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PAPER

Patient Monitoring for Personalized Mobile Health (PMH) Based on Medical Virtual Instruments

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ABSTRACT

One of the newest technologies, mobile health, has the potential to support the provision of care for older adults and offer them individualised treatment. This study's goal is to evaluate the benefits and challenges of personalised mobile health (PMH) for elderly residential care. Virtual worlds are quickly integrating into the landscape of instructional technologies. One of the most well-known of these settings is Second Life (SL). Despite the potential of SL for health professions education, there aren't many official SL applications for this purpose, and the effectiveness of these applications hasn't been evaluated to the fullest extent possible. Similarly, it appears that nothing is known about the use of virtual worlds for continuing medical education. In order to better grasp the fundamentals of the aid of MVIs for personal health monitoring (PHM), we were able to pinpoint the key disease regions, sensors, channels, calculations and communication protocols. The main obstacles limiting MVIs' degree of integration into the international health care system were also identified. The analysis demonstrates that MVIs offer an excellent possibility for the creation of affordable, personalised health systems that meet the unique equipment requirements of a certain field of medicine.

KEYWORDS

personalised mobile health (PMH), medical composition, mobile health, patient monitoring

1 INTRODUCTION

Population ageing is a worldwide issue that has an impact on everyone. The United Nations' demographic reports show that the global median age is currently 28 years old. It is expected to rise by 10 years by 2050, reaching 38 years. The percentage of individuals over 65 in the world rose from 8% to 11% between 1950 and 2009 and is projected to reach 22% by 2050. The effects on social services, wellness, retirement, living conditions, transportation and economic growth are extensive. The annual cost of identifying and treating persistent illnesses is rising dramatically, even in modern health care systems. In recent years, the delivery of health care and

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nursing facilities has moved from hospitals to residences, known as home care, as a result of rising illness burdens and expenditures, particularly among the elderly. The goal is to lower hospitalisation and transportation expenses, boost patient freedom and contact at home and eventually improve health-care quality by lowering medical mistakes.

One of the latest technologies, mobile health (m-health), has the capability to be a successful method for enhancing nursing care, enabling distant visits and reducing health-care expenses. The elderly would be given more control over their lives as a result, and tracking would be improved. Mobile communications systems that support health-care delivery while promoting health are referred to as mobile health [1]. A growing number of people are using smartphones to deliver behavioural change interventions because of how widely accessible and available they are. M-Health platforms can be used to provide many BCTs, either as independent interventions or as components of broader programming. These platforms, as opposed to in-person treatments, allow for the option of receiving real-time response, social contrast and self-monitoring. They also boost the personalisation of the intervention [2].

Additionally, there is no requirement for real-time communication between medical specialists and end consumers. The long-term effects are yet to be fully understood, but it has been demonstrated by numerous meta-analyses and research studies that m-Health tools (apps) may be helpful in improving lifestyles, dietary habits and preventing illnesses. The majority of m-Health apps that are available to the general public are weight management-focused and mostly rely on self-monitoring of food consumption and exercise. Some of them have a lot of potential for behaviour modification and leading healthier lifestyles because they also contain health recommendation systems. The behaviour of users is substantially more affected by personalised recommendations than by generic ones. By identifying certain profile signals and configuring interventions accordingly, recommendation systems use algorithms to assist users in forming better habits.

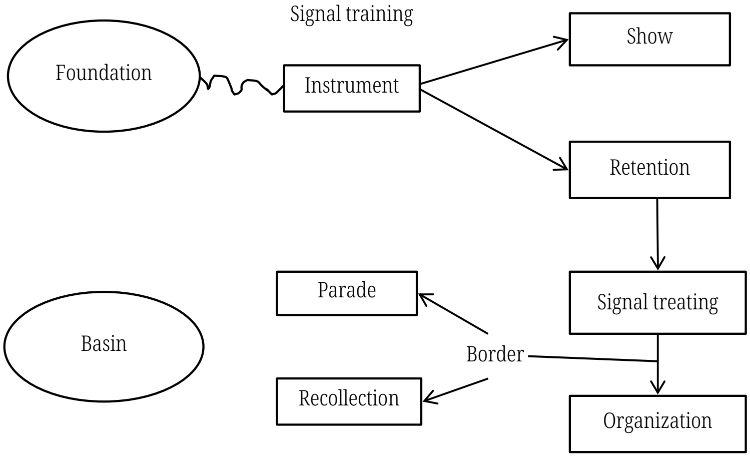

Fig. 1. Some modules in medical virtual instruments

Hard digital instrumentation is a strategy in which some virtual instruments operate as embedded devices. This is a reference to virtual instruments created on reconfigurable hardware systems, such as an FPGA (Figure 1). As a result, recommendation systems are thought to be useful technological tools to assist users in changing their eating habits and may enable users to make wiser decisions to adopt a healthier diet and lifestyle. In this investigation, we present a m-Health framework for altering dietary behaviour using the CarpeDiem app, whose general features have already been published. In a word, the Carpe Diem app focuses on the three main pillars of health—sleep, nutrition and exercise—in an effort to encourage healthy lives among the general public. Its state-of-the-art user interface encourages and amuses users while educating them about healthy behaviours, setting alarms and reminders, and motivating them to stick to personal goals.

The rest of this examination is divided into the following sections: We outline the materials and methods utilised to conduct the evaluation in Section 2. We present the findings for the most prevalent personal health monitoring (PHM)-based medical equipment features in Section 3. The results are then discussed in Section 4, and Section 5 serves as the conclusion.

2 RELATED WORKS

According to Ferré-Bergadà, M., Valls, A., et al. [3] once a person's level of personalised mobile health (PMH) has been assessed, it is vital to create an acceptable, adaptable and simple improvement process to meet that goal. The technologies used to rank exercises and determine their impact are based on artificial intelligence (AI) techniques for customization and computation. This study carries on this effort to enhance Depending on the requirements of improving each person's various mental health-related features, the app could be improved by adding a mechanism to identify the best order of delivering the exercises to each carer. The goal is to create a method that will allow the app to quickly choose and rate a group of exercises for each carer that will successfully halt the deterioration of particular mental health features.

Rosenfeld, E. A., Lyman, C., et al. [4] in their study observe that existing evidence-based m-Health apps, like Motivate, target indicators of depression by providing an app-version of a traditional face-to-face psychotherapy procedure using a wide range of non-overlapping abilities (such as value explanation, mental restructuring and activity scheduling). These are frequently delivered in a non-stepwise manner, with all psycho-educational information available right away in hand-out form. This method goes against how users typically use apps, which is in brief, frequent spurts. As the user went through the apps, each target talent would build on previously acquired abilities. The intervention would primarily concentrate on short, consecutive skill-oriented exercises that were "gamified," with minimal, focused psych education.

According to Wac, K., Bults, R., Van Beijnum, B., et al. [5] this vision, the Mobi Health project, which was carried out from 2002 to 2004 and was funded by the European Union's Commission under the 5th Research System under the project number FP5-IST-2001-36006, has started to develop a cutting-edge platform for value-added mobile medical care for individuals as well as physicians. MobiHealth is the term given to this service architecture after that. Incorporating sensors into a wireless body area network and utilising state-of-the-art communications technology, the stage enables distant patient monitoring and treatment. The platform maximises patient mobility while enabling remote management of chronic illnesses. The purpose of our research is to develop a platform that will automatically forecast, recognise and treat medical emergencies according to a patient's monitored health status.

Shahriyar, R., Bari, M. F., Kundu, G., et al. [6] state that designing, developing and evaluating mobile devices that enable citizens to take a more active role in their health care are all aspects of mobile health care. People frequently have known medical problems yet are unable or unwilling to visit a doctor regularly. Common health issues include diabetes, obesity, high blood pressure and an irregular heartbeat. In these situations, it is typically recommended that people regularly visit their doctors for standard medical exams. However, if we can give people a more intelligent and individualised way to receive medical input, it will save them important time, satisfy their need for individual control over their health and lower the cost of ongoing medical care.

Varshney, U., et al. [7] believe that the growth of m-Health is being fuelled by numerous developments in sensing technology, miniaturisation of low-power gadgets and wireless networks. When infrastructure capabilities and health care needs are matched, wireless technology can be used efficiently. One of them is the employment of immediately adaptive and widespread wireless access to improve the accessibility of health care practitioners. Another is the utilisation of trustworthy communication for efficient evacuation between medical devices, patients, health care providers and vehicles. These include body detectors, short-range wireless connectivity, computerised user interfaces and position tracking.

Olla, P., and Shimskey, C., et al. [8] have stated that while creating a taxonomy, it's crucial to take into account how to properly divide up a group's components into subgroups that are mutually exclusive, clear and encompass all potential outcomes. Taxonomy needs to be simple, easy to grasp and practical to be useful in the real world. Instead of using our taxonomy as a final classification system, we want to use it as a springboard for further investigation into the essential elements of the measurements and categories of m-Health apps. The World Health Organisation (WHO) wrote a piece about the difficulties of integrating mHealth into medical procedures. Lack of expertise was evaluated as the second-biggest implementation hurdle out of those considered.

Sleurs, K., Seys, S. F., Bousquet, J., et al. [9] observe that, from the standpoint of the doctor, mHealth technology offers tools that assist patients in tracking the progression of their diseases and triaging patients so that those who require more testing will be informed. Additionally, using mHealth instruments, patients can be divided into types of diseases that benefit from a certain treatment or do not, based on co-morbidities, lifestyle characteristics and other person-related aspects. Finally, remote surveillance of chronic conditions helps health care systems since it may save needless hospital stays and meetings, which lowers the cost of care. A minority of 10 to15% of adult asthmatics still have uncontrolled asthma despite current treatment options, with persistent symptoms and a higher risk of flares, hospitalisations, substantial absenteeism and mortality.

Triantafyllidis, A., Velardo, C., et al. [10] In more detail, the personalized mobile health monitoring system's practical characteristics include, in addition to monitoring vital signs, self-reporting of signs based on clinically validated instruments, reviewing individual readings through graphical displays, access to self-management education about heart failure and text message interaction with medical personnel. The system's architecture allows for the seamless recording of user actions, remote service updates delivered via a secure application distribution method, and runtime activation and deactivation of functional components by medical professionals. Below is a description of how this mobile system evolved. Initial qualitative user experience findings and preliminary results are also provided.

3 METHODS AND MATERIALS

3.1 Personalised endorsement-based mobile internet wealth management

The real-time user attention model may determine an operator's passion based on their browsing preferences, which can be useful. However, there are many fewer standard tags than there are objects. The similarity between users can be determined easily using the user-standard tag matrix [11]. The issue of filling values doesn't need to be taken into account. Additionally, the algorithm does not need to actively supply goods. The scoring information effectively lowers the level of user interaction and system collaboration. Figure 2 displays the flowchart for the personalised monitoring system.

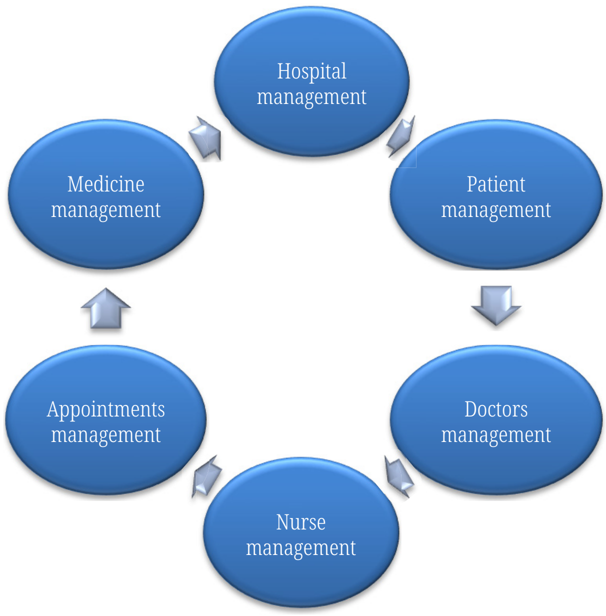

Fig. 2. Flowchart for personalized monitoring system

The similarity of users can be determined in a variety of ways. Cosine similarity is a strategy that is frequently employed.

$$\varnothing_l = \partial_l (m_l - p_l) = \partial_l (J - \partial_l)(m_l - p_l) \tag{1}$$

Equation (1) is used to calculate the degree of similarity between the items in order to retrieve the ones the user is most interested in.

$$\partial_m = (P_m - K_m) P_m (J - P_m) \tag{2}$$

To calculate the relevance scores between the materials, utilise equation (2).

$$\begin{aligned} Q\left(x = \frac{2}{l}; \varnothing\right) &= l_{\varnothing}(l), \\ Q\left(x = \frac{2}{l}; \varnothing\right) &= 2 - l_{\varnothing}(l), \end{aligned} \tag{3}$$

Based on the appropriateness score, the Top-N items are chosen using Equation (3).

$$X_1 = max \sum_{l=1}^{m} e(R_l), \quad (C)^y = B.S^y = (C_1^{(y)}, C_2^{(y)}, C_3^{(y)}, C_4^{(y)}, C_5^{(y)}) \tag{4}$$

The user's fresh curiosity cannot be detected when there is an abundance of data in the future.

$$L_J^T = \sqrt{\sum_I (\cup_1 ji - y) * C_1 ji} \tag{5}$$

As a result, in order to maximise strengths and minimise shortcomings, it is required to modify the influence of each algorithm throughout dissimilar periods by adjusting weights.

$$g1(y) = \frac{2}{2 + f^{-Bx}} \tag{6}$$

Divide the information into a test set and a training collection in order to calculate the weight of the system at hand. User data in various environments have distinct properties.

$$\forall \cup_{ji} = \cap \partial_j y_{ji} \tag{7}$$

In order to find the weights *b* and *q* with the best efficiency, the personalisation method is trained numerous times using the training set of data, using dissimilar values for *b* and *q* each time.

$$B = \frac{\sum \frac{x_i}{y_j} . e^{3b}(x1j + x2j)}{e^{3b}(x1j + x2j)} \tag{8}$$

Under typical conditions, a personalised system for suggestion works in steps to make suggestions. The interest modelling step is the first, the item pairing stage is the second and the suggestion result reporting stage is the last.

3.2 Benefits of music virtual instruments

Over traditional musical instruments, virtual instruments provide a lot of benefits. In this section [12], we briefly go over a few advantages of music virtual instruments (MVIs) have over their conventional counterparts. These advantages have contributed to MVIs being used more frequently in Ambient Assisted Living (AAL) initiatives.

- The MVIs are vendor-agnostic tools, in contrast to the general virtual instruments that some vendors advertise. Additionally, because they are modular and self-contained, they may operate without external personal computers.
- Music virtual instruments' portability is their primary benefit. Virtual instruments are a simple way to provide seniors with the mobility and versatility they need without limiting their movement. MVIs are more portable than traditional medical devices used to monitor seniors since a significant element of the instrument

is built as software. This makes it possible for them to be used for evaluating elders at home, which is a key driver of Ambient Assisted Living.

- The versatility of an MVI is its next advantage. It is easy to change the settings in real time to fit the specific demands of the patient or doctor thanks to the system's versatility. Rapid changes in health monitoring standards and technologies make it simple for conventional devices to become obsolete. But since a significant portion of the MVI is software-based, it is simpler to ensure that it remains current because design changes can be performed more quickly and easily. Due to MVIs' adaptability, certain parts of one instrument can be simply changed to be used as another type of instrument.

Mobile health monitoring device. Mobile PHM systems offer individualised, intelligent, trustworthy, non-intrusive, continuous and widespread health monitoring [2]. They are a component of a body area network, which comprises a mobile base unit collection of wearable wireless sensors with the ability to store energy and transmit wireless data. The user's body is equipped with sensors, which can process the gathered data both locally within the body sensing and/or remotely via wireless transfer to the mobile base unit (MBU). Real-time data analysis by the MBU enables the user to receive personalised information and fast feedback. To receive medical advice and aid in clinical choices, the analysed data can also be distributed to licenced medical specialists. While mobile PHM systems have several qualities that make them appealing to users worldwide, some of those features may also limit how widely accepted and used they can be.

Pervasive surveillance. Personal health monitoring systems' ubiquitous monitoring aims to provide health care services to anyone at any time, regardless of location, moment, or persona. Data processing needs to be integrated into the context of the subject so that communication with the MBU is organic, and the user can receive personalised information in a completely open way.

The platform for integrated multisensing. A multi-sensing platform that is integrated into PHM systems can accommodate biosensors that monitor position, environmental variables like heat, humidity and daylight, and physiological parameters like blood pressure, blood sugar levels and heart rate. Long-term, inconspicuous, non-invasive and ambulatory health monitoring is made possible by lightweight and accessibility.

Analysing data in real time. Real-time data storage and analysis are performed on the data collected by the sensors by the mobile PHM application of the MBU, giving the user immediate feedback. PHM systems may vibrate, make a loud noise, or flash information on the screen to warn the user in near real-time of anomalous events or rapid changes.

Individualised health care. Depending on the biological profile of the user and the clinical setting, mobile PHM devices can be configured to meet the user's unique health care requirements and desires. The user's ethnic background, age and gender could be used to define the clinical criteria of the risk factor under research.

Digital data gathering. In comparison to conventional data collection techniques with subsequent transmission to computer systems, mobile PHM devices provide quick digitization of the information captured, considerably enhancing quality and efficiency. A substantial clinical database is made available via ongoing monitoring and later distribution to health-care practitioners for data mining evaluation of possible hazards and/or relationships between clinical features.

Protocol for flexible connectivity. A mobile PHM system's method for communication is quite flexible because local interaction within the BAN can be carried out using WiFi, Bluetooth, or ZigBee, and it is possible to communicate with the outside world via 3G or other readily available web protocols.

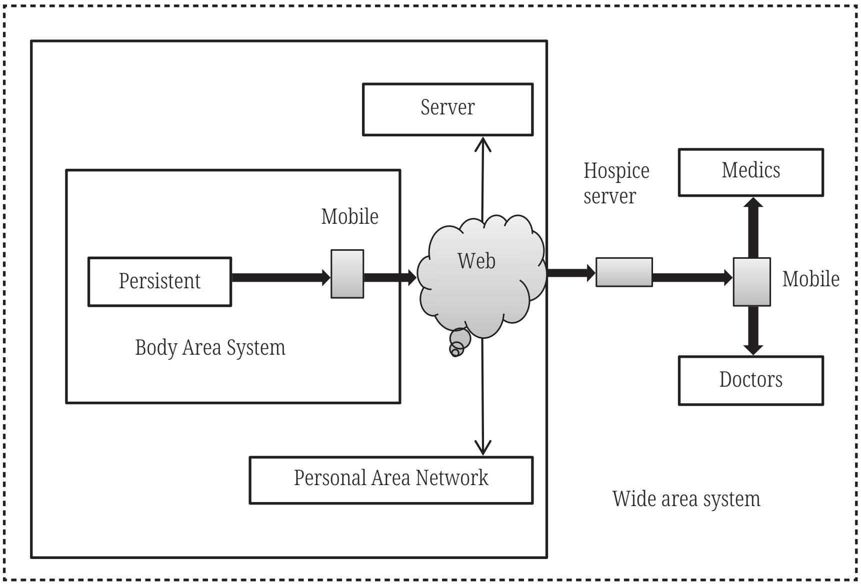

Fig. 3. Construction of a mobile personal health monitor system

3.3 Data privacy, security and confidentiality

In Figure 3, construction of a mobile personal health monitor system is examined. The deployment of mobile PHM systems is significantly hampered by concerns over the safety, anonymity and confidentiality of user health data. A heart patient's proprietary data, for instance, might be manipulated by fraudsters; Regular readings might be changed to indicate a serious issue, and incorrect feedback might even cause the patient to experience a heart attack. On the other hand, the information might be helpful to parties the user did not invite, like insurance firms or superiors, and this access might raise privacy issues. In light of these reasons, security concerns in the setting of mobile medical care must be understood by policymakers and programme managers in order to establish and implement the appropriate rules and safeguards [13].

4 IMPLEMENTATION AND EXPERIMENTAL RESULTS

The MVI's hardware and communication interface are described in the concept. It consists of the detectors, system platform and communication interface used by the MVI's local and distant endpoints.

Communication systems and model networks. The client-server network model served as the foundation for each MVI in the publications under examination. For transmission to an external attendant at the faraway (doctor) end, the local (client) end would frequently transmit the sensed signals to an access point device nearby the sensors [14]. Regular access points include the platforms mentioned in the previous section. One improvement in MVI network models worth highlighting is the departure from the physician's connection to a particular remote server to an instantaneous relationship between the results of the bio-signals and a far-off web server or cloud service. This model was used in five of the articles we reviewed.

The use of this strategy has several benefits. The possibility of "geographically separating" the biosignals is one of these benefits.

Table 1. MVI platforms and protocol types

Platforms	Custom Devices	Laptops	Mobile/PDA
Protocols for Local-MVI Communication	18	7	2
Protocols for Remote MVI Communication	18	3	4
Cellular/wifi	15	10	3

The purpose of MVIs is to support PHM systems, which place a high priority on portability. Unlike the conventional virtual instrument method, the majority of MVIs employ a customised device or a personal digital assistant (PDA) as their platform, as indicated in Table 1. The two instances of cardiac implantable electronic gadgets that only employ mobile phones to communicate with remote systems were left out of the analysis.

Outcomes/results. Medical design development, medical uses, health care data management, mathematical modelling of physiologic systems and medical research applications are only a few of the uses for MVIs [18, 19]. But it appears from a review of the scientific literature that the use of MVIs for PHM is mostly concentrated on a small number of unique disease domains.

Table 2. Scenarios for monitoring the heart area

No	Monitoring Scenario	Cases
1	Heart-rate tracking	9
2	persistent heart failure	3
3	Spirometry	2
4	Hypertension	3
5	Amount of blood flowing	2
6	Obstructive snoring	2
	Total	**21**

In Figure 4, these domains are displayed. Over half of these instances fall under the category of cardiovascular disease (CVD). Given that CVDs account for the single largest cause of death worldwide, this is reasonable. Table 2 lists the possibilities for constituent monitoring that fall under the cardiovascular area.

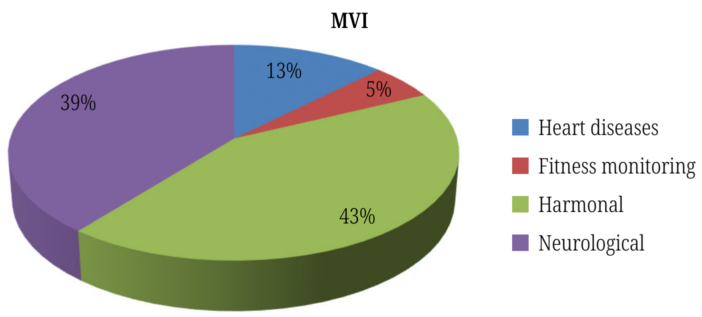

Fig. 4. Medical virtual instruments domains

The term "modality" refers to the anticipated impact on the patient's health. In 93.3% of the cases examined, extracting, examining and reporting a person's bio-signals was the only goal. Only three MVI systems (8.7%) responded to the analysis's findings by initiating some sort of treatment. In the first instance, the diabetic patient's insulin administration was managed, and in the second, a stimulus was used to prevent the patient from snoring while they were sleeping.

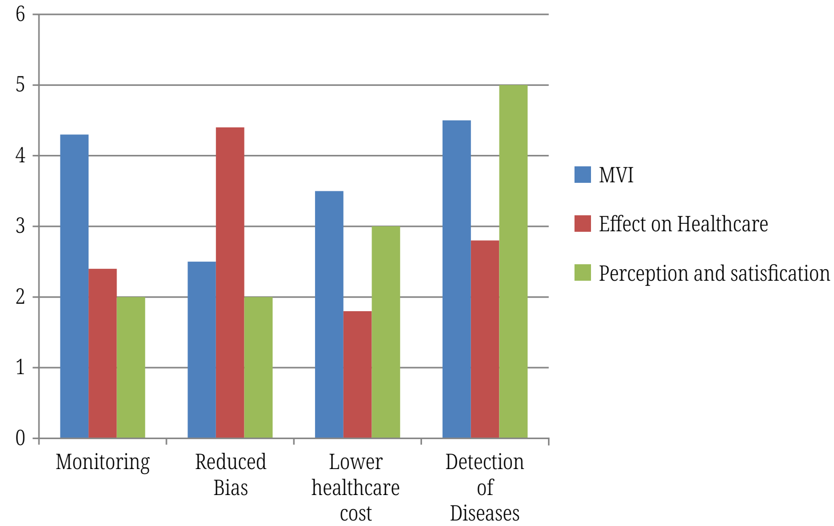

Fig. 5. Comparing the use of MVIs with conventional medical devices for PHM

Numerous studies claimed that the MVI technique had a beneficial impact on the usefulness of medical equipment. The most significant justification for employing MVIs was identified in this research as miniaturisation in Figure 5. MVIs give doctors the ability to measure the evolution of the disease and to make well-informed decisions free from the prejudice of operators using comparable conventional medical tools. According to one of the research projects on MVIs, they can regulate CIEDs and other implanted devices and keep track of leads, battery level and device impedance.

Training attempting to change behaviour and uphold healthy diet and lifestyle utilising personalised feedback from electronic health and mobile-health interventions has demonstrated encouraging outcomes in the prevention of NCDs [15]. A student with a child, for instance, should make childcare plans for the online appointment just as they would for the in-person one. Another disadvantage of virtual clinical training may be the lack of input from different clinical dosimetrists. This can be improved by having numerous board-certified medical dosimetrists collaborate with the students, which the clinical instructor can arrange [16, 17]. Diagnosis, decision-making, therapy and administration are all parts of a typical health-care workflow. The implementation of MVIs would most likely affect diagnostics and decision-making.

As a result, it might be required to adapt the organisational structure and process in health care to account for the usage of MVIs. Along the same lines, workflows based on the utilisation of MVIs must be included in reimbursement plans. The possibility of websites as a tool for separating the monitoring process from the constraints imposed by location is another factor to keep in mind while considering the difficulties and potential futures of MVI in PHM. MVIs can offer sensors that instantly communicate the signals to an always-on, local, or distant website by utilising miniaturised integrated circuits and microprocessors. This would enable real-time surveillance and permit simultaneous viewing of the signals by all authorised parties. Additionally, it would enable MVIs to benefit from the enormous memory and processing power of the web.

5 CONCLUSION

Mobile health is a hot topic right now, and numerous apps are being created to support various health care systems. The field that promotes the mental health of carers is fascinating. However, the majority of systems are static programmes that act as self-help manuals. An innovative approach is suggested in this study to make it possible to create personalised smartphone apps that take each user's demands into account. Current PHM systems are primarily utilised for specialised purposes and health monitoring. In order to become the system of choice in the contemporary health care industry, PHM equipment must offer higher degrees of adaptability and robustness. The analysis reveals that there are still lots of issues to be solved in the investigation of MVIs' use in personal health monitoring.

Because of the burdensome nature of their circumstances, caring for the elderly is frequently complicated. Health systems must adopt technology-based solutions because of the rising number of older people with ongoing medical conditions and the expanding clinical causes of those illnesses. By presenting the basics of PMH used for older patients, the current research effectively created a list of advantages and difficulties for aged care. Because there were often more advantages than obstacles in this study, these data on barriers can help people understand the challenges of developing information systems.

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