancements in technology have also led to the introduction of wearable technology that has been immensely used in numerous fields such as healthcare, gaming, fashion, and the military. The history of wearable devices dates back to as early as the 1500s, during which Peter Henlein came up with the first-ever watch, which was worn as a necklace. Since then, a myriad of other wearable technologies such as smart watches, smart rings, and other prototypes have entered the global market (Angurala, 2022). A substantial

1 First Author, Lecturer, Department of Leisure and Sports Studies, Sahmyook University, Seoul, South Korea, Email: jhkim831024@gmail.com
2 Corresponding Author, Full-Time Faculty, Becamex School of Business, Eastern International University, Binh Duong, Vietnam. Email: ekang@eiu.edu.vn

number of researchers argue that wearable medical devices are gradually gaining a promising market as people are gradually moving from traditional approaches to healthcare and are embracing physical fitness and healthier lifestyles in general.

Among the countries with the highest for wearable medical devices is the United States of America. Based on studies conducted in the recent past, a considerable percentage of the adult population in the United States has embraced wearable medical devices to track some of their health parameters, such as heart rate and body temperature (Zou & Schiebinger, 2021). Globally, the mobile healthcare market is predicted to shoot up to $90.4 billion and above, considering that the popularity of these devices is increasing by the day (Mukherjee, Banerjee, Mitra, & Mukherjee, 2022). The proliferation of this industry has been massively linked to the increased prevalence of lifestyle diseases and other medical issues in the last couple of decades, accessibility of the internet in many parts of the world, development of intelligent hardware and big data, as well as changes in approaches to health where prevention and management of health issues are gaining more preference than treatment.

According to the prior study (Awotunde, Jimoh, Folorunso, Adeniyi, Abiodun, & Banjo, 2021), wearable devices in healthcare come in various forms. They can include a wide range of gadgets, including electronic skin patches, spirometers, glucose monitors, and ECG monitors. These devices monitor and record data pertaining to the patient's health parameters such as temperature, heart rate, and glucose levels, after which the observed data is sent to a cloud server where physicians can track how their patients are progressing, thus making it easier to prescribe treatments and make an informed diagnosis (Banka, Madan, & Saranya, 2018). The medical wearable devices have, therefore, proven to be pretty convenient, especially during the Covid-19 pandemic where demand for home healthcare is increasing at an incredible rate. Although numerous research has covered content on trends in the adoption and use of wearable devices, their uses across several sectors such as healthcare, gaming, and fashion, there seems to be a considerable paucity with regard to empirical research focusing on the solutions for factors that undermine the effectiveness of wearable devices in healthcare. Therefore, this paper will highlight what has been covered on wearable devices in healthcare while highlighting the limitations for future research. Peer-reviewed sources from credible databases such as PubMed, Google Scholar, Scopus, and EMBASE will be utilized.

The objectives of this research include:

1. To explore the available empirical research on the types and uses of wearable devices.
2. To analyze how wearable devices have been used in the healthcare industry.
3. To identify study gaps in the literature on wearable devices in healthcare.
4. To identify the role played by wearable devices in the success of healthcare businesses.
5. To identify factors that limit the effectiveness of wearable devices in healthcare provision and how these issues can be resolved.

2. Literature Review

This literature review section seeks to survey past studies that have been undertaken by various researchers with respect to the topic of wearable devices in healthcare. Specifically, this part will focus on the forms and classifications of wearable devices, applications of wearable devices in the field of healthcare, and factors that limit the effectiveness of wearable devices in healthcare delivery.

2.1. Forms and Classifications of Wearable Devices

Lopez and his colleagues (2020) argue that with the rapid technological advancements in recent years, wearables can now be used as medical devices in various forms. Firstly, these devices can be worn as accessories such as wristbands and wristwatches. More often than not, accessorized medical devices are used by persons who are trying to monitor their physical fitness and overall well-being. For instance, someone working out can wear a wristwatch that tracks their calories and distance covered by the individual. The wearable device can also be linked with a smartphone which then sends the information to a cloud server, making it easy for people to evaluate and keep track of some of their health parameters. Additionally, Jarusriboonchai, and Hakkila (2019) identify that wearable devices in healthcare can come in the form of outfits. Jiang, Stange, Bätcke, Sultanova, and Sabantina (2021) mentioned that smart clothing usually contains computer chips that make it possible to monitor changes in temperature, blood flow, and breathing patterns. Smart clothing is often synced to a computer or smartphone. Collected data is sent to cloud servers in the computer where an individual can keep track of the various changes that are taking place in their bodies.

Wang, Lou, Jiang, and Shen (2019) reveal that wearable medical devices can also be worn on the skin while others have to be transplanted into the body of the patient. For example, patients with glaucoma can have small contact lens-like devices

attached to their skin to monitor the variations in their intraocular pressure. The gathered data is then used by healthcare personnel to inform the kind of treatment to the patient. According to the Ho and his colleagues (2020), wearables implanted in the patients' bodies are often referred to as biopsy wearables. They inform patients and their patients on whether or not administered medication is working effectively. According to many researchers, the use of these forms of research will continue to proliferate due to the aging population, especially in the global north, and the flexibility they accord the users as the barriers of time and space are removed. The development of wearable technologies that can be worn on different parts of the body has led to the categorization of wearable devices into three distinct groups. According to the past literature (Lu, Zhang, Xie, Gao, Xu, Wu, & Ye, 2020), the torso, head, and limb wearable devices are the three categories. Wearable devices worn on the head include earphones, earrings, helmets, headbands, patches, hearing aids, and glasses. An excellent example of a head wearable device that has gained immense popularity in the field of medicine, according to the previous research (Xue, 2019), is the Google Glass. Google Glass is a special type of sunglasses that employs artificial intelligence to take photographs, make video calls, and even determine the GPS positioning of the user. In healthcare, Google glasses can enhance efforts in intraoperative navigation, administering medical education, and fostering telemedicine.

On the other hand, Limb wearable devices include various technologies placed on hands, feet, and the legs, such as shoes, socks, bracelets, and smartwatches. These technologies have been used by numerous persons across the world in the assessment of various physiological health parameters such as body temperature, heart rate, blood flow, levels of exposure to harmful sun rays like ultraviolet and infrared rays, among others. The previous research (Ferreira, Fernandes, Rammal, & Veiga, 2021) stated that in the past few years, the fashion industry has contributed to the improvement of healthcare delivery by making wearable devices that can be used to assess and monitor health parameters among the wearers. Examples of torso wearable devices include underwear, belts, and other pieces of clothing such as suits and socks.

2.2. The Applications of Wearable Devices in Healthcare Delivery

Wearable clinical devices have interfaces that allow the patients, healthcare personnel, admins, and the technicians of the medical devices to understand the user's health better, hence making informed decisions when it comes to diagnosis of health issues and identification of treatment options. Al-Turjman and Baali (2019) seem to agree that wearable devices have four main applications in medical care. The four applications include disease diagnosis and treatment, health and safety monitoring among the patients, rehabilitation, and chronic disease management. These applications are further discussed in detail below.

(1) Health and Safety Monitoring: Healthcare personnel in various healthcare facilities can monitor a patient's health status in real-time by analyzing the data that has been garnered by wearable technologies and saved in cloud servers. Through the collected information, health practitioners are able to adjust the patient's treatment plans accordingly. Moreover, Poongodi, Krishnamurthi, Indrakumari, Suresh, and Balusamy (2020) stated that the patient can monitor the changes in their health parameters and contact their physicians for medical advice if there proves to be a serious concern. Excellent examples of the common wearable devices used in the medical profession for health and safety monitoring include hemodynamic assessment devices, ECG patches, and wearable spirometers. Health and monitoring wearable medical devices can be used by all patients, including the older members of society, children, and expectant mothers, among others. Most older adults require regular nursing and persons to take care of them from time to time as they are highly susceptible to a myriad of health issues. However, the prior study (Fetjah, Azbeg, Ouchetto, & Andaloussi, 2021) revealed that it is not easy to ensure quality healthcare, especially when living independently. Nonetheless, the proliferation of wearable devices in the field of medicine has made it possible for physicians to monitor the health parameters of elderly persons by looking into the data in their clinical cloud servers. Moreover, teaching the elderly how the wearable devices work can enable them to identify when health issues occur in real-time, thus enabling them to seek medical attention as soon as possible before the issues persist.

Comprehensive research identifies that the market for wearable devices has expanded significantly in the past couple of years. Examples of such devices include smartwatches, wristbands, and even backpacks. These wearable devices are able to keep track of the children's movements and activities by recording the GPS positioning of the users now and then. Moreover, it is now possible to monitor an individual's mood using different wearable devices. Through this, healthcare practitioners have an easier time determining which of their patients are depressed or on the verge of depression, allowing them to take relevant precautionary procedures before the condition worsens. Additionally, Signorini, Lanzola, Torti, Fanelli, and Magenes (2018) claim that wearable devices are often prescribed for pregnant women to enable the medical personnel to monitor the health of both the mother and the fetus, hence contributing to the reduction of fatalities associated with pregnancy and childbirth. According to recent research, the most monitored health parameters include dyskinetic characteristics for people with neurological issues, respiratory patterns in users with respiratory issues, and aspects such as temperature and breathing in patients recuperating at home from Covid-19.

(2) Management of Chronic Ailments: The use of wearable devices to track the health of persons living with chronic diseases has been on the rise, especially in global north countries such as the United States of America. Some of the chronic healthcare issues that can be managed effectively through the use of wearable devices include pulmonary diseases, cardiovascular disease, diabetes, and hypertension. The prior study (Rudd, Ghanayem, Hill, Lambert, Mussatto, Nieves, & Pike, 2020) reveal that regular monitoring of myocardial electrophysiology in persons with a high susceptibility to heart disease enables healthcare providers to track the disease early enough and administer appropriate medication before the disease starts to weigh down on the affected patients. According to the Quan and his associates (2021), both invasive and non-invasive monitoring wearable devices can be worn by the patients to make healthcare delivery easier for both the patient and medical personnel. Through effective monitoring, Quan et al. (2021)
Also stated that the healthcare sector can lower the prevalence of chronic diseases by keeping track of the common healthcare parameters in these ailments. Successful monitoring thus helps lower mortality rates associated with chronic diseases. It allows patients to lead healthier lives as treatment and management plans can be adjusted from time to time depending on the progress of the patients' health.

(3) Disease Treatment and Diagnosis: As many researchers have already identified in numerous pieces of research, early identification of symptoms is vital for speedy diagnosis and timely intervention of the diseases before they persist. Various wearable devices in healthcare go a long way in checking health parameters in real-time among the patients using these devices, allowing the patients and their physicians to notice when there is a cause for alarm. According to Van Bulck and his colleagues (2019), among the diseases that require an early diagnosis to prevent proliferation and to make the treatment process easier include neurological issues such as Alzheimer's disease, respiratory issues such as obstructive sleep apnea-hypopnea syndrome, cardiac issues, as well as diseases associated with issues in the urinary system. People can live healthy and productive lifestyles with enhanced patient treatment and therapy.

(4) Patient Rehabilitation: Extensive study (Bahadori, Immins, & Wainwright, 2018) seem to agree that wearable devices are effective in promoting the success of rehabilitation programs for patients going through a myriad of health issues. Among the most common healthcare wearable devices used in rehabilitation include smart gloves, EMC sensors, and range-of-emotion assessment sensors, among many more. These wearables have been used extensively to monitor the rehabilitation progress of patients undergoing sports rehabilitation, cognitive rehabilitation, and also the rehabilitation of persons with various forms of disabilities such as visual impairment.

2.4. Factors Limiting the Effectiveness of Wearable Devices in Healthcare Delivery

Despite wearable devices proving to have helped immensely in the diagnosis, monitoring, treatment, and rehabilitation of patients suffering from various health issues, extensive research by Kadhim and his associates (2020) showed that several issues limit the use of wearable devices in efforts to foster quality healthcare delivery. According to the prior research (Khakurel, Melkas, & Porras, 2018), the first issue is the lack of adequate user-friendly devices. Indrakumari, Poongodi, Suresh, and Balamurugan (2020) state that wearable devices gather a wide range of data concerning the patient, such as their physical location based on their GPS standing, their activities, as well as health parameters such as body temperature and heart rate, among many more. Although this information has immense usefulness to both the patient and their physicians, there is a high likelihood that other companies may take this information without the consent of the users of the wearable devices, thus causing a myriad of ethical issues. Moreover, Zhang, Li, Wen, and Luo (2021) argued that any defaults in the wearable devices may result in false information, which further leads to misdiagnosis on the end of the medical personnel and false anxiety on the users due to the constant false alarms. It is, therefore, imperative to resolve this issue as soon as possible to ensure that healthcare delivery services are kept top-notch.

In addition, some researchers have identified that there are numerous technological issues associated with wearable devices. First and foremost, most devices require recharging from time to time, especially those worn on the limbs, and thus become unreliable when the battery dies. There is a likelihood that an individual may experience extreme changes in their health parameters when the wearable devices are not working, thus leading to deleterious consequences as the users and their healthcare providers are not able to monitor what is going on hence derailing medical interventions. Furthermore, Díaz, Stephenson, and Labrador (2020) report that most wearable devices promoting healthcare delivery are often costly. Therefore, a considerable number of people may not have the financial capacity to purchase them. In this case, timely diagnosis, treatment, and rehabilitation of patients may be challenging to accomplish, resulting in poor health outcomes across the United States and other parts of the world.

Based on the literature review from the above studies, it is clear that wearable devices come in numerous forms, can be worn in various parts of the body, and have also proven to be highly effective in improving healthcare delivery to patients.

However, no significant research has been conducted with regard to how issues affecting the usage of wearable devices in healthcare can be resolved, thus proliferating the success of healthcare businesses and health delivery in general. Therefore, the following section seeks to find the solutions to this research gap.

Table 1: Summary of Literature Review

	Literature Review	Description
Forms and Classifications of Wearable Devices	Lopez and his colleagues (2020) Jarusriboonchai & Hakkila (2019) Jiang et al. (2021) Wang et al. (2019), Ho et al. (2020) Lu et al. (2020) Xue (2019) Ferreira et al. (2021)	Wristbands and wristwatches The form of outfits Smart clothing Wearables implanted in the patients' bodies Torso, head, and limb wearable devices Head wearable device, Google Glass Torso wearable devices
The Applications of Wearable Devices in Healthcare Delivery	Al-Turjman & Baali (2019) Poongodi et al. (2020), Fetjah et al. (2021), Signorini et al. (2018) Rudd et al. (2020), Quan et al. (2021) Van Bulck et al. (2019) Bahadori et al. (2018)	Four main applications in medical care of Wearable devices (disease diagnosis and Treatment, health and safety monitoring Among the patients, rehabilitation, chronic Disease management) Health and Safety Monitoring Management of Chronic Ailments Disease Treatment and Diagnosis Patient Rehabilitation
Factors Limiting the Effectiveness of Wearable Devices in Healthcare Delivery	Kadhim et al. (2020) Khakurel et al. (2018) Indrakumari et al. (2020) Zhang et al. (2021) Diaz et al. (2020)	Issues limit the use of wearable devices The lack of adequate user-friendly devices Ethical issues False information Cost issues

3. Research Design (PRISMA Methodology)

The present authors conducted one of the most famous qualitative literature approach which has been called as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement. The selecting criteria for eligible prior studies was estimated by whether studies are suitable for the current research, identifying they are peer-reviewed and issued by notable publishers between 2017 and 2022. Scientific authors can utilize PRISMA to assist them describe a wide range of systematic studies and meta, generally used to measure the benefits and hazards of a national healthcare intervention. It is the goal of PRISMA to make it easier for researchers to disclose their findings clearly and comprehensively (Kang, et al, 2022).

The QUOROM standard was replaced by PRISMA. It has the comparability of a review of the literature. As a result, scientists must devise specific goals for their studies, as well as a collection of inclusion and intended that address the research topic. Relevant articles were found and eliminated during the review step. According to pre-determined categories, publications are assessed. The PRISMA statement aims to assist researchers in better documenting systematic reviews as well as meta-analyses in scientific journals. When publishing systematic reviews and meta-analyses, PRISMA is most commonly used for clinical studies, but it could be used to describe reviews of other kinds of research, such as diagnostic or empirical evidence, as long as they follow the PRISMA guidelines (Kang et al, 2022). PRISMA is highly recommended for authors performing methodical reviews and meta-analyses who want to better communicate their findings. Editors and reviewers of

other publications: However, PRISMA isn't a tool for evaluating the quality of systematic reviews, only the critical evaluation of published ones.

Studies were searched in major databases such as, Google Scholar, ProQuest and Emerald databases. The search terms and phrases included specific terms such as 'Wearable Devices', 'Healthcare Technology', 'Aging Senior', 'Qualitative Systematic Review'. As shown by the below Figure 1, out of the 93 papers meeting the inclusion criteria, finally, 20 articles met the criteria and were assessed based on their methodological quality.

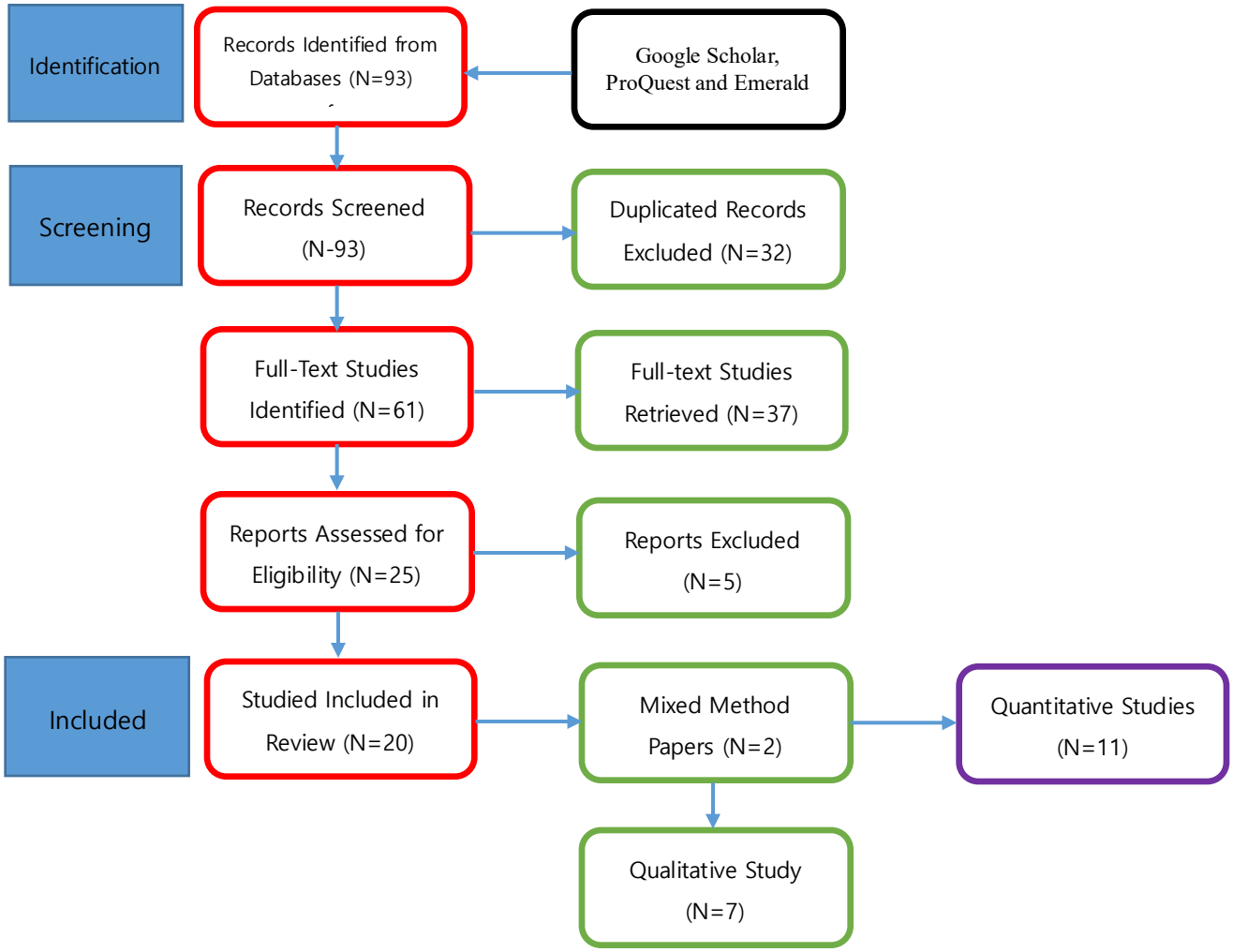

Figure 1: Summary of Literature Review

4. Solutions from Systematic Review

4.1. Increasing the Affordability and User Education on Wearable Devices in Healthcare

As it has already been established from numerous pieces of research, the pros of wearable devices in ensuring the success

of healthcare around the world are undeniable. However, extensive research reveals that a considerable percentage of persons who require wearable devices the most cannot afford to get them due to financial constraints (Shirani, Groves, Henwood, Pidgeon, & Roberts, 2020). For instance, studies have shown that a significant percentage of persons suffering from chronic diseases such as diabetes reside in developing countries (Weaver & Fasel, 2018). High rates of poverty characterize developing countries, and it is, therefore, not easy to achieve better healthcare delivery in these areas using wearable devices. Moreover, researchers have identified that despite many citizens in the United States adopting the use of wearable devices, a massive population of American Americans and the Hispanic population, especially those living in the south, can barely afford the devices. Despite having the highest rates of obesity that would otherwise require regular monitoring of health parameters to avoid further deleterious effects (Stewart, Watters, Horowitz, Larson, Sargent, & Uggen, 2022). With most wearable devices by huge companies such as Apple going for thousands of dollars, it is improbable that many people would invest in the devices instead of catering to their basic needs.

Research indicates that there is a considerable lack of marketing for wearable devices among the poverty-stricken population because although they are the ones who would benefit the most from the gadgets, companies do not view them as potential clients due to their financial status. Moreover, the lack of literacy skills and knowledge on the use of wearable devices makes it quite challenging to assist illiterate and semi-literate populations (Smith & Magnani, 2019). To bridge this gap, many researchers suggest that companies in charge of manufacturing wearable devices should strive to make affordable devices that can be afforded by a broader population, thus making it easier to foster success in healthcare delivery across the general population. Additionally, healthcare organizations and companies making the wearable devices should make efforts to educate members of the public on how to go about the devices, thus making it easier for patients and their physicians to work together in preventing, managing, and treating various medical conditions hence minimizing their prevalence in the long run. Furthermore, researchers claim that it is imperative for companies to advertise diverse ranges of wearable devices to enable all potential consumers to gain an awareness of the currently available devices in the market and how it can assist them to take better care of themselves (Yang & Lee, 2019). With the implementation of these suggestions and integrating wearable devices in the normal healthcare processes, healthcare organizations and their staff can have an easier time attending to their clients, thus resulting in their overall success.

4.2. Tackling the Technological Issues in Wearable Devices to Promote Healthcare Delivery

Numerous researchers in their studies identify that it is vital to resolve the technological barriers associated with the use of wearable devices in healthcare. Among the possible solutions in this context would include developing wearable devices that are less bulky, thus making it easier for the users to carry around (Fernández-Caramés, & Fraga-Lamas, 2018). Several studies have shown that some devices worn on the body to monitor various health parameters among the users may be quite heavy, thus discouraging most potential clients from purchasing and wearing them (Rajendran, Chaudhari, & Giridhar, 2021). Therefore, smaller devices are convenient, and their adaptability allows healthcare personnel to offer better medical services to the clients as they can review their health trends from the healthcare cloud servers, thus allowing them to make informed decisions during treatment and other possible interventions.

Additionally, Izmailova, Wagner, and Perakslis (2018) stated that healthcare organizations can combine efforts with the companies that manufacture wearable devices to ensure that the devices made have longer battery life. Improved battery life in wearable devices can go a long way in ensuring that the devices are operational for more extended periods. Therefore, data concerning the health status of the patients is constantly collected and sent to the servers to enable admins and healthcare personnel to understand better how the client is fairing (Akkas, Sokullu, & Cetin, 2020). Moreover, it has become evident that many wearable devices have single usage and thus only measure one health parameter, which may be insufficient for the proper diagnosis of medical issues (Benson, Clermont, Bošnjak, & Ferber, 2018). For this reason, researchers and experts in the field of health have, on numerous instances, suggested that companies should introduce wearable devices with multiple functions, thus making it easier to extend better healthcare services to their users.

In handling the technological issues with wearable devices in healthcare delivery, the companies should look into the variations deviations that occur during the collection and transmission of data. This helps the users in avoiding incidences of false alarms (Lown, Brown, Brown, Yue, Shah, Corbett, & Little, 2020). When wearable devices start giving false alarms, it is unlikely that the users and their physicians will consider them reliable data sources in the overall healthcare processes (Ahuja, 2019). By developing effective mechanisms that conduct regular diagnoses and identify possible issues with wearable devices, healthcare businesses will be able to offer way better services to their clients (Vollmer, Mateen, Bohner, Király, Ghani, Jonsson, & Hemingway, 2020). Therefore, this will reduce the prevalence of various diseases, especially chronic ones, in most parts of the world.

4.3. Solving Security and Privacy Issues Associated with Wearable Devices

Another issue that has been identified in the literature review is the numerous security and privacy concerns associated with the use of wearable devices in health promotion. More often than not, wearable devices capture the users' personal information, ranging from their location to health status (Ometov, Shubina, Klus, Skibińska, Saafi, Pascacio, & Lohan, 2021). Considering that outside parties can access this information, users of wearable devices are often worried about their privacy as well as their security (Cilliers, 2020). Following extensive studies, researchers agree that the way forward is to come up with systems and features that protect the users' data from any manipulation and access without their consent (Atlam & Wills, 2020). By doing this, public members are bound to develop more confidence and trust in wearable devices and the healthcare sector.

4.4. Promoting Standards and Appropriate Regulations for Wearable Devices

Rigorous research (Farahani, Firouzi, & Chakrabarty, 2020) also shows that there still exists a gap in the creation of bodies that assess the effectiveness of wearable devices in meeting the healthcare need of the users. The companies dealing with manufacturing come up with prototypes that are often later developed without considering the aspect of quality assurance (Nguyen-Duc, Khalid, Shahid Bajwa, & Lønnestad, 2019). This explains why so many wearable devices offer unreliable information due to poor quality (Baig, Afifi, GholamHosseini, & Mirza, 2019). It is, therefore, advised that a body that deals in healthcare should be set up to assess the effectiveness of the wearable devices that are put on the market for consumption by patients suffering from varying medical problems (Rath & Pattanayak, 2019). Furthermore, companies that fail to follow the laid-out regulations with regard to wearable devices in healthcare should face legal action (Karale, 2021). With firms regulations governing the quality of wearable devices, there is a high likelihood of improving their effectiveness, thus promoting better health among the members of society.

Table 2: Solutions from Systematic Review

	Literature Review	Description
Increasing the Affordability and User Education	Shirani et al. (2020) Smith & Magnani, (2019) Yang & Lee (2019)	Financial constraints The lack of literacy skills and knowledge on use of wearable devices Advertisement ranges of wearable devices
Technological Issues	Rajendran et al. (2021), Fernández-Caramés, & Fraga-Lamas (2018) Izmailova et al. (2018), Akkas et al. (2020) Benson et al. (2018) Lown et al. (2020), Ahuja (2019) Vollmer et al. (2020)	Size and convenience of wearable devices Battery life of wearable devices Multiple functions of wearable devices False alarms on wearable devices Effective mechanisms on wearable devices
Security and Privacy Issues	Ometov et al. (2021), Cilliers (2020), Atlam & Wills (2020)	Security and privacy concerns
Standards and Appropriate Regulations	Farahani et al. (2020), Rath & Pattanayak (2019) Nguyen-Duc et al. (2019) Baig et al. (2019) Karale (2021)	The effectiveness of wearable devices Wearable devices quality assurance Wearable devices quality and reliable Information Wearable devices regulations and legal action

5. Conclusions

This research delved into numerous pieces of literature in a bid to identify the various impacts of wearable devices in healthcare. Researchers agree that the origin of wearable devices dates back to many decades ago and has been used in numerous fields, including education and culture, sports, fashion, entertainment, gaming, and the healthcare sector. Based on

empirical evidence gathered from a myriad of studies, it is clear that the adoption of wearable devices has proliferated in the past few years, especially in the developed nations located in the global north. It has attracted a vast market that streams in billions of dollars. Rigorous research that numerous factors have contributed to the increment in the use of wearables over the past couple of years. Some of these factors comprise the advancements and proliferation in the use of mobile technologies and the paradigm shift in the way members of society approach healthcare issues. According to researchers, people are gradually embracing disease prevention and management in the past years instead of waiting until they are critically ill to seek treatment.

In addition, research has concluded that the prevalence of chronic diseases has witnessed a dramatic increment over the years. In a bid to control these diseases from further proliferation, people in society are accepting the idea of using wearable devices that allow them to monitor their health status, making it easier for them to understand what is required of them and to also assist their physicians in delivering the best healthcare they can. Moreover, wearable devices have been seen to reduce costs in the treatment of health problems, as the users do not have to visit healthcare centers from time to time as they can track their health status from home through the analysis of their health parameters. Excellent features associated with wearable devices such as wireless mobility, wearability and portability, durability, interactivity, and intelligence further contribute to the growing popularity of wearable devices in healthcare.

The research has also revealed that wearable devices are often divided into three categories, depending on which part of the body they are worn. From the findings, the three categories are the torso, limb, and head wearable devices. Excellent examples of the wearable devices in each category include headbands and helmets on the head, smartwatches, wristbands on the arms, socks, and shoes on the feet and legs, as well as belts and underwear on the torso. Additionally, it is evident from the research that wearable devices are made for all groups, ranging from children to pregnant women and persons with disability and other patient groups. More often than not, wearable devices operate by monitoring the variations in the user's health parameters, such as heartbeat, temperature, breathing, and glucose levels, among many more. The wearable devices are usually synced with a computer or smartphone belonging to the user to allow them to track their health parameters. Additionally, the data collected from these wearable devices is channeled to cloud servers. The admins and healthcare professionals can assess how the patients are doing, thus enabling healthcare workers to guide the users according, get an informed diagnosis, and prescribe the proper treatment. Wearable devices in the healthcare sector have been shown to have four primary functions. These areas are concerned with the management of chronic diseases such as diabetes, cancer, and hypertension, health and safety monitoring among the users of wearable devices by keeping track of their health parameters and making them accessible to healthcare professionals, rehabilitation, as well as monitoring and informing the proper treatment for a patient based on the observed trends in their healthcare parameters.

Although many researchers unanimously agree that wearable devices have had immense contributions to the improvement and success of healthcare delivery, there seem to be several issues limiting the adoption and effectiveness of wearable devices. These issues comprise the high cost of the devices, which renders them unaffordable to most people of a low socioeconomic class, especially those in developing nations. Moreover, a considerable population that may need wearable devices due to various health issues may not be able to use them due to lack of literacy skills and the failure of wearable device companies to advertise to all groups. The research has also revealed that safety and security issues, technological problems, and lack of proper standards and regulations hinder optimal adoption of wearable devices for healthcare purposes, thus resulting in poor health outcomes and immense difficulties in healthcare organizations.

Despite extensive research on wearable devices in the healthcare field, findings revealed a shortage of empirical research on the solutions that can be implemented to ensure that wearable devices foster healthcare delivery and minimize the prevalence of medical issues. Among the solutions that were identified included producing affordable wearable devices and incorporating them into the regular healthcare processes, educating the masses on how various wearable devices work, introducing wearable devices with multiple functions in the market, increasing the battery life of the devices, and creating security mechanisms to ensure that the data of wearable device users are safe from any form of manipulation or access by unauthorized parties.

6. Implications

This The research on the role of wearable devices for the success of healthcare organizations has numerous academic implications. First and foremost, as it has already been identified in numerous studies, wearable devices are a massive topic at the moment as their usage and popularity are growing by the day in all parts of the world. It is, therefore, highly likely that many persons looking to invest in wearable devices for health reasons will look up information relating to them. This research

paper will thus offer great insight to prospective clients of wearable devices. Additionally, more often than not, researchers identify studies that pique their interest and opt to further research on those topics. In that case, there exists a high chance that a researcher may pick the topic under discussion and further it after identifying gaps or insufficient data on some of the provided information. For instance, someone who has thoroughly read through this research may opt to look into the various attitudes by members of society concerning the use of wearable devices to enhance healthcare delivery. Scholars from the United States and across the globe will also be able to review this paper and inform their writing while conducting research relating to wearable devices and their effectiveness in the healthcare sector. Moreover, the research has identified that the adoption and usage of wearable devices around the world has been crippled by several factors whose solutions have also been provided. It is, therefore, possible that the audience of this research, which may comprise healthcare practitioners, policymakers, and governments, may land on this paper and consider the proposed solutions in the research, thus resulting in a massive improvement in healthcare and the quality of life of the people. Last but not least, peer-reviewed sources are often used in teaching across all academic institutions worldwide. While teaching about healthcare and wearable devices in specific, educators can recommend that their students use this piece of research as one of the course materials to garner a better understanding of what they are taught in class.

In addition to the academic implications, this research on the role of wearable devices for the success of the healthcare business may have several practical implications. Implementing the recommended solutions would have immense impacts on many parties ranging from the users of wearable devices, prospective markets for wearable devices, the companies that manufacture the devices, healthcare organizations, their staff, and policymakers. First and foremost, manufacturing cheaper wearable devices that a higher population can afford will enable persons from low socioeconomic status and living with several health conditions to purchase the devices that will boost their health, hence reducing mortality rates and lowering the prevalence of chronic diseases. Moreover, extensive marketing will allow the companies that manufacture wearable devices to have a broader range of clients who will bring substantial profits to these businesses and allow the buyers to get an opportunity to better their quality of life as their health parameters will be constantly monitored. An alarm will be raised when their health seems to deteriorate. Another practical implication of this study is that healthcare facilities will have fewer people coming in for check-ups as that can be done remotely through the use of wearable devices. Therefore, fewer hospital visits will translate to reduced patient-to-nurse ratios in the healthcare centers, thus resulting in better health. Older adults who have no persons to take care of them at home will also be at an advantage as their physicians will be able to check their health remotely by looking into the healthcare cloud servers.

To add, resolving the technological issues associated with wearable devices in healthcare will ensure that the new devices in the market will have longer battery life, multiple functions, and enhanced accuracy, thus ensuring that patients receive better care. Necessary interventions are taken on time to avoid any deleterious consequences such as proliferating mortality rates among the different patient groups. Furthermore, the introduction of policies, regulations, and creation of bodies to oversee the quality of wearable devices will ensure that the devices provide accurate and reliable data to the users and healthcare professionals, thus enhancing the success of healthcare delivery not only in the United States of America but the world at large. Enhancing the security and safety of wearable devices and the data they gather will also boost the confidence and trust of the users in the companies they purchased the devices from, thus leading to an increase in the sales and brand recognition of the said organizations.

References

Ahuja, A. S. (2019). The impact of artificial intelligence in medicine on the future role of the physician. *PeerJ, 7*, e7702.

Akkas, M. A., Sokullu, R., & Cetin, H. E. (2020). Healthcare and patient monitoring using IoT. *Internet of Things, 11*(September), 100173.

Al-Turjman, F., & Baali, I. (2019). Machine learning for wearable IoT-based applications: A survey. *Transactions on Emerging Telecommunications Technologies, May*, e3635.

Angurala, M. (2022). Latest Advancements in Wearable Devices: A Review. *Futuristic Design and Intelligent Computational Techniques in Neuroscience and Neuroengineering,* 58-64.

Atlam, H. F., & Wills, G. B. (2020). *IoT security, privacy, safety and ethics. In Digital twin technologies and smart cities* (pp. 123-149). Springer, Cham.

Awotunde, J. B., Jimoh, R. G., Folorunso, S. O., Adeniyi, E. A., Abiodun, K. M., & Banjo, O. O. (2021). *Privacy and security concerns in IoT-based healthcare systems. In The Fusion of Internet of Things, Artificial Intelligence, and Cloud Computing in Health Care* (pp. 105-134). Springer, Cham.

Bahadori, S., Immins, T., & Wainwright, T. W. (2018). A review of wearable motion tracking systems used in rehabilitation following hip and knee replacement. *Journal of rehabilitation and assistive technologies engineering, 5*, 1-8.

Baig, M. M., Afifi, S., GholamHosseini, H., & Mirza, F. (2019). A systematic review of wearable sensors and IoT-based monitoring applications for older adults–a focus on ageing population and independent living. *Journal of medical systems, 43*(8), 1-11.

Banka, S., Madan, I., & Saranya, S. S. (2018). Smart healthcare monitoring using IoT. *International Journal of Applied Engineering Research, 13*(15), 11984-11989.

Benson, L. C., Clermont, C. A., Bošnjak, E., & Ferber, R. (2018). The use of wearable devices for walking and running gait analysis outside of the lab: A systematic review. *Gait & posture, 63*(June), 124-138.

Cilliers, L. (2020). Wearable devices in healthcare: Privacy and information security issues. *Health information management journal, 49*(2-3), 150-156.

Díaz, S., Stephenson, J. B., & Labrador, M. A. (2020). Use of wearable sensor technology in gait, balance, and range of motion analysis. *Applied Sciences, 10*(1), 234.

Farahani, B., Firouzi, F., & Chakrabarty, K. (2020). *Healthcare IoT. In Intelligent internet of things* (pp. 515-545). Springer, Cham.

Fernández-Caramés, T. M., & Fraga-Lamas, P. (2018). Towards the Internet of smart clothing: A review on IoT wearables and garments for creating intelligent connected e-textiles. *Electronics, 7*(12), 405.

Ferreira, J. J., Fernandes, C. I., Rammal, H. G., & Veiga, P. M. (2021). Wearable technology and consumer interaction: a systematic review and research agenda. *Computers in Human Behavior, 118*(May), 106710.

Fetjah, L., Azbeg, K., Ouchetto, O., & Andaloussi, S. J. (2021). Towards a Smart Healthcare System: An Architecture Based on IoT, Blockchain, and Fog Computing. *International Journal of Healthcare Information Systems and Informatics, 16*(4), 1-18.

Ho, D., Quake, S. R., McCabe, E. R., Chng, W. J., Chow, E. K., Ding, X., & Zarrinpar, A. (2020). Enabling technologies for personalized and precision medicine. *Trends in Biotechnology, 38*(5), 497-518.

Indrakumari, R., Poongodi, T., Suresh, P., & Balamurugan, B. (2020). *The growing role of the Internet of Things in healthcare wearables. In Emergence of Pharmaceutical Industry Growth with Industrial IoT Approach* (pp. 163-194). Academic Press.

Izmailova, E. S., Wagner, J. A., & Perakslis, E. D. (2018). Wearable devices in clinical trials: hype and hypothesis. *Clinical Pharmacology & Therapeutics, 104*(1), 42-52.

Jarusriboonchai, P., & Häkkilä, J. (2019, November). Customisable wearables: exploring the design space of wearable technology. *In Proceedings of the 18th International Conference on Mobile and Ubiquitous Multimedia* (pp. 1-9).

Jiang, S., Stange, O., Bätcke, F. O., Sultanova, S., & Sabantina, L. (2021). Applications of Smart Clothing–a Brief Overview. *Communications in Development and Assembling of Textile Products, 2*(2), 123-140.

Kadhim, K. T., Alsahlany, A. M., Wadi, S. M., & Kadhum, H. T. (2020). An overview of patient's health status monitoring system based on internet of things (IoT). *Wireless Personal Communications, 114*(3), 2235-2262.

Karale, A. (2021). The Challenges of IoT Addressing Security, Ethics, Privacy, and Laws. *Internet of Things, 15*(September), 100420.

Khakurel, J., Melkas, H., & Porras, J. (2018). Tapping into the wearable device revolution in the work environment: a systematic review. *Information Technology & People, 13*(3), 791-818.

Leliveld, A., & Knorringa, P. (2018). Frugal innovation and development research. *The European Journal of Development Research, 30*(1), 1-16.

Lopez, X., Afrin, K., & Nepal, B. (2020). Examining the design, manufacturing and analytics of smart wearables. *Medical Devices & Sensors, 3*(3), e10087.

Lown, M., Brown, M., Brown, C., Yue, A. M., Shah, B. N., Corbett, S. J., & Little, P. (2020). Machine learning detection of Atrial Fibrillation using wearable technology. *PLoS One, 15*(1), e0227401.

Lu, L., Zhang, J., Xie, Y., Gao, F., Xu, S., Wu, X., & Ye, Z. (2020). Wearable health devices in health care: narrative systematic review. *JMIR mHealth and uHealth, 8*(11), e18907.

Mukherjee, T., Banerjee, A., Mitra, S., & Mukherjee, T. (2022). *COVID-19: In the direction of monitoring the pandemic in India. In Data Science for COVID-19* (pp. 705-728). Academic Press.

Nguyen-Duc, A., Khalid, K., Shahid Bajwa, S., & Lønnestad, T. (2019). Minimum viable products for internet of things applications: common pitfalls and practices. *Future Internet, 11*(2), 50.

Ometov, A., Shubina, V., Klus, L., Skibińska, J., Saafi, S., Pascacio, P., & Lohan, E. S. (2021). A survey on wearable technology: History, state-of-the-art and current challenges. *Computer Networks, 193*(July), 108074.

Poongodi, T., Krishnamurthi, R., Indrakumari, R., Suresh, P., & Balusamy, B. (2020). *Wearable devices and IoT. In A handbook of Internet of Things in biomedical and cyber-physical system* (pp. 245-273). Springer, Cham.

Quan, X., Liu, J., Roxlo, T., Siddharth, S., Leong, W., Muir, A., ... & Rao, A. (2021). Advances in non-invasive blood pressure monitoring. *Sensors, 21*(13), 4273.

Rajendran, S., Chaudhari, S., & Giridhar, S. (2021). *Advancements in healthcare using wearable technology. In Computational Intelligence in Healthcare* (pp. 83-104). Springer, Cham.

Rath, M., & Pattanayak, B. (2019). Technological improvement in modern health care applications using Internet of Things (IoT) and proposal of novel health care approach. *International Journal of Human Rights in Healthcare, 12*(2), 148-162.

Rudd, N. A., Ghanayem, N. S., Hill, G. D., Lambert, L. M., Mussatto, K. A., Nieves, J. A., & Pike, N. A. (2020). Interstage home monitoring for infants with single ventricle heart disease: education and management: a scientific statement from the American Heart Association. Journal of the American Heart Association, 9(16), e014548.

Shirani, F., Groves, C., Henwood, K., Pidgeon, N., & Roberts, E. (2020). 'I'm the smart meter': Perceptions of smart technology amongst vulnerable consumers. *Energy Policy, 144*(September), 111637.

Signorini, M. G., Lanzola, G., Torti, E., Fanelli, A., & Magenes, G. (2018). Antepartum fetal monitoring through a wearable system and a mobile application. *Technologies, 6*(2), 44.

Smith, B., & Magnani, J. W. (2019). New technologies, new disparities: the intersection of electronic health and digital health literacy. *International journal of cardiology, 292*(October), 280-282.

Stewart, R., Watters, B., Horowitz, V., Larson, R. P., Sargent, B., & Uggen, C. (2022). Native Americans and Monetary Sanctions. RSF: *The Russell Sage Foundation Journal of the Social Sciences, 8*(2), 137-156.

Van Bulck, M., Sierra-Magro, A., Alarcon-Gil, J., Perez-Castillo, A., & Morales-Garcia, J. A. (2019). Novel approaches for the treatment of Alzheimer's and Parkinson's disease. *International journal of molecular sciences, 20*(3), 719.

Vollmer, S., Mateen, B. A., Bohner, G., Király, F. J., Ghani, R., Jonsson, P., & Hemingway, H. (2020). Machine learning and artificial intelligence research for patient benefit: 20 critical questions on transparency, replicability, ethics, and effectiveness. *bmj, 368*, 16927.

Wang, L., Lou, Z., Jiang, K., & Shen, G. (2019). Bio-Multifunctional Smart Wearable Sensors for Medical Devices. *Advanced Intelligent Systems, 1*(5), 1900040.

Weaver, L. J., & Fasel, C. B. (2018). A systematic review of the literature on the relationships between chronic diseases and food insecurity. *Food and Nutrition Sciences, 9*(5), 519-541.

Xue, Y. (2019). A review on intelligent wearables: Uses and risks. *Human Behavior and Emerging Technologies, 1*(4), 287-294.

Yang, H., & Lee, H. (2019). Understanding user behavior of virtual personal assistant devices. *Information Systems and e Business Management, 17*(1), 65-87.

Zhang, W., Li, J., Wen, Y., & Luo, Y. (2021). Toward a wearable crowdsource system to monitor respiratory symptoms for pandemic early warning. *Ieee Network, 35*(3), 56-63.

Zou, J., & Schiebinger, L. (2021). Ensuring that biomedical AI benefits diverse populations. *EBioMedicine, 67*(May), 103358.