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Architectural design for remote patient monitoring system implementation in haematology units: a proposed model

Research – Full text

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Abstract

Information and communication technology (ICT) has been pivotal in healthcare. In particular, wireless communication and wearable sensors technology have garnered more attention in healthcare. They allow for real-time healthcare monitoring systems, early diagnosis, and timely treatment, which can significantly reduce unnecessary loss of lives primarily due to delays of response healthcare providers, Furthermore, low healthcare professionals-to-patient ratios.

This study proposes a framework of remote patient monitoring (RPM) for managing haemophilic children in Egypt. This program is designed for health data management inside the Regional Blood Transfusion Center (RBTC) at the Therapeutic Unit in Alexandria. Meanwhile, it employs a descriptive-analytical method to investigate the impact of Wireless Body Sensor Networks (WBSN) on the timely collection of physical health data. Moreover, this study outlines a planning strategy for integrating Wireless Body Area Network (WBAN) technology into telemonitoring systems, emphasizing its applications within healthcare, particularly in haematology.

The results of this study indicate the effectiveness of RPM in improving patient experience, and medication compliance, and reducing hospital readmissions. RPM monitors wirelessly patients' physiological parameters in real-time transmitting data to the Electronic Medical Record (EMR) in real-time, and alerting healthcare providers when abnormal readings are detected. The study concludes that home therapy can

lead to prompt and optimal treatment, thereby reducing pain, dysfunction, and long-term disability for patients.

Keywords

Wireless Body Area Network (WBSN); Remote Patient Monitoring (RPM); Medical information

1. Introduction

One of the significant pillars of the Internet of Things (IoT) applications is Wireless Sensor Networks (WSN). It is often considered the future of ad hoc networks. that is defined as a network of wireless devices, called nodes, which integrate processing, communication, and acquisition capabilities and communicate via wireless links. WSN collects a set of physical or environmental conditions to transmit them cooperatively and autonomously for treatment points to control a particular phenomenon. [2] The adoption of WSNs in healthcare is growing rapidly. Body Sensor Network (BSN) systems can help people by providing medical services such as telemonitoring, memory enhancement, timely data access, and communication with healthcare providers in emergencies through SMS or Mobile applications.[11]

The Remote Patient Monitoring (RPM) system gained traction in the front line of healthcare with the introduction of (BSN) technologies, which are designed to assist clinicians with additional support to provide care for the elderly, children, and movement disorders or psychological conditions inside the home using wearable devices. In addition, RPM will increase the detection of emergency conditions in at-risk patients. Moreover, the patient and their families will benefit from these, for instance, it will reduce the admission rate at the hospitals. thus, protecting the patient's family from a hospital infection. Also, these systems provide advanced methods to remotely acquire and monitor physiological signals without the need to bring the patients to hospitals.[18] [21]

The haematology unit is one of the hospital departments responsible for diagnosing and treating patients with disorders of the blood and bone marrow. Their patients may have serious life-threatening illnesses such as leukemia, Haemophilia, Thalassemia...etc. That requires continuous blood transfusion or emergency intervention. Meanwhile, Haematologists and caregivers help patients how to care in their homes. [30] Therapeutic Units is a department that

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works under the Blood Transfusion Centers at Egyptian Ministry of Health MOH, it provides medical care and blood treatment services for chronic blood disorders. [12] So, it works to ensure safe blood transfusion services through the recent development of revised National Standards for Blood Transfusion Service. Haemophilia is a hereditary blood disorder characterized by the inability to properly clot blood, leading to prolonged bleeding after injuries and the potential for internal bleeding, especially in joints such as the knees, ankles, and elbows. This condition primarily affects males due to its genetic inheritance pattern. [3] Haemophilia is categorized based on the levels of clotting factor activity into mild, moderate, or severe forms. Individuals with severe haemophilia tend to experience more significant bleeding challenges. [33]

In Egypt, conventional treatments for managing bleeding episodes in patients with haemophilia include the use of plasma, cryoprecipitate (Cryo), and recombinant factor injections. These treatments aim to replace the deficient clotting factors and help manage bleeding effectively.

This study aims to propose a program of remote patient monitoring (RPM) for managing haemophilic children in Egypt. The program will be designed to be applied on health data management inside the Regional Blood Transfusion Center (RBTC) at the Therapeutic Unit in Alexandria. The study depended on using bio-wearable sensors to assist healthcare providers to identify potential problems and take timely action. thus, reducing morbidity risk due to failure to provide quickly assistance to haemophilic patients. as well as, empowering people towards a major awareness in the management of their health.

2. Literature review

One of the most important studies of RPM is (Demir et al.2017) which presented an integrated system design that allows collection, recording, and transmission through a cloud application of the data from different sensors placed in the house of a person having dementia. This system is based on the Internet of Things (IoT) where information from smart things around us can be evaluated and transmitted over the internet. The system used seven kinds of sensors placed in four different locations in the house. The system was developed to identify activities and their logical consequences in such a way that actions done halfway or forgotten (situations such as the forgetting tap open, the oven door open, the doors and the windows open, etc.) are reminded to the patient as well as to his caregiver/doctor. These situations are also sent as photo notifications through the Pushbullet application, which runs on an Android operating system. it also

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Situations such as fire hazards that are of vital importance for the patient can be detected in real time.

Whereas (Malasinghe et al.2017) discussed contact and noncontact monitoring - based on images in the RPM system., that all methodologies focus on human vital signs extraction, they addressed heart and blood-related systems, fall detection systems, brain and nervous system-related systems, diabetics, and mental health as the deterioration of these vital signs affects the human health system. Furthermore, this study analyzed the developments in the remote health monitoring field from 2012 to 2016, with high scope on the activity detection of patients like fall detection and mobility-related diseases. The authors reviewed ambiance device-based and vision-based fall detection systems but addressed significant problems like higher accuracy, precision, dependability, and usability that remain pending for contactless monitoring. While (Boccalandro et al.2019) emphasized the importance of telemedicine which has been increasingly proposed as a way to provide persons with hemophilia PWH with a range of services designed to improve their health, saving the time and cost involved in going to the treatment center, and increasing therapeutic adherence. The authors expressed available tools for managing hemophilia such as videoconferencing, mobile phones, wearable sensors, and serious games (exergames) for telerehabilitation. In general, the study pointed to the need of extensive data in the near future through participation of different centers specialized in hemophilia, with respect to privacy protection that must be tackled. Patients should be adequately informed and signing an informed consent form should be mandatory.

Thoughtfully, (J. Gordon et al. 2020) deployed a Remote Patient Monitoring (RPM) program to monitor patients with coronavirus disease (COVID-19) upon hospital discharge. They designed an electronic questionnaire embedded in patient portal software called (MyChart Care Companion) which has both mobile and desktop versions and was available in English and Spanish. The mobile version reminds a patient each morning to complete a survey, at which point the patient is able to self-enter their device data (oxygen saturation and temperature) and answer five symptom questions related to shortness of breath, cough, appetite, weakness, and vomiting. This program conducts five hospitals in Massachusetts. At the end of the program, A majority of enrolled patients (66%) completed the

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monitoring period without triggering an abnormal alert. Enrollment was associated with a decreased odds of ED or hospital readmission. therefore. RPM for COVID-19 provides a mechanism to monitor patients in their home environment and reduce hospital utilization.

In another study (Sharma et al .2021) proposed a framework based on the Internet of Things and an alarm-enabled bio-wearable sensor for early detection of COVID-19 in rural areas. Also, the same information can be used to warn the people in the vicinity to get cautious and adopt preventive measures with utmost care. The proposed system tracks the individuals and records their behavior. It may also receive online diagnoses to manage its health. Thus, the proposed system can manage health from a mobile phone's without leaving home. the authors relied on techniques. RFID, microcontrollers, and sensors for patient monitoring applications. It also designed an analytical system for recorded COVID-19 parameters to predict COVID-19 infection. whereas, the model was trained on the collected dataset to classify the patients into an infected and non-infected category. the results obtained from the efficiency of the proposed model are validated in terms of accuracy and power consumption during the simulation of the model, it was evidenced that the model gives an accuracy of 96.33 %. Additionally, it is also observed that the proposed model is also efficient in terms of power consumption.

The comprehensive study of (El-Rashidy et al. 2021) stated trends and challenges of adopting a wireless body area network (WBAN), a subdomain of IoT that connects wireless sensors with the patient's body to the network. The authors reviewed 56 papers in the period of (2015–2019) that cover several features related to RPMs, including IoT, WBAN, cloud computing, fog computing, and Clinical decision support systems CDSS. This survey was conducted in five main databases (IEEE, Springer, PubMed, Scince.Gov, and Science Direct). thereafter, it provided a case study of remote patient monitoring for chronic disease patients that tries to cover several limitations of the state-of-the-art architectures. In the reviewed study of (Shaik et al .2022) advanced technologies such as video-based monitoring, IoT-enabled devices, cloud, edge, fog, and blockchain and AI algorithms such as reinforcement learning, and Traditional machine learning adopted by RPM systems. moreover, they described technologies adopted in current RPM systems for noninvasive techniques to monitor vital signs, physical activities, emergency events, and chronic diseases. it also presented the impact of AI in enhancing RPMs with its ability to learn, predict, and classify patients'

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behavior and vital signs. Finally, they discussed current challenges in adopting AI algorithms to remote monitoring systems for vital signs precision and activity recognition such as AI or ML explainability, Privacy, Uncertainty, Signal processing, Imbalanced dataset, Dataset volume, and Feature extraction.

In another study (Gualtierotti et al .2022) designed a computer-aided diagnosis (CAD) system for the automatic detection of joint recess distension in patients with hemophilia could support physicians in prioritizing interventions for managing hemophilia therapy. they developed a deep-learning algorithm to automatically recognize joint capsule distension as a proxy of hemarthrosis in MSK-US images. The algorithm is based on an object detection framework that is trained to detect the normal and distended joint recesses. Meanwhile, the authors collect (2,267 knee scans). Of these, 483 were considered valid and used for the learning model. 330 images were used for training and 120 images for testing the classifier, leading to the detection of joint recess distensions with a 78% accuracy (69% sensitivity; 87% specificity).

3.Problem of study

Usually, remote patient monitoring RPM measures symptoms of chronic conditions, such as cardiac diseases, diabetes, and asthma. RPM or telemonitoring is a way that allows clinicians to observe patients' physiological parameters remotely and to intervene if abnormalities appear. [25] People with multiple chronic conditions are suffering from the increasing risk of day-to-day body system failure and increased mortality rates.[26] Therefore, implementation of the RPM program at the therapeutic unit needs to define the problems faced by healthcare practitioners, which are summarized as follows:

- **Information:** in some cases, there are suffering from adverse reactions that develop within 72 hours of completion of the transfusion. At the same time, some blood disorders don't cause noticeable symptoms. In this situation, the healthcare team should monitor the overall health, paying close attention to any new signs or symptoms that develop. Additionally, children can't express their pain clearly, moreover, miscommunication between their parents and healthcare providers except for a few calls and sending some images on WhatsApp group that of course, negatively reflects on clinical decision support.
- **Cost:** in fact, Healthcare resource utilization is affected by direct medical costs which include the cost of visits to doctors, investigations, low funds for

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some treatment, and complications management. as well as, indirect costs associated with the management of haematology diseases. it includes costs of productivity loss, caregiver time, and transport to the health care facility, in addition, Blood disorder patients suffer from multiple intangible costs which include psychological stress and withdrawal from society.

- **Care Plan:** caregivers are unable to track the patient's activities and reduction of fatigue, as evidenced by reports of increased movement and ability to perform desired activities. Also, increase the family risk of infection as evidenced by a fever infection, and implementation of preventive measures such as proper hand washing.
- **Follow up:** even with good healthcare, complications can develop, and when they do, they usually require immediate medical attention. Some can quickly become life-threatening without treatment. For example, excessive internal bleeding is one common complication that requires medical care right away.

4. Methodology

This descriptive-analytical study examines the impact of Wireless Body Sensor Networks (WBSN) on timely physical data collection to enhance healthcare. It also explores WBSN-enabled self-monitoring programs for remotely monitoring patients with chronic Haemophilia and presenting standard care. The study involved interviews with 17 children with haemophilia, their parents, 2 haematology doctors, and 5 caregivers. Interview questions focused on four main topics: abnormal sign measurement, team eligibility, patient eligibility with consideration of severity of disease, and program framework. This study introduces a planning strategy for integrating Wireless Body Area Network (WBAN) technology into telemonitoring systems, emphasizing its applications within healthcare, particularly in haematology.

5. Proposed Framework

Remote patient monitoring (RPM) program for haemophilic children is a transformative healthcare approach consisting of several key stages as shown in Figure 1.

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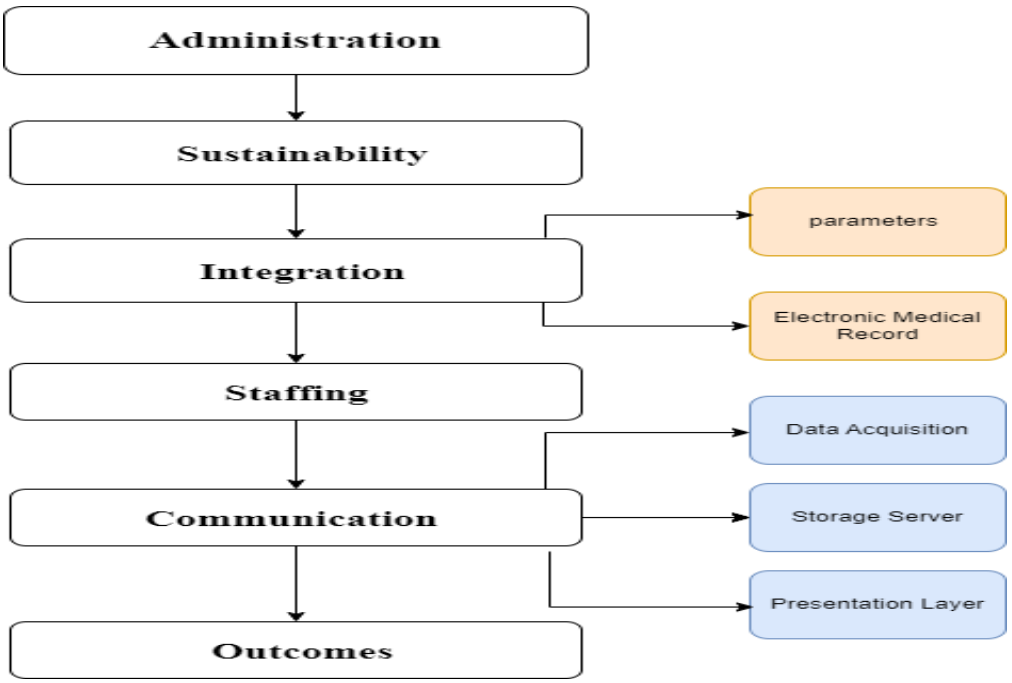

Figure1: Stages of RPM program in therapeutic unit

5.1 Administration

In these initial stages, it is essential to identify the appropriate strategies for successfully implementing the RPM program to ensure that all aspects of the program operate smoothly. Accordingly, project objectives were defined for both healthcare practitioners and patients.

For healthcare practitioners, objectives may include:

1. Reducing the likelihood of errors in diagnosis or treatment, which ultimately leads to decreased risks of medical mistakes.
2. Lowering overall healthcare costs through more efficient monitoring and management.
3. Decreasing the rate of hospital readmissions by proactively managing patient health and addressing issues before they escalate.

For patients objectives might include:

1. Helping patients avoid unnecessary visits to therapeutic units /clinics.
2. Reducing morbidity risk due to failure to provide timely assistance.
3. Enhancing patient engagement in their own health management and medication adherence.

5.1.1 Resources

To implement RPM program effectively, several key resources and considerations must be evaluated, such as:

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- **Regulatory approval:** when selecting wearable devices, it should be confirmed that devices are listed with the MOH and have passed necessary evaluations for safety and efficacy, there are several key factors to consider, including their functionalities, compatibility with existing health system, availability, and cost.
- **Patient Education Materials**: by developing various educational resources to help them understand the significance of monitoring their health and the benefits of participating in the RPM program and tips on maintaining a proactive approach to their well-being health.

5.1.2 Limitation

The limitations of RPM program in therapeutic unit can include the following aspects:

- **severity of disease:** haemophilic children with mild and moderate can significantly benefit from RPM program. These systems allow for continuous monitoring of vital signs and health data, which can help in identifying potential complications before they escalate into emergencies.
- **Telemonitoring Duration:** will be conducted continuously for 12 hours daily. from 8:am to 8: pm. This time is a peak period for patients, especially children, and it's a time of working in the unit.
- **Medication adherence:** for remote patient monitoring to be truly effective, it's important to address medication adherence and ensure patients understand the importance of their prescriptions concerning their overall health and the monitoring they are receiving.

5.1.3 Patient Consent

patients must agree to use the monitoring device provided. They should also be informed about their responsibilities, such as regularly using the device to collect their biometrics and responding to any surveys or assessments as instructed. Consent should be documented to ensure that patients understand their participation and can withdraw at any time if they choose.

5.2 Sustainable Plan

Many healthcare programs also develop a business plan to strategize for long-term sustainability. This plan could identify the regulatory environment for understanding ongoing costs for reimbursement, licensing, and credentialing. These handle several factors that ensure effective integration and ongoing

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success. In this context, RPM program addresses several keys that are essential for sustainability [22][25]:

- **Analyze Financial Data**: this involves careful budgeting for the implementation, maintenance, and periodic upgrades of technology.
- **Analyze Patient Data**: utilizing the capabilities of artificial intelligence (AI) and machine learning (ML) algorithms can enhance the ability to predict complications arising from blood transfusions and medications. By assessing symptoms from the patient's history, healthcare providers can make informed decisions that improve patient outcomes.
- **Ongoing Promotion to Patients**: marketing RPM services to community members, healthcare providers, and other stakeholders is crucial. Building partnerships with payers such as health insurance organizations and government entities can expand coverage for RPM services, fostering broader adoption. This strategic approach can help transition RPM from a local initiative to a national program.

5.3 Integration

Wearable devices have revolutionized the healthcare system by decreasing the load on hospitals and by providing more reliable and timely information. They can be employed for different body parts, e.g., head-based wearables, eye-based wearables, and wrist-based wearables. These wearables are embedded with built-in sensors that keep track of body movements, provide biometric identification, or assist with location tracking.[10] [18] Presently, major companies like Apple, Google... etc offer various wearable devices using their restrictions and limitations.[17] Among these options, wrist-based wearables tend to be a more attractive choice due to their affordability and advanced safety features, making them appealing for both children and adults.[6][36] In remote patient monitoring is crucial to integrate vital signs collected with the existing health system in a hospital like Electronic Medical Record (EMR) which is considered a subsystem in the Blood Management System (BMS). This program tracks 5 biometrics data consisting of with:

- **Body Weight**: it is important to follow up body weight for haemophilic patient as a part of medical history for calculating factor dose. For example; 70kg administer 700 ml of plasma for appropriate dosage. Regularly

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monitoring body weight helps ensure the right dosage is administered based on the patient's current weight.[23]

- **Blood Pressure**: is an essential factor in assessing the risk of bleeding, particularly in patients with haemophilia. These patients may be more prone to hypertension due to the frequent use of analgesics, which can affect blood pressure regulation. Elevated blood pressure can lead to increased stress on blood vessels and may heighten the risk of bleeding events. Haemophilic patients must monitor their blood pressure regularly and manage their pain effectively while considering the implications for their overall health.[41]
- **Pulse Rate**: this is an additional factor that can predict cardiac function issues in haemophilic patients. An irregular pulse rate may indicate a defect in cardiac function. In this case, it is Intervene urgently to refer the patient to a cardiologist for further evaluation and management.[34]
- **Body Temperature:** if the temperature rises 1 C or higher from the temperature during transfusion, the transfusion should be stopped. After the transfusion, Fever/chills are most commonly associated with a febrile, non-hemolytic reaction, however; they can also be the first sign of a more serious hemolytic delayed response that is important to rapid medical intervention.[27]
- **Respiration Rate:** is a critical parameter to monitor in patients with haemophilia, especially due to the potential for severe reactions. Dyspnea, or shortness of breath, is a significant indicator and may arise from serious conditions such as anaphylaxis, transfusion-related acute lung injury (TRALI), and transfusion-associated circulatory overload (TACO). It is important to note that dyspnea can occur independently, without other accompanying symptoms. Therefore, careful monitoring and evaluation of respiratory signs are essential for accurate diagnosis and timely intervention in such patients. [30]

5.3.1 Electronic Medical Record (EMR)

Electronic Medical Record (EMR) is defined as "an electronic record of health-related information on an individual that can be created, gathered, managed, and consulted by authorized clinicians and staff within one health care organization,".[44] EMR has the potential to improve the accuracy of information,

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support decision-making, and facilitate the accessibility of medical information for continuity of care.[20] In BMS system there is a patient records management module that works on the web based on an internal network (LAN). As well as, EMR is based on the server/client approach in working, where it can work on the server using the Windows Server 2012, 2016 operating system, utilizing the Java SDK Kit, and Apache Tomcat (8.5.42) packages, while the client device works on the Windows 7, 8 or Windows 10 operating system and using SQL server 2014 as storage database.[19]

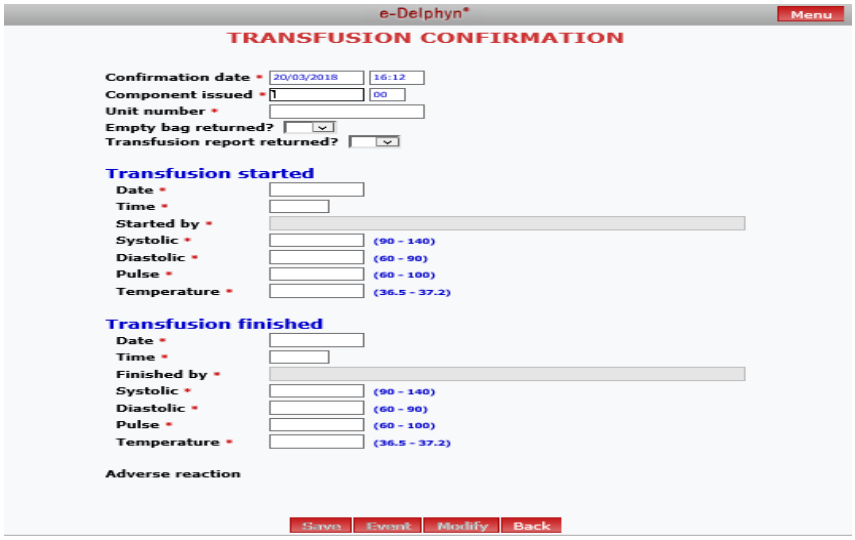

Figure2: Registration of patient vital signs in EMR.

Successfully integration between wearable devices and patient portal involves a multi-step process, as seen in figure 3:

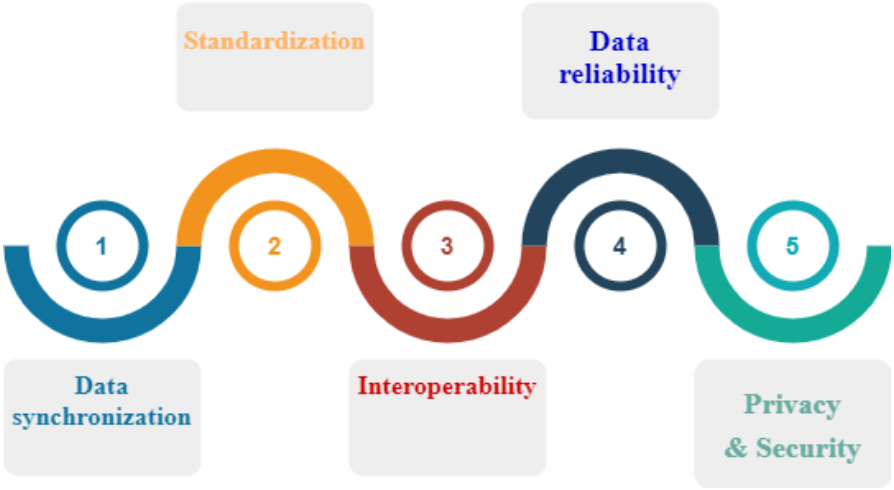

Figure 3: Steps to merge wearable devices within EMR

- **Data Synchronization:** implementing real-time data synchronization mechanisms to ensure patient data is up-to-date and available within the

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EMR, by getting alerts directly into the clinical workflow using notification messages whenever abnormal indicators, so a clinician's team can respond as quickly as possible besides real-time alerts if a device issue occurs. [17] However, several challenges remain regarding data synchronization, including issues related to standardization, interoperability, and security. These aspects will be further explored in the section addressing challenges in integration.

5.4 Staffing

The healthcare team should be multidisciplinary, with expertise and experience to attend to the physical and psychosocial health of patients and their families. [27] In RPM program the staffing consists with:

1. **Clinical team**: the core team consists of the medical director, physicians. They responsible for overall medical care, diagnosis, and treatment planning.
2. **Nurses:** they play a vital role in the program, there will be 6 nurses to act as the direct contact for patients with acute problems or who require follow-up. Furthermore, able to assess patients and institute initial care where appropriate. Their expertise ensures that patients receive timely attention and appropriate interventions, enhancing overall patient outcomes
3. **Pharmacists:** they offer educating patients and their families about frequency and dosing and counseling to optimize pharmacotherapy. Otherwise, Oversight & medication adherence.
4. **Administrative officers:** they are responsible for managing patient billing, documenting all medical services, and overseeing the revenue cycle within healthcare centers manage patient billing and financial claims among center and other stakeholders.
5. **IT Support:** for ensuring the technology infrastructure is functioning properly, also, monitoring, testing software and hardware. In addition, provide in-the-moment support for issues that arise during telemonitoring.

5.4.1 Design Conceptual Model

When developing staffing for remote patient monitoring (RPM) programs, it's essential to establish a clear conceptual model based on several key components such as:

1. Review job descriptions for clinical staff and responsibility.

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2. Understand RPM and Its purpose.
3. Patient enrollment and workflow engagement.
4. Consistent management throughout the process.

5.5 Communication

Current patient monitoring primarily relies on one-way communication, where vital signs collected by sensors are transmitted through smartphones that serve as a gateway to a central BMS server, allowing the clinical team to access patient information. In this context, the main layers of building RPM architecture can be summarized as follows,

5.5.1 Data Acquisition

The wearable device comprises many components that can be considered as a major like a microcontroller and accelerometer sensors that connect wireless to the patient. Data collected is transmitted via Bluetooth to a paired smartphone, as well as, using an external network to transfer data into EMR via Wi-Fi or 4G mobile data. This seamless integration allows healthcare professionals to remotely access and analyze patient information, facilitating timely interventions when necessary. Additionally, the device is equipped with a rechargeable battery, ensuring extended operational time without frequent interruptions. [24][28]

5.5.2 Storage layer

The existing health system (BMS) in the therapeutic unit is currently connected to local server. In this proposed model, the system can enhance its functionality by integrating with Egyptian cloud computing services, offering storage, deployment, and technical support as a Software as a Service (SaaS). This transition can improve data accessibility, scalability, and operational efficiency, also facilitates remote access to the BMS/EMR, thereby increasing access to care for patients in rural areas. [14] In terms of security, cloud server offers multiple authentication layers. That include utilizing monitoring as a service for monitoring and protect data, as well as detect vulnerabilities, implementing multi-authorization levels. Moreover, conventional cryptographic methods can be employed to safeguard data. [37]

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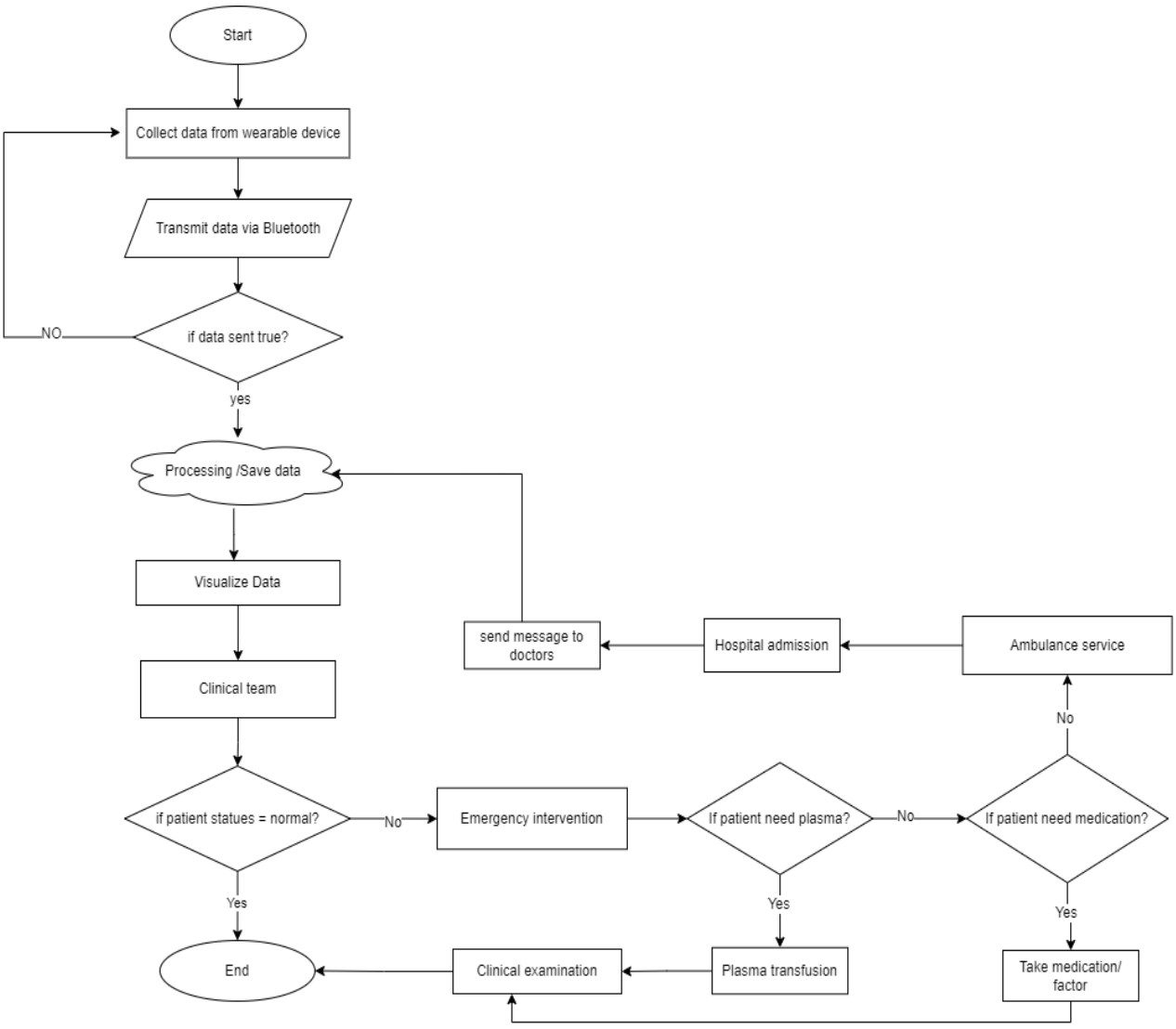

Figure 4. Flowchart of Remote Patient Monitoring RPM work

5.5.3 Presentation layer

To implement the proposed solution, it is crucial to develop a dashboard that enables healthcare providers to monitor patient health status and identify anomalies in the data. This dashboard should feature real-time data visualization, alerts for unusual patterns, and an intuitive interface to facilitate quick decision-making.[22]

The dashboard will design to display the collected data in a visually appealing and early warnings or guidance provided as needed. [39]A chart library will be utilized to create a graphical user-interface (GUI) capable of displaying various types of data effectively, as shown in Figure 5

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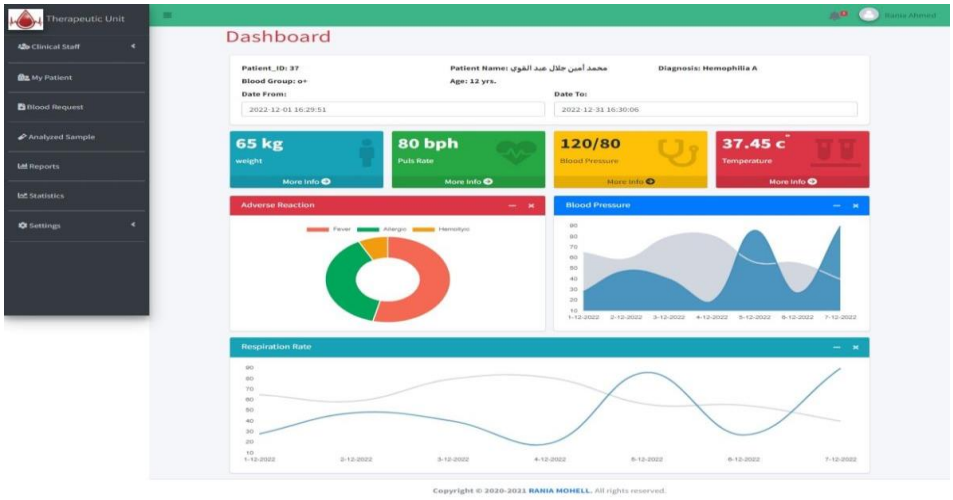

Figure 5. Dashboard of visualize patient health status in BMS

6. Challenges

Implementing a program-enabled patient monitoring system would face some technical issues, including:

- **Data Standardization:** in general, data collected from wearables might not adhere to the format of the EMR system in which it is trying to integrate. So, compatibility and seamless integration with current EMR requiring significant customization. [29]
- **Interoperability:** different devices and systems may not communicate effectively, leading to fragmented data and difficulties in real-time patient monitoring. [45]
- **Data reliability:** ensuring consistent and accurate data transmission from devices to the central monitoring system can be affected by network issues or hardware failures.[43]
- **Privacy and Security:** in fact, protecting sensitive patient information is critical. but unsecured network connections and poor authentication are both concerns with wearable devices, additionally, there's a risk of data breaches and unauthorized access, which can compromise patient privacy.[14]

Discussing these issues proactively can help ensure a smoother implementation of RPM.

7. Results

The study focuses on the use of wearable devices for tracking and monitoring patients with hemophilia outside of clinical settings. It outlines the various stages of the program implemented for this purpose, as well as, discusses the challenges associated with using wearables in healthcare. The findings indicate a trend towards the adoption of mobile health solutions, emphasizing the role of

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digital tools such as wearable technology in collecting health data effectively. Moreover, it provides opportunities for future researchers to conduct further experiments in this topic.

The first implication of this study is to identify the significant factors that contribute to progress in sustainable development within healthcare organizations through investment in digital tools. That enables clinical staff to view, discuss, and assess patient issues in real time, thereby supporting decision-making. Moreover, the integration of wearable devices within the RPM framework allows for better complications management and adverse reactions that reduce healthcare care direct costs. Therefore, RPM Improves treatment outcomes so, fewer interventions and medications are needed to enhance productivity. Thus, reduction in readmission rate, and of course, hospital-acquired infections. Also, finding RPM program would be well-served care for uninsured patients, and rural areas.

As a recommendation for RPM system, the literature review and interview findings indicate that there is a need to address inadequate knowledge about digital tools among patients and healthcare providers. To enhance patient engagement, it is advisable to develop a mobile app that facilitates communication, provides educational resources, and enables easy access to monitoring features. Additionally, incorporating features such as tutorials, reminders, and feedback mechanisms would further support patient involvement and improve health outcomes. Furthermore, it is recommended that healthcare providers expand their services beyond telemonitoring to implement effective hospital-at-home solutions. This holistic approach can lead to a more engaged patient population and better overall healthcare results.

8. Conclusion

Technological innovation in health information systems has transformed healthcare applications by introducing telemedicine services, personalized healthcare, Electronic Health Records (EHRs), and remote patient monitoring. These advancements have improving health data management and enhanced patient engagement, ultimately leading to improved health outcomes and a more responsive healthcare system. This paper tried to introduce telemonitoring system for haemophilic patient which built on three layers. The first layer is concerned with data acquisition, it is used to gather data using wearable devices. Patients' measurements are transmitted to the second layer using various transmission protocols. The second layer consists of cloud and web servers that

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receive, process, and store date. The third layer is the presentation layer that develop dashboard for display the collected data in a visually appealing.

In conclusion, this program highlights the potential for enhancing healthcare through advanced digital tools, particularly with remote patient monitoring. However, challenges remain in the implementation process. Future efforts should address these critical factors affecting technology adoption and develop strategies to mitigate them before launching technology implementation initiatives.

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