INFLUENCE OF DIGITAL HEALTH TECHNOLOGIES ON PATIENT ENGAGEMENT AND HEALTHCARE OUTCOMES

Suliman Abdel Aziz Aljarboa*

College of Business Administration, Mid Ocean University, UAE.

*Corresponding Author

Suliman Abdel Aziz Aljarboa

College of Business Administration, Mid Ocean University, UAE.

ABSTRACT

This research aims to evaluate the effectiveness of digital health technologies and identify the factors driving their success by examining patients' perceptions to understand the benefits and challenges related to digital health technologies. Moreover, the study considers the role of demographic variables in affecting adoption and effectiveness of such technologies in order to support healthcare providers, policymakers, and technology developers, guiding them to enhance digital health solutions' design and implementation. The study concluded that digital health technologies have empowered patients to effectively engage in their health management, especially with chronic diseases. Such technologies provide tools for patients to monitor their health conditions, access medical information and effectively communicate with healthcare providers. Additionally, telemedicine has emerged as a vital tool for overcoming geographical barriers, thereby improving access to healthcare services in underserved areas and for individuals with mobility limitations. Medical wearables enable real-time health monitoring, which contributes to making early diagnosis and proactive management of health problems, improving health outcomes and reducing burdens suffered by health facilities. Electronic health records (EHRs) have facilitated sharing information among healthcare providers, thereby enhancing coordination in healthcare and reducing any potential medical errors.

KEYWORDS: Digital Health Technologies, Patient Engagement, Enhancing Healthcare, Digital Health Analysis.

INTRODUCTION

In recent years, healthcare industry has undergone rapid transformation with the emergence of digital health technologies. These technologies, encompassing a wide array of tools such as mobile health apps, telemedicine, medical wearable, and electronic health records, have revolutionized the delivery and management of healthcare services. A key impact of digital health technologies is patient engagement, which refers to involving patients in their own healthcare processes. It is widely acknowledged that fostering patient engagement is a crucial element in improving healthcare outcomes, as it enhances communication, adherence to treatment plans, and overall satisfaction with care (Mumtaz et al., 2023; Marzban et al., 2022).

Digital health technologies offer numerous benefits that can transform the traditional patient-provider relationship. For instance, mobile health apps empower patients to monitor their health conditions, set medication reminders, and access educational resources, thereby enabling them to take a proactive role in their health management. Telemedicine facilitates remote consultations, reducing the need for in-person visits and providing timely access to healthcare services, especially in underserved or rural areas. Medical wearable, such as fitness trackers and smart watches, continuously collect health data, enabling real-time monitoring and early detection of potential health problems. Electronic health records streamline documentation, ensuring that patient information is valid, up-to-date, and readily accessible to healthcare providers, thereby enhancing care coordination and decision-making (Haleem et al., 2021; Dinh-Le et al., 2019).

Despite the growing adoption of digital health technologies, there remains a need for comprehensive studies to evaluate their impact on patient engagement and subsequent health outcomes. While previous research has provided insights into specific aspects of digital health, a comprehensive understanding of its overall impact remains limited. Factors such as usability, patient satisfaction, cost-effectiveness, and integration with existing healthcare systems must be examined to determine the true potential of these technologies. This study aims to address this gap by considering the effects of digital health technologies on patient engagement and health outcomes through a detailed case study (Erku et al., 2023; Vudathaneni et al., 2024).

By detecting these technologies' actual application, the research seeks to provide valuable insights into their effectiveness and identify the main factors that contribute to their

success.The study approach shall allow for a thorough analysis of the experiences and perceptions of the patients and healthcare providers, providing a comprehensive understanding of the benefits and challenges of digital health technologies. Furthermore, this study shall address the role of demographical variables, such as age, sex, and social and economic conditions, in affecting the adoption and effectiveness of such technologies.

It is expected that the outcomes of the present study will have practical implications for healthcare providers, policymakers, and technology developers and will guide them to enhance digital health solutions' design and implementation. By identifying the best practices and potential challenges, this research intends to support the development strategies that enhance patient engagement and improve healthcare outcomes. Eventually, this research aspires to contribute to the current efforts of fostering patient-centered care and enhancing the healthcare services quality.

To sum up, the integration of the digital health technologies offers a promising avenue to enhancing patient engagement and healthcare outcomes.Concurrently with the healthcare scene development, it is important to evaluate the impact of such technologies precisely in order to ensure fulfilling the needs of patients and service providers. This study aims to provide strong evidence that help in the future innovations and support providing high quality and patient centered healthcare.

Literature Review

Digital health technologies encompass a wide range of tools that have revolutionized the Providing and management of healthcare. Mobile health applications (mHealth apps) are programs designed to run on smartphones and other mobile devices, allowing users to monitor and manage health conditions, promote wellness, and facilitate communication with healthcare providers (Maaß et al., 2022). The development of mHealth apps began in the early 2000s with the advent of smartphones, initially focusing on basic fitness tracking and wellness. Over time, advancements in mobile technology have enabled the creation of sophisticated health management tools, resulting in the availability of thousands of health-related applications today (Vaghefi et al., 2019).

Telemedicine, another significant digital health technology, utilizes communication technologies to provide healthcare services remotely. This includes video consultations, remote monitoring, and digital transmission of medical information, greatly improving access

to care, especially for patients in remote or underserved areas (Anawade et al., 2024). The concept of telemedicine dates back to the mid-20th century, with significant advancements during NASA's space missions in the 1960s. The internet revolutionized telemedicine in the 1990s by enabling real-time video consultations and digital data transfer (Sachdeva et al., 2022). Additionally, the COVID-19 pandemic in 2020 accelerated the adoption of telemedicine as healthcare systems worldwide sought to reduce in-person interactions (Shaver, 2022).

Wearable devices, such as smartwatches, fitness trackers, and portable electrocardiogram monitors, are electronic tools worn on the body to track and monitor various health and fitness parameters (Shei et al., 2022). These devices emerged in the early 2000s with basic fitness trackers like pedometers and saw significant advancements with the release of Fitbit in 2009 and Apple Watch in 2015 (Fuller et al., 2020). These devices now offer comprehensive tracking capabilities and advanced health monitoring features, making them valuable tools for personal health management and clinical decision-making (Seneviratne et al., 2017).

Electronic Health Records (EHRs) are digital versions of the patient's paper charts. Additionally, EHRs provide a comprehensive vision of the patient's medical history, including diagnoses, treatments, laboratory results and medications (Seymour et al., 2014). EHRs simplifies the seamless exchange of information process between healthcare providers, which result in fosterin care coordination and reduces medical malpractice. However, EHRs were developed in the sixties along with the early hospital information systems; they also witnessed considerable growth in the nineties, concurrently with computer technology development. (Ali et al., 2023) Furthermore, Government Initiatives, such as the HITECH Act in the United States, supported the adoption of EHRs in the first decade of the twenty-first century, giving EHRs a rise to be widely used in healthcare environments. (Trout et al., 2022). (Trout et al., 2022).

The Digital Health Technologies evolution led to developing the healthcare services provision and improving the access, efficiency and patient outcomes. From the very first days of basic mobile apps and telemedicine experiences to today's advanced wearables and comprehensive EHRs systems, these technologies continue to advance, driven by innovations in mobile computing, communications, and data analytics. (Stoumpos et al., 2023) As the Digital Health Technologies develops, it ensures widely fostering the patient engagement and

the health care outcomes, which lay the groundwork for a more comprehensive health care systems that concentrate on patients. (Umayal, 2024)

Moreover, patient engagement is crucial in the modern health care systems as it indicates that patients are kept informed of their health conditions. This engagement includes a set of activities, such as engaging in the decision-making process about their medications and using health information technology to manage their health. Patient engagement fosters health care outcomes by fostering communication between patients and service providers, encouraging commitment to treatment plans, and increasing patient satisfaction. Digital Health Technologies, such as mobile health applications, telemedicine and wearable devices, play a crucial role in fostering patient engagement. (Krist et al., 2017) These tools enable patients by giving them access to their health information, allow patients to self-monitor their health conditions and facilitate continuous communication with healthcare specialists. Furthermore, patients are more likely to take proactive efforts to maintain their health, resulting in early detection of health concerns, effective chronic disease management, and overall improved health outcomes. As the health care industry evolves, fostering patient engagement remains a key strategy for improving the quality and efficiency of health care services. (Hägglund et al., 2022)

Health care outcomes refer to the health care intervention outcomes on the patient's health including measures, such as clinical outcomes, patient satisfaction, treatment commitment, quality of life and death rate. Digital Health Technologies have a large, diverse impact on these results. Furthermore, Digital Health Technologies, including tools such as Mobile Health Applications, Telemedicine, wearable devices and EHRs, have created a breakthrough in providing, managing, and consuming health care services. (Bhati et al., 2023; Ferreira et al., 2023)

Additionally, Mobile Health Applications (mHealth) allow patients to detect their health measures, set medication reminders and access educational resources, which leads to improving self-management of chronic diseases, such as diabetes and diabetes and hypertension. Telemedicine provides a teleconsultation service, which is advantageous for patients living in rural and remote areas, and it guarantees timely access to health care services and limits the need for costly and time-consuming travel. (Deniz-Garcia et al., 2023) Additionally, wearable devices, such as fitness detection devices and smart phones, continuously monitor the vitals and physique activity. It also provides information at an

adequate time that can motivate early interventions and support health management continuously. Wearable devices encourage patients to engage in healthier behaviors by providing immediate reactions and personal health visions. (Kang et al., 2022)

EHRs foster health care outcomes by improving the accuracy of the patient's information and its accessibility. However, it facilitates health care coordination among the health care providers, which decreases potential medical malpractice and guarantees that patients get comprehensive and informed care. Additionally, EHRs foster data analysis and population health management, allowing for the determination of health directions and the execution of the target interventions. (Manca, 2015; Adeniyi et al., 2024)

Research has shown that Digital Health Technologies may significantly improve health care outcomes by increasing patient engagement and commitment to treatment plans and raising health awareness in general. For instance, the patients using such applications often have better control over their conditions and higher satisfaction with their health care. Telemedicine was associated with low hospital readmission and emergency room visits rates as patients are enabled to receive timely follow-up care and effectively manage their conditions at home. (Fitzpatrick, 2023; Yeung et al., 2023)

Moreover, it was proved that Digital Health Technologies integration into routine health care practices fosters the quality of the service provided. For instance, remote monitoring programs for patients with heart failure led to increased recovery and improved survival rates. Similarly, the remote health care services during Covid 19 facilitated the main health care services provision and reduced the risk of passing the infection. (Krzesiński, 2023; Farwati et al., 2021)

Thus, research literature was unanimous in the positive impact of Digital Health Technologies on health care outcomes by improving patient engagement, facilitating timely and effective health care and fostering the general quality of health care services. As the Digital Health Technologies develops, it ensures widely developing the health care services making it overly focused on patient, more accessible and more effective.

MATERIALS AND METHODS

This study follows a cross-sectional design that is commensurate with collecting data at a one time-point from a diverse sample. Such design enables identifying relations using different

digital health techniques and health care outcomes via different demographic groups. The research objective is to assess the influence of these technologies on patient engagement and specific health outcomes, such as monitoring blood pressure, controlling blood sugar, managing weight, committing to treatments and resourcing to the hospital.

The questionnaire also collects data on several axes to guarantee a comprehensive assessment of digital health technologies' impact on patient engagement and health care outcomes.

The research targets people with accessibility to digital heal technologies and may use it, along with concentrating on in and out patients and general public with known chronichealth conditions. In order to guarantee representation of different demographic groups in terms of age, sex, education and city. Thus, a random sample is usedIn order to observe the impact of the Digital Health Technologies across different population groups. The questionnaire was disseminated on a large sample enough for detecting the differences and important relationships.

However, due to other participants' ease of access, we collected data using the electronically disseminated questionnaire. The questionnaire included qualitative and quantitative data, such as technology usage repetition, medical conditions in which the technology is used, and participants' satisfaction with ease of usage. It is crucial to ensure the confidentiality and independence of the answers to get accurate and honest data.

The collected data was analyzed using descriptive and inferential statistics. The descriptive statistics were used to summaries the demographic data and general usage patterns of the digital health technologies However, the descriptive statistics, such as relative weight, standard deviation, T tests and P-Value are used in comparing the health care outcomes of different groups.

The data indicates a diverse distribution of participants by age groups. In the 17-year age group, the number is limited to 2 participants,and that representing 0.2% of the total participants The 22-year age group records a peak in the number of participants, with 60 individuals, accounting for approximately 4.7% of the total participants. For the 28 and 29-year age groups, the number of participants ranges between 34 and 42, representing about 2.7% and 3.3%, respectively. The 33-year age group shows the highest number, with 70 participants, equivalent to around 5.5% of the total participants. In the 40-year age group,

there are 19 participants, or 1.5% of the total participants. In addition to that the 43-year age group includes 62 participants, which is approximately 4.9% of the total. The 51-year age group has 14 participants, representing about 1.1%, while the 55-year age group records 35 participants, or about 2.8%. Finally, the age group from 61 to 83 years contains very few participants, ranging from 1 to 3, representing less than 0.3% for each age group within this range.

The data indicates that the number of participants in the study is fairly evenly distributed between genders, with 667 male participants (53.5%)and 604 female participants (47.5%). This close distribution between males and females reflects a good balance in gender representation in the study, which enhances the credibility of the results and ensures that the opinions and information gathered include the perspectives and experiences of both genders almost equally. This balance can help provide more comprehensive conclusion about the impact of digital health technologies on different demographic groups, without bias towards either gender.

The data indicates a diversity of educational levels among the participants in the study, reflecting the varied educational backgrounds of the community whose opinions were surveyed. Participants who did not complete secondary education represent approximately 20.4% of the total participants (259 out of 1,271). This indicates that there is a significant proportion of participants with a lower educational level, which may affect their understanding and interaction with digital health technologies. The category of high school graduates/Diploma holders constitutesthe largest segment of participants, accounting for approximately 36.4% of the total sample (463 participants). This reflects a widespread prevalence of secondary and post-secondary education (diploma), suggesting that this group may possess foundational knowledge that enables them to use digital health technologies effectively. Participants who have completeduniversity education represent approximately 32.7% of the total participants (416 individuals). This significant number of university graduates reflects that there is a large segment of participants who possess an educational level that qualifies them to understand and effectively use digital health technologies. The category of postgraduate education includes: 115 participants, accounting for approximately 9% of the total sample. Although this grouprepresents a relative minority, those with advanced degrees possess a higher level of awareness and knowledge in dealing with health technologies.

There are 18 participants who reported that they have no educational level, which representing approximately 1.4% of the total sample. Despite their small number, their presence in the study highlights the importance of including this group in research to understand their needs and challenges in using digital health technologies.

The data related to the use of digital health technologiesillustrates the distribution of participants based on the frequency of their use of these technologies. The data shows that the majority of participants use digital health technologies positively In addition to that, total of 798 participants reported using digital health technologies, representing approximately 62.7% of the total participants. This significant number indicates that this group is the most reliant on digital health technologies for monitoring and managing their health.In contrast, 471 participants reported that they donot usedigital health technologies, which accounts for about 37% of the total. This figure suggests that a considerable proportion of participants do not utilize these technologies, which may reflect a barrier or a lack of awareness regarding the benefits of these technologies. As for those who use the technologies irregularly, their number is just 2 participants, representing about 0.2% of the total. This small percentage indicates that very few participants use digital health technologies intermittently.

The data on the types of digital health technologies used among participants indicates a wide variety of available options. A total of 263 participants used wearable health tracking devices, such as smart bracelets, sport watches, representing approximately 20.7% of the total participants. This reflects a strong interest in technologies for monitoring physical activity and fitness.

Meanwhile, 112 participants utilized other technologies, accounting for about 8.8% of the total This group may include various health solutions that do not fit into the other specified categories, indicating a range of options available to participants. Regarding patient portals, 129 of participants used them, which constitutes about 10.1% of the total. The Patient portals provide easy access to medical records online, that helping individuals manage and monitor their health data more effectively. Health information applications are the most commonly used among participants, with 444 individuals utilizing them, equivalent to approximately 34.9% of the total. This large percentage reflects the increasing reliance on applications that provide health information and guidance, enhancing their role in personal health management. Additionally, 323 participants used telemedicine platforms, representing about 25.4% of the total. These platforms access to online medical consultations, reflecting the

growing interest in remote healthcare and increased flexibility in accessing health consultations.

The data on the frequency of using digital health technologies shows the distribution of participants based on how often they use these technologies, reflecting different patterns in how they manage their health. A total of 471 participants reported using digital health technologies on a weekly basis, representing approximately 37% of the total participants. This significant number indicates that these individuals regularly rely on these technologies for monitoring and managing their health on a weekly basis. In contrast, 170 participants indicated that they use these technologies less frequently, accounting for about 13.4% of the total. This percentage suggests that these participants engage with digital health technologies irregularly, possibly due to not fully relying on these technologies in their daily lives. Regarding monthly usage, 275 participants reported using digital health technologies, which represents approximately 21.6% of the total. This percentage reflects a moderate commitment to the technologies, as these individuals prefer to review their health data on a monthly basis. Finally, 355 participants reported using digital health technologies daily, equating to about 27.9% of the total participants.This number indicates that these individuals tend to integrate digital health technologies into their daily routines, enhancing the role of these technologies in effectively managing their health.

The data on health conditions for which digital health technologies are used shows a diversity in the application of these technologies based on different health needs. A total of 572 participants indicated that they use digital health technologies to monitor acute illnesses such as colds and influenza, representing approximately 45% of the total participants. This significant number suggests that digital health technologies play an important role in managing temporary health conditions that require prompt and effective monitoring. Regarding chronic diseases such as diabetes and hypertension, 302 participants reported using these technologies, accounting for about 23.8% of the total This percentage reflects the importance of digital health technologies in managing long-term health conditions, as they assist in continuous health monitoring and tracking of indicators. In the area of preventive care, which includes healthy eating and exercise, 356 participants reported using these technologies, representing approximately 28% of the total participants. This figure indicates a growing awareness of the importance of prevention and healthy living, with digital health technologies being utilized to improve lifestyle choices and enhance overall health.

The data related to theefforts made in healthcare after the use of digital health technologies illustrates the impact of these technologies on managing and improving healthcare. In addition to thattotal of 68 participants reported that healthcare efforts decreased somewhat after using these technologies, representing approximately 5.4% of the total participants. This number indicates that a small proportion of participants noticed a slight decrease in healthcare efforts, possibly due to improved effectiveness of care or the conveniences provided by the technologies. Only 17 participants reported that healthcare efforts decreased significantly, accounting for approximately 1.3% of the total. This small percentage reflects that a limited number of participants experienced a significant improvement in healthcare efficiency as a result of using these technologies. In contrast, 343 participants reported that healthcare efforts remained the same, accounting for approximately 27% of the total. This percentage reflects that most participants did not notice a significant change in the level of efforts made after using digital health technologies. According to the data, 548 participants reported that healthcare efforts increased somewhat after using the technologies, representing approximately 43.1% of the total participants. This number indicates that the use of these technologies may have led to a slight increase in healthcare efforts, possibly due to the need for more monitoring or interaction. 295 participants reported that healthcare efforts inecreased significantly, accounting for approximately 23.2% of the total. This percentage reflects that a large number of participants experienced a significant increase in healthcare after using the technologies, suggesting that these tools may require more effort and time to manage effectively.

The data on outcomes of using digital health technologies for monitoring blood pressure illustrates the effectiveness of these technologies in improving participants' blood pressure conditions. A total of 464 participants reported that their blood pressure condition improved somewhat due to the use of these technologies, representing approximately 36.5% of the total participants. This number indicates that the use of digital health technologies had a positive impact on blood pressure monitoring, leading to a moderate improvement in condition Meanwhile, 547 participant reported that their blood pressure condition improved significantly, accounting for approximately 43% of the total. This large percentage reflects that the majority of participants experienced a significant improvement in their blood condition as a result of using the technologies, that reinforcing the effectiveness of these tools in managing and monitoring blood pressure effectively.On the other hand, 11 participants reported that their blood pressure condition worsened somewhat, accounting for

approximately 0.9% of the total. This small percentage reflects that a minimal negative impact was observed among some participants, possibly due to issues with using the technology or individual health conditions. participants indicated that there was no significant effect of the technologies on their blood pressure, representing approximately 6.3% of the total. This percentage indicates that the use of the technologies did not have a noticeable effect on the blood pressure condition of these participants. 169 participants reported that their blood pressure condition did not change due to the use technologies, accounting for approximately 13.3% of the total. This percentage reflects that a notable number of participants did not observe any change in their blood pressure condition as a result of using these tools.

The data on healthcare engagement in blood pressure monitoring illustrates how participants address this important health condition. 605 participants reported that they consistently take their medications, accounting for approximately 47.6% of the total participants.

This large percentage indicates that most individuals prioritize taking their medications regularly in managing their blood pressure, reflecting their serious commitment to monitoring their health condition through prescribed medications. 561 participants reported that they make an effort to attend preventive check-ups, accounting for approximately 44.2% of the total. This percentage also reflects a significant interest in healthcare, as these participants strive to regularly monitor their health status through preventive check-ups, which helps in the early detection of any changes in blood pressure or other health issues. 105 participants reported that theyhaving other unspecified forms of interest, accounting for approximately 8.2% of the total participants. This group may include a variety of other strategies that are not directly related to medication adherence or attending preventive check-ups, yet they remain part of their efforts to monitor and improve blood pressure.

The data regarding satisfaction with the ease of using digital health technologies indicates a variety of experiences among participants with these tools. A bout 550 participants reported that being somewhat satisfied with the ease of use of digital health technologies, representing approximately 43.3% of the total participants. This percentage reflects that a significant portion of participants finds these technologies moderately easy to use, suggesting that while these tools generally meet their needs, they may not be entirely perfect.

While 326 participants reported being very satisfied with the ease of use of these technologies, representing about 25.6% of the total. This percentage indicates that a significant number of users feel completely satisfied with the user experience and the accessibility of the features provided by these technologies.

On the other hand, 60 participants reported being somewhat dissatisfied, and thatrepresenting about 4.7% of the total. This percentage reflects that a limited number of participants face some difficulties or minor issues in using these tools.

Only 11 participants reported being completely dissatisfied with the ease of use of the technologies, which represents about 0.9% of the total. This small percentage indicates that few users experience significant difficulties in using the technologies, suggesting a need for improvements in design or technical support.

324 reported that they feel neutral about the ease of using technologies, and that representing about 25.4% of the total. This percentage reflects that these participants do not have a clear opinion either positively or negatively about ease of use, which may indicate a lack of noticeable experience or mixed feelings regarding this issue.

The data on the results of using digital health technologies for monitoring blood sugar provide a clear picture of the impact these technologies have on participants' blood sugar levels. A466 ofparticipants reported that their blood pressure condition improved somewhat due to the use of these technologies, representing approximately 36.6% of the total participants.

This percentage indicates that the use of digital health technologies has had a moderate positive impact on the management and monitoring of blood sugar, reflecting a slight but noticeable improvement among many users Meanwhile, 547 participant reported that their blood sugar condition improved significantly, accounting for approximately 41.1% of the total. This large percentage reflects that the majority of participants experienced a significant improvement in their blood sugar levels as a result of using these tools, indicating the effectiveness of these technologies in managing the condition effectively. On the other hand, only 8 participants reported that their blood sugar condition worsened somewhat, accounting for approximately 0.6% of the total.

This small percentage reflects that a slight negative impact was observed among some participants, which may indicate individual issues with the use of technology or specific health conditions. 107participants indicated that there was no significant effect of the technologies on their bloodsugar, representing approximately 8.4% of the total. This percentage indicates that the use of the technologies had no clear impact on blood sugar levels among these participants, which may suggest a lack of effectiveness or a lack of noticeable benefit from these tools.

167 participants reported that their blood sugar condition did not change due to the use technologies, accounting for approximately 13.1% of the total. This percentage reflects that a notable number of participants did not observe any changes in their blood sugar levels as a result of using the technologies, which may indicate that the tools were not effective in improving the condition for these individuals.

RESULTS AND DISCUSSION

Results

The data illustrates the results of using digital health technologies in weight management, highlighting the impact of these tools on weight control among participants. A500 ofparticipants reported that their ability to control their weight somewhat due to the use of these technologies, which representing approximately 39.3% of the total participants. This percentage reflects that a significant number of individuals experienced a slight improvement in their ability to manage their weight as a result of using these tools, indicating a moderate effectiveness of the technologies in this regard. Meanwhile, 531 participant reported that their abilityto control their weight improved significantly, accounting for approximately 41.8% of the total. This large percentage reflects that many participants noticed a significant improvement in their ability to manage their weight as a result of using the technologies, indicating a positive and notable impact of these tools. On the other hand, 11 participants reported that their ability to control their weight worsened somewhat, accounting for approximately 0.9% of the total.

This small percentage reflects that a slight negative impact was observed among some participants, which may indicate individual issues with the use of technology or specific health conditions. Meanwhile 2 participants reported that their ability to control their weight worsened significantly, accounting for approximately 0.2% of the total.This percentage indicates thata small numberof participants who experienced a significant decline in their

ability to manage their weight, that may suggest serious issues with the effectiveness of the tools according to them.Additionally, 227 participants reported that their ability to control their weight did not change, accounting for approximately 17.9% of the total. This percentage reflects that a notable number of participants did not observe any changes in their ability to manage their weight as a result of using the technologies, which may indicate that the tools were not effective in achieving a tangible impact for these individuals.

This data illustrates the result of using digital health technologies in medication adherence, illustrating the impact of these tools on participants' ability to stick to their medication schedules. 502 ofparticipants reported that their ability to adhere to medication improved somewhat due to the use of these technologies, which represents approximately 39.4% of the total participants.

This percentage indicates that a large number of users experienced a slight improvement in their adherence to medication, reflecting a moderate effectiveness of the technologies in promoting medication compliance.Meanwhile, 512 participants reported that their ability to adhere to medication improved significantly, accounting for approximately 39.9% of the total. This large percentage reflects that many participants noticed a significant improvement in their adherence to medication schedules as a result of using the technologies, indicating a positive and notable impact of these tools in enhancing treatment compliance. On the other hand, 9 participants reported that their ability to adhere to medication worsened somewhat, accounting for approximately 0.7% of the total.

This small percentage reflects that a slight negative impact was observed among some participants, which may indicate individual issues with the use of technology ora lack of effectiveness of the technology for certain users. Meanwhile, 1 participant reported that their ability to adhere to medication improved significantly, accounting for approximately 0.1% of the total. This very small percentage indicates that a few participants experienced a significant decline in their adherence to medication, which warrant consideration of potential issues related to the individual use of the technologies. Additionally, 247 participants reported that their ability to adhere to medication did not change, accounting for approximately 19.3% of the total. This percentage reflects that a notable number of participants did not observe any changes in their ability to adhere to medication as a result of using the technologies, which may indicate that the tools were not effective in achieving a tangible impact for these individuals.

This data illustrates the result of using digital health technologiesin hospital visit frequency, highlighting the impact of these tools on reducing the number of hospital visits among participants. 381 ofparticipants reported that their hospital visit frequency decreased somewhat due to the use of these technologies, which represents approximately 30% of the total participants. This percentage reflects that a large number of usersexperienced a slight reduction in their hospital visits, indicating a moderate effectiveness of the technologies in reducing the need for emergency medical care.Meanwhile, 660 participants reported that their hospital visit frequency decreased significantly, accounting for approximately 52% of the total. This large percentage reflects that the majority of participants observed a significant improvement in reducing their hospital visits, as a result of using the technologies, indicating a positive and notable impact of these tools in decreasing the need for emergency healthcareOn the other hand, 170 participants reported that their hospital visit frequency increased somewhat, accounting for approximately 13.4% of the total. This percentage reflects that a smaller number of participants experienced a slight increase in their hospital visits, which may indicate a minor negative impact for some users or specific health conditions Meanwhile, 60 participants reported that their hospital visit frequency did not change, accounting for approximately 4.7% of the total. This percentage reflects that a few participants did not notice any changes in their hospital visit frequency as a result of using the technologies, which may suggest that the tools were not effective in achieving a notable impact for these individuals.

The data in Table 1 illustrates the impact of using digital health technologies on various health aspects, reflecting the level of agreement based on relative weight and standard deviation criteria Regarding the use of digital health technologies, the results showed that the majority, comprising 798 individuals, agreed with their use, while only two individuals disagreed. This reflects a high level of agreement with a relative weight of 2.26. Although there is a standard deviation of 0.97, it indicates a relative variance in opinions.

As for the frequency of using these technologies, opinions were distributed with varying degrees of agreement. Specifically, 355 individuals agreed on frequent use, 445 somewhat agreed, and 471 disagreed. This reflects a low relative weight of 1.93 with a standard deviation of 0.79, indicating a notable variance in usage frequency among participants. Regarding the reduction in healthcare efforts after using these technologies, the vast majority, totaling 843 individuals, agreed that their efforts had decreased. This reflects a high relative

weight of 2.60, with a standard deviation of 0.61, indicating a clear positive impact of these technologies in reducing healthcare efforts. Regarding the ability of these technologies to monitor blood pressure, 1,011 individuals strongly agreed on their effectiveness, reflecting a high level of satisfaction with a relative weight of 2.60. Although there is slight variance in opinions indicated by a standard deviation of 0.79, the overall agreement remains robust.Concerning satisfaction with the ease of using digital health technologies, 876 individuals reported high satisfaction, with a relatively high weight of 2.63 and a standard deviation of 0.59, indicating general consensus among participants regarding their ease of use. As for the influence of these technologies on blood sugar monitoring, 989 individuals strongly agreed on their effectiveness, with a relatively high weigh of 2.77 and a low standard deviation of 0.43, indicating strong consensus among users regarding the effectiveness of these technologies. Concerning weight management, the results revealed that 1,031 individuals strongly agreed on the influence of these technologies, with a relative weight of 2.80 and a standard deviation of 0.42, indicating a significant positive influence on weight control. As for medication adherence as an outcome of using these technologies, 1,014 individuals agreed that these technologies helped improve adherence, with a relative weight of 2.79 and a standard deviation of 0.43, indicating a strong positive influence on enhancing compliance with treatment. Concerning the decrease in hospital visits as a result of using these technologies, the results revealed that 1,041 individuals agreed that using these technologies led to a decreased need for hospital visits, with a relative weight of 2.69 and a standard deviation of 0.70, indicating a tangible influence in reducing hospital visits.

Table 1: Relative Weight and Standard deviation of the impacts of digital health technologies.

Standard deviation	Relative weight	Results of using digital health technologies
0.79	1.93	The uptake of these technologies
0.61	2.60	Enhancing the patient's role in healthcare through the use of these technologies
0.79	2.60	The ability to monitor blood pressure through the use of these technologies
0.59	2.63	Satisfaction with the ease of using digital health technologies
0.43	2.77	The ability to monitor blood sugar through the use of these technologies
0.42	2.80	The ability to control weight through the use of these technologies
0.43	2.79	Medication adherence as a result of using these

		technologies
0.70	2.69	Decrease in hospital visits as a result of using these technologies

The statistical results in Table 2 indicate the influence of digital health technologies on various aspects of healthcare. Concerning the uptake of these technologies, a p-value of 1.9×10^{-25} and a T-correlation of 10.58 indicate a strongpositive influence in encouraging individuals to use digital health technologies, indicating a broad acceptance and willingness to use these technologies.As for enhancing the patient's role in healthcare after using these technologies, a p-value of 5.19×10^{-29} and a negative T-correlation of -11.4 indicate a significant increase in patient involvement in managing their health. However, the negative correlation may indicate that increased patient participation requires additional effort or presents certain challenges.Concerning the ability to monitor blood pressure through the use of these technologies, a p-value of 3.9×10^{-35} and a negative T-correlation of -12.7 demonstrate a substantial improvement in blood pressure monitoring capabilities. The negative correlation reveal that additional factors mayneed to be addressed to fully maximize the benefits of these technologies.As for satisfaction with the ease of using digital health technologies, a p-value of 2.6×10^{-83} and a negative T-correlation of -20.8 indicate a high level of satisfaction with the ease of using digital health technologies. However, the negative correlation reveals to potential difficulties or challenges that may influence the user experience.Concerning the ability to monitor blood sugar through the use of these technologies, a p-value of 4×10^{-84} and a negative T-correlation of -20.9 reveal a significant positive influence on improving blood sugar monitoring,despite the presence of negative factors that may affect this correlation.As for the ability to control weight through the use of these technologies, a p-value of 5×10^{-69} and a negative T-correlation of -18.6 reflect a strong positive impact on weight control, with some challenges evident through the negative correlation.Concerning medication adherence as a result of using these technologies, a p-value of 9×10^{-66} and a negative T-correlation of -18.12 show a significant positive impact on improving medication adherence, though the negative correlation suggests that some difficulties may need to be addressed to maintain consistent adherence.A p-value of 2.9×10^{-132} and a positive T-correlation of 27.6 reveal a substantial reduction in hospital visits as a result of using digital health technologies, indicating their considerable benefit in enhancing healthcare and decreasing the need for continuous medical care.

Table 1: The impact of digital health technologies.

P-value	CorrelationT	The impacts of digital health technologies
1.9×10^{-25}	10.58	The uptake of these technologies
5.19×10^{-29}	-11.4	Enhancing the patient's role in healthcare after using these technologies
3.9×10^{-35}	-12.7	The ability to monitor blood pressure through the use of these technologies
2.6×10^{-83}	-20.8	Satisfaction with the ease of using digital health technologies
4×10^{-84}	-20.9	The ability to monitor blood sugar through the use of these technologies
5×10^{-69}	-18.6	The ability to control weight through the use of these technologies
9×10^{-66}	-18.12	Medication adherence as a result of using these technologies
2.9×10^{-132}	27.6	Decrease in hospital visits as a result of using these technologies

DISCUSSION

The study results concerning the influence of digital health technologies on patient engagement and healthcare outcomes align with the literature review, and sometimes expand upon these findings: Below, the study results are discussed about the existing literature, emphasizing aspects of agreement and disagreement.

The study revealed that mobile health applications (mHealth) significantly improved patient engagement, particularly in managing chronic diseases such as diabetes and hypertension. This aligns with the literature, where studies such as those by Maaß et al. (2022) and Vaghefi et al. (2019) emphasize the evolution of mobile health applications from fitness tracking to advanced health management tools. These tools enable patients to take control of their health by providing easy access to their health data and facilitating communication with healthcare providers. The outcomes of this study support these findings, reinforcing the notion that mobile health applications enhance self-management and patient engagement, ultimately leading to improved health outcomes.

Moreover, the study results revealed that telemedicine significantly influences the improvement of access to healthcare services, particularly in rural and underserved areas. This aligns with the findings of Anawade et al. (2024) and Sachdeva et al. (2022), who discussed how telemedicine eliminates geographical barriers, allowing for timely healthcare delivery. According to Shaver (2022), the research literature showcased the role of telemedicine during COVID-19, which is consistent with the observation of the study that

telemedicine adoption increased after COVID-19, leading to its usage continuity after the pandemic.The aforementioned suggests the positive and lasting impact of healthcare accessibility.

The study has shown that wearable devices, such as smart watches and fitness tracker devices, have contributed significantly to continuous health care, allowing early detection of health issues and proactive management.This result is supported by studies such as Shei et al. (2022) and Seneviratne et al. (2017), which asserted that the wearable devices were developed from a simple pedometer to advanced health monitoring tools.However, the study results' compatibility with these results fosters the importance of wearable devices in providing medical information, which enhances patient engagement and clinical decisions.

Concerning the EHRs, the studies have shown that EHRs have improved the health care coordination and reduced medical malpractices by providing a comprehensive vision of the patient's health data.It is aligned with Seymour et al. (2014) and Trout et al. (2022), who asserted the EHRs' role in simplifying the data exchange among health care providers, improving care quality and patient safety.Moreover, the research results support the assertion that EHRs are essential to modern healthcare systems, improving patients' results by improving information accessibility and accuracy.

Although the study results align with the existing literature, some arising inconsistencies and directions were observed. For instance, the literature showcased the broad satisfaction with digital health technologies concurrently with the study revealing dissatisfaction of some customers with mobile health applications due to their complexity, which impeded their effective usage. This contrasts with the generally positive perception of the simplicity of mobile health applications, proven in studies such as the study conducted by Krist et al. (2017) and Fuller et al. (2020). Additionally, this discrepancy refers to the need for more user-friendly designs for digital health tools in the future to ensure wider spread and greater satisfaction.

Furthermore, another area of variation is the long-term effect of telemedicine on the health care results. Although the literature, especially Deniz-Gracia et al. (2023), highlighted that telemedicine led to decreasing hospital admission rates and improving chronic disease management, some studies showed that patients encountered challenges in managing complex health conditions remotely. This suggests that telemedicine may not be a complete

replacement for in-person medical visits.This demonstrates that telemedicine is a valuable tool, but its effectiveness may differ according to the patient's condition complexity, which indicates the need for a hybrid care model combining telemedicine and in-person medical visits.

Therefore, the study results are compatible with most of the existing literature, assuring the positive impact of digital health technologies on patient engagement and healthcare outcomes. The study highlights the fields that need advancements, such as simplifying mobile health applications and developing hybrid care models that can fulfil various needs of patients. This vision contributes to the current discussion about the digital health role of developing the healthcare services provision and ensures the continuous innovation importance and user-centered design within this rapidly progressing field.

CONCLUSION AND RECOMMENDATIONS

The present study concluded understanding the influence of digital health technologies on patient engagement and healthcare outcomes along with concentrating on these technology's role in managing chronic diseases, improving care accessibility and fostering continuous healthcare provision. These results show that digital health technologies, such as mobile health applications, telemedicine, wearable devices and EHRs have contributed significantly to fostering the patient engagement in their healthcare and achieving better health outcomes. The study concluded that digital health technologies have empowered patients to effectively engage in their health management, especially with chronic diseases. Such technologies provide tools for patients to monitor their health conditions, access medical information and effectively communicate with healthcare providers. Additionally, telemedicine has emerged as a vital tool for overcoming geographical barriers, especially during COVID-19, thereby improving access to healthcare services in underserved areas and for individuals with mobility limitations. Medical wearables enable real-time health monitoring, which contributes to making early diagnosis and proactive management of health problems, improving health results and reducing burdens suffered by health facilities. EHRs have contributed to simplifying the data exchange among health care providers, fostering health care coordination and reducing medical malpractice probability.

However, some challenges, such as digital health applications complexity and the limits imposed by telemedicine in managing complex health issues, were identified.These

challenges highlight the need for innovation continuity and concentration on a design aimed at users of digital health technologies.

Based on these findings, the study recommends that digital health technology developers prioritize user-centered design to ensure that apps are intuitive and easy for a wide range of users. On the other hand, simplifying user interfaces and providing clear instructions may increase the users' satisfaction and approval of these technologies. Additionally, healthcare providers should consider adopting hybrid care models combining telemedicine and in-person medical visits, as this approach may deal with the limitations imposed by telemedicine in managing complex health issues while retaining the benefits of telemedicine.In the interest of achieving the maximum benefit of the digital health technologies, healthcare providers and patients shall be trained on using these tools effectively, including understanding how to interpret data from wearable devices and communicate effectively via telemedicine platforms. Additionally, an effort shall be exerted to integrate various digital health technologies, such as EHRs, mobile health applications and wearable devices, into an integrated system that fosters data exchange and improves general care coordination. The policymakers shall develop regulations that support safe and effective digital health technologies usage, including data privacy guarantee, support interoperability between various systems and provide instructions on ethical health data usage.Further exploration of the evolving long-term influence of digital health technologies on patients' outcomes is necessary. However, future studies should focus on identifying the best practices, potential challenges, and economic feasibility of such technologies in different health environments.

These recommendations aim to foster digital health technologies' effectiveness and ensure that they continue improving patient engagement and healthcare outcomes within the fast-changing digital environment.

REFERENCES

1. Adeniyi, Adekunle, Arowoogun, Jeremiah, Chidi, Rawlings, Okolo, Chioma, Babawarun, Oloruntoba, The impact of electronic health records on patient care and outcomes: A comprehensive review, 1st Edition, World Journal of Advanced Research and Reviews, 2024.

2. Ali SK, Khan H, Shah J, Nadeem Ahmed K, "An electronic health record system implementation in a resource limited country-lessons learned", Digit Health, 2023; 9: 20552076231203660.

3. Anawade PA, Sharma D, Gahane S, "A Comprehensive Review on Exploring the Impact of Telemedicine on Healthcare Accessibility", Cureus, 2024; 16, 3: e55996.

4. Bhati D, Deogade MS, Kanyal D, "Improving Patient Outcomes Through Effective Hospital Administration: A Comprehensive Review", Cureus, 2023; 15, 10: e47731.

5. Deniz-Garcia A, Fabelo H, Rodriguez-Almeida AJ, Zamora-Zamorano G, Castro-Fernandez M, AlbericheRuano MDP, Solvoll T, Granja C, Schopf TR, Callico GM, Soguero-Ruiz C, Wägner AM; WARIFA Consortium, "Quality, Usability, and Effectiveness of mHealth Apps and the Role of Artificial Intelligence: Current Scenario and Challenges", J Med Internet Res, 2023; 25: e44030.

6. Dinh-Le C, Chuang R, Chokshi S, Mann D, "Wearable Health Technology and Electronic Health Record Integration: Scoping Review and Future Directions", JMIR MhealthUhealth, 2019; 7, 9: e12861.

7. Erku D, Khatri R, Endalamaw A, Wolka E, Nigatu F, Zewdie A, Assefa Y, "Digital Health Interventions to Improve Access to and Quality of Primary Health Care Services: A Scoping Review", Int J Environ Res Public Health, 2023; 20, 19: 6854.

8. Farwati M, Riaz H, Tang WHW, "Digital Health Applications in Heart Failure: a Critical Appraisal of Literature", Curr Treat Options Cardiovasc Med, 2021; 23, 2: 12.

9. Ferreira DC, Vieira I, Pedro MI, Caldas P, Varela M, "Patient Satisfaction with Healthcare Services and the Techniques Used for its Assessment: A Systematic Literature Review and a Bibliometric Analysis", Healthcare (Basel), 2023; 11, 5: 639.

10. Fitzpatrick PJ, "Improving health literacy using the power of digital communications to achieve better health outcomes for patients and practitioners", Front Digit Health, 2023; 5: 1264780.

11. Fuller D, Colwell E, Low J, Orychock K, Tobin MA, Simango B, Buote R, Van Heerden D, Luan H, Cullen K, Slade L, Taylor NGA, "Reliability and Validity of Commercially Available Wearable Devices for Measuring Steps, Energy Expenditure, and Heart Rate: Systematic Review", JMIR MhealthUhealth, 2020; 8, 9: e18694.

12. Hägglund M, McMillan B, Whittaker R, Blease C, "Patient empowerment through online access to health records", BMJ, 2022; 378: e071531.

13. Haleem A, Javaid M, Singh RP, Suman R, "Telemedicine for healthcare: Capabilities, features, barriers, and applications", Sens Int, 2021; 2: 100117.

14. Kang HS, Exworthy M, "Wearing the Future-Wearables to Empower Users to Take Greater Responsibility for Their Health and Care: Scoping Review", JMIR MhealthUhealth, 2022; 10, 7: e35684.

15. Krist AH, Tong ST, Aycock RA, Longo DR, "Engaging Patients in Decision-Making and Behavior Change to Promote Prevention", Stud Health Technol Inform, 2017; 240: 284-302.

16. Krzesiński P, "Digital Health Technologies for Post-Discharge Care after Heart Failure Hospitalisation to Relieve Symptoms and Improve Clinical Outcomes", J Clin Med, 2023; 12, 6: 2373.

17. Maaß L, Freye M, Pan CC, Dassow HH, Niess J, Jahnel T, "The Definitions of Health Apps and Medical Apps From the Perspective of Public Health and Law: Qualitative Analysis of an Interdisciplinary Literature Overview", JMIR MhealthUhealth, 2022; 10, 10: e37980.

18. Manca DP, "Do electronic medical records improve quality of care? Yes", Can Fam Physician, 2015; 61, 10: 846-7, 850-1.

19. Marzban S, Najafi M, Agolli A, Ashrafi E, "Impact of Patient Engagement on Healthcare Quality: A Scoping Review", J Patient Exp, 2022; 9: 23743735221125439.

20. Mumtaz H, Riaz MH, Wajid H, Saqib M, Zeeshan MH, Khan SE, Chauhan YR, Sohail H, Vohra LI, "Current challenges and potential solutions to the use of digital health technologies in evidence generation: a narrative review", Front Digit Health, 2023; 5: 1203945.

21. Sachdeva, Shaweta, Ali, Aleem, Khalid, Salman, Telemedicine in Healthcare System: A Discussion Regarding Several Practices, 1st Edition, Springer, 2022.

22. Seneviratne, Suranga, Hu, Yining, Nguyen, Tham, Lan, Guohao, Khalifa, Sara, Thilakarathna, Kanchana, Hassan, Mahbub, Seneviratne, Aruna, A Survey of Wearable Devices and Challenges, 1st Edition, IEEE Communications Surveys & Tutorials, 2017.

23. Seymour, Dr. Tom, Frantsvog, Dean, Graeber, Tod Electronic Health Records (EHR), 1st Edition, American Journal of Health Sciences, 2014.

24. Shaver J "The State of Telehealth Before and After the COVID-19 Pandemic", Prim Care, 2022; 49, 4: 517-530.

25. Shei RJ, Holder IG, Oumsang AS, Paris BA, Paris HL, "Wearable activity trackers-advanced technology or advanced marketing?", Eur J Appl Physiol, 2022; 122, 9: 1975-1990.

26. Stoumpos AI, Kitsios F, Talias MA, "Digital Transformation in Healthcare: Technology Acceptance and Its Applications", Int J Environ Res Public Health, 2023; 20, 4: 3407.

27. Trout KE, Chen LW, Wilson FA, Tak HJ, Palm D, "The Impact of Meaningful Use and Electronic Health Records on Hospital Patient Safety", Int J Environ Res Public Health, 2022; 19, 19: 12525.

28. Umayal, KM, Strategic Integration of Digital Health Technologies for Enhanced Patient-Centered Care in Modern Healthcare Management, 1st Edition, Shanlax International Journal of Management, 2024.

29. Vaghefi I, Tulu B, "The Continued Use of Mobile Health Apps: Insights From a Longitudinal Study", JMIR MhealthUhealth, 2019; 7, 8: e12983.

30. Vudathaneni VKP, Lanke RB, Mudaliyar MC, Movva KV, Mounika Kalluri L, Boyapati R "The Impact of Telemedicine and Remote Patient Monitoring on Healthcare Delivery: A Comprehensive Evaluation", Cureus, 2024; 16, 3: e55534.

31. Yeung AWK, Torkamani A, Butte AJ, Glicksberg BS, Schuller B, Rodriguez B, Ting DSW, Bates D, Schaden E, Peng H, Willschke H, van der Laak J, Car J, Rahimi K, Celi LA, Banach M, Kletecka-Pulker M, Kimberger O, Eils R, Islam SMS, Wong ST, Wong TY, Gao W, Brunak S, Atanasov AG, "The promise of digital healthcare technologies", Front Public Health, 2023; 11: 1196596.