Digital transformation solutions in healthcare for remote health monitoring

Doan Thanh Nghi[1*], Duong Thi Kim Ngan[2]

[1]*An Giang University, Vietnam National University Ho Chi Minh City*

[2]*Kien Giang University*

[*]*Corresponding author: Đoàn Thanh Nghị (dtnghi@agu.edu.vn)*

ABSTRACT

Digital transformation in healthcare refers to the integration of technology into healthcare operations in order to improve the delivery of healthcare services. This process aims to optimize healthcare data management, enhance the quality of care, and enable remote health monitoring. The ultimate goal is to establish a smart healthcare system that prioritizes public health and promotes sustainable development. In this context, the development of high-tech and multifunctional healthcare is an inevitable and crucial trend that aligns with the principles of security and efficiency in healthcare. To achieve this, the implementation of digital technology solutions is both important and urgent. These solutions include the use of electronic health records, artificial intelligence (AI), smart wearables, telemedicine, and blockchain technology to secure healthcare data. However, the successful implementation of these solutions relies heavily on effective collaboration and innovation among stakeholders, such as researchers, technology companies, governments, and patients. Therefore, addressing this issue effectively will support the healthcare sector in developing sustainably and adapting to the evolving healthcare environment.

TÓM TẮT

Chuyển đổi số trong lĩnh vực y tế là quá trình thay đổi phương thức chăm sóc sức khỏe bằng cách tích hợp công nghệ vào hoạt động y tế. Điều này nhằm tối ưu hóa việc quản lý dữ liệu y tế, cải thiện chất lượng chăm sóc và tăng cường khả năng theo dõi sức khỏe từ xa. Mục tiêu là xây dựng một hệ thống y tế thông minh, bảo vệ sức khỏe cộng đồng và đảm bảo phát triển bền vững. Trong ngữ cảnh

này, phát triển y tế công nghệ cao và đa chức năng là xu thế tất yếu, mang tính quyết định, tuân thủ các nguyên tắc bảo mật và hiệu quả trong chăm sóc y tế. Để xây dựng nền y tế thông minh, bền vững và thích nghi với những thách thức mới thì việc triển khai các giải pháp công nghệ số là quan trọng và cấp thiết. Các giải pháp này tập trung vào việc sử dụng hồ sơ sức khỏe điện tử (EHR), trí tuệ nhân tạo (AI), thiết bị đeo thông minh, telemedicine và công nghệ blockchain để bảo mật dữ liệu y tế. Tuy nhiên, việc triển khai thành công các giải pháp công nghệ số này phụ thuộc nhiều vào sự kết hợp thông tin, tương tác và sáng tạo giữa các bên liên quan, bao gồm các nhà nghiên cứu, doanh nghiệp công nghệ, chính phủ và bệnh nhân. Do đó, nếu giải quyết tốt vấn đề này thì sẽ hỗ trợ nền y tế phát triển một cách bền vững và thích ứng với những thay đổi trong môi trường y tế hiện đại.

1. INTRODUCTION

1.1 The importance of digital transformation in healthcare

Health is the foundation of individual achievement, satisfaction, and happiness, as well as that of families and society at large. In addition to critical issues such as climate change and poverty, public health is a top priority that consumes significant resources from nations worldwide. The topic of health becomes even more crucial as the world enters a new era marked by revolutionary changes. Figure 1 illustrates the profound changes and significant development within the medical revolution.
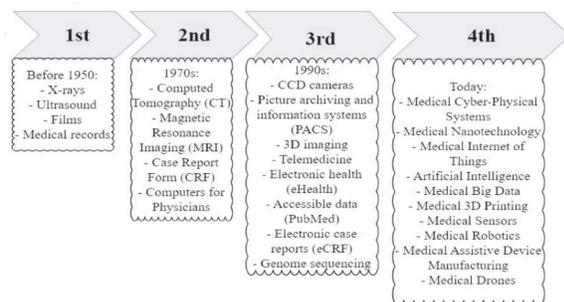

Figure 1. The history of the medical revolution

Digital transformation is the process of applying disruptive technologies to increase productivity, create value, and enhance social welfare. Healthcare encompasses all services provided to maintain and protect the physical and mental health of individuals and is one of the key sectors undergoing digital transformation [1]. The digital revolution in healthcare creates new opportunities and business models to address healthcare challenges and related issues such as population aging. Since 2010, the digitization of healthcare has become inevitable, and the global healthcare sector has deeply engaged in digital transformation.

The digital transformation process will positively impact and change healthcare activities in three main areas: First, it will affect the leadership, management, and executive operations within healthcare organizations, moving towards precise, timely, and effective decision-making based on digital technology. Second, it will directly impact the provision and

access to healthcare services, shifting from traditional methods to those based on digital platforms, thereby facilitating quick, timely, and ubiquitous access to healthcare services. Third, it will affect the working and communication methods of healthcare professionals, transitioning from a traditional work environment to a digital one, thus creating the "digital physician".

Developing a national healthcare data integration platform to connect and share among national healthcare databases, specialized health systems, and healthcare statistics; building and developing a primary healthcare data integration platform. Establishing platforms for non-cash medical service registration and payment; remote medical consultation platforms; super-app mobile platforms for providing healthcare services, aiming towards a healthcare service social network. Developing open healthcare data platforms, collecting health data from various sources such as citizens, businesses, social networks, and medical Internet of Things (IoT) devices related to health information, combined with data sharing from healthcare databases, to form an open data ecosystem in healthcare and a national health information network.

Accelerating the implementation of digital transformation in healthcare will help establish a smart disease prevention and health care system, enabling citizens to proactively prevent diseases, easily access health information, and receive timely, effective health care consultations and assistance. It will also lead to the creation of a smart medical examination and treatment system, allowing citizens to access advanced, high-quality, and convenient medical services, save time and costs, and reduce risks and complications during treatment. A smart healthcare management system will support healthcare management agencies in making timely policy decisions based on big data analytics, monitoring the effectiveness of the entire national healthcare service network, and improving responsiveness to unexpected situations, such as controlling and containing epidemics, sharing new treatment methods, and providing remote training, enabling the Vietnamese healthcare system to seamlessly connect and integrate with the world.

1.2 The role of smart healthcare in the development of telemedicine

1.2.1 Smart healthcare

Smart healthcare represents an advanced healthcare system where technologies such as AI, the IoT, Big Data, wearable devices, and automation are integrated to enhance the quality of healthcare services. This combination not only increases efficiency in diagnosis and treatment but also enables the personalization of healthcare processes, improves the ability to monitor and predict health conditions, and optimizes the management of medical data [2]. It often utilizes wearable devices, such as smartwatches, to monitor key health indicators like heart rate, physical activity levels, and sleep patterns. Additionally, AI applications play a crucial role in supporting more accurate diagnoses, analyzing medical images, and providing appropriate treatment options [3]. This combination not only improves healthcare outcomes but also allows patients to access medical services conveniently and efficiently through telemedicine applications.

A smart healthcare model, as shown in Figure 2, has been implemented in Ninh Thuan [4]: featuring various functions: when patients visit

the hospital for examination and treatment, their medical records are digitized, saving time and costs while increasing work efficiency and treatment effectiveness. Patients benefit from smart services such as using a "Smart Card" to access and utilize all integrated services on the system platform, including the Access Control System (ACS); the Intelligent Queue System (iQ); the Integrated Smart Operating Room System (AVAS); the premium Smart Inpatient Ward solution (iWard); the Bedside Consultation solution for doctors and nurses (AMIS); and Telehealth services for remote consultation and diagnosis.
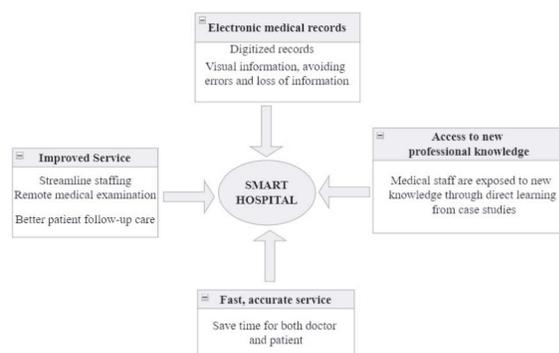

Figure 2. Smart hospital model

1.2.2 Telemedicine

Telemedicine, also known as remote medicine, telehealth, or e-health [5] is a term derived from "tele" in Greek, meaning "remote," and "medicine" from the Latin "mederi," meaning "to heal." The concept of telemedicine was first used in 1970 to describe the provision of healthcare services remotely through the use of information technology. These healthcare services can include diagnosis and treatment, medication provision, counseling, prevention and rehabilitation, health insurance, education, and research [6].

It is a branch of e-health that uses communication networks to provide healthcare

and medical education from one geographic location to another. It is implemented to address issues such as uneven distribution and shortages of infrastructure and personnel [7]. It offers numerous potential benefits, including: improved patient control, allowing individuals to better manage their health conditions and their lives while maintaining independence at home; in-home services, enabling access to services that were previously only available in hospitals; reduced need for hospital visits, decreasing the need for in-person visits to hospitals and doctors, thus saving time and travel costs; long-term management, supporting long-term management of chronic conditions at home; personalized technology, with technology tailored to individual needs; enhanced access in remote areas, improving access to services in remote or underserved regions; cost reduction, lowering overall healthcare costs; direct access to experts, providing direct access to healthcare specialists and eliminating waiting times; and continuous monitoring, offering continuous, 24/7 monitoring to address shortages of healthcare providers [5].

1.2.3 Role of smart healthcare in the development of telemedicine

Smart healthcare plays a crucial role in the development of telemedicine by enhancing the quality and effectiveness of healthcare services through the application of advanced technologies. Specifically, wearable devices and biosensors enable continuous monitoring of important health metrics such as heart rate and blood pressure. This allows doctors to remotely monitor and intervene in a timely manner [8].

Additionally, AI and big data enable the analysis and personalization of treatment protocols, optimizing effectiveness and

minimizing medical risks [9]. AI also supports remote diagnosis by analyzing medical images and health data, which helps shorten response times and improve accuracy in emergency diagnoses [10].

Moreover, smart healthcare combined with telemedicine helps expand access to medical services, particularly for individuals living in remote areas or with mobility limitations. These platforms also enable the sharing of patient data between different healthcare facilities, enhancing coordination in patient care and improving treatment outcomes [11].

2. RESEARCH METHODS

This study was conducted to study the cost of implementing digital transformation in healthcare in Vietnam, the role of smart healthcare in developing telemedicine, current formulas and propose suitable solutions. To achieve this goal, the study uses methods of analyzing and synthesizing documents from many reliable data sources.

2.1 Data source

Research data is collected from the following sources:

- Official reports: Documents of the Ministry of Health of Vietnam, the World Health Organization (WHO), the International Telecommunication Union (ITU), along with research and statistical reports on digital transformation in healthcare.

- Previous scientific articles and research: Domestic and international research works on smart healthcare, technology applications in distance learning, and the impact of digital transformation on the healthcare system.

2.2 Methods

The study uses the following main research methods to analyze and evaluate the problem:

- Methodological analysis documents: The study synthesizes and analyzes research documents, reports from medical organizations, scientific research and related data sources. This method helps to assess the actual state, identify trends and identify important issues in the digital transformation of healthcare.

- Qualitative research methods: The study assesses the impact of quantitative research on smart healthcare through analyzing factors such as technology application, health system performance, accessibility to remote healthcare services and the level of availability of the healthcare system in Vietnam.

- Methodological comparison: To have a comprehensive view, the study compares the digital transformation process in healthcare in Vietnam with other countries that have successfully applied smart healthcare and telemedicine models. This comparison helps to draw lessons and propose solutions suitable to the practical conditions of Vietnam.

3. RESULTS AND DISCUSSION

3.1 Current status of digital transformation in healthcare in Vietnam

In line with global trends, Vietnam is working to improve and develop its healthcare system to provide comprehensive health services to its citizens. Decision No. 4888/QD-BYT dated October 18, 2019, by the Ministry of Health, approves the "Project on the Application and Development of Smart Healthcare Information Technology for the Period 2019-2025" [12]. It emphasizes that digital technology is rapidly advancing and having a profound impact on all

aspects of economic and social life worldwide. Revolutionary advancements in digital science and technology are leading to trends that demand significant changes in national economic and social structures, as well as management systems across various sectors and fields. Digital transformation solutions play a crucial role in implementing the smart healthcare model.

Decision No. 749/QD-TTg dated June 3, 2020, by the Prime Minister approved the "National Digital Transformation Program until 2025, with a Vision to 2030" [13] identifying healthcare as one of the top eight priority areas for digital transformation. This reflects the government's significant expectation and interest in public health care. Furthermore, healthcare is recognized as "A sector with extensive social impact, closely related to people's daily lives, with the potential for rapid changes in perception, notable effectiveness, cost savings, and should be prioritized in the digital transformation process". Based on this, the Ministry of Health issued Decision No. 5316/QD-BYT dated December 22, 2020, on the "Approval of the Digital Transformation Program in Healthcare until 2025, with a Vision to 2030" [14]. The objectives include: (i) developing digital government in healthcare, (ii) promoting social development in the healthcare sector, (iii) maintaining indicators in prevention and health care, and (iv) implementing digital transformation in medical examination and treatment.

In line with global trends, Vietnam is striving to improve and develop its healthcare system to provide comprehensive health care for its citizens. Decision No. 4888/QD-BYT dated October 18, 2019, by the Ministry of Health, on the "Approval of the Project on the Application

and Development of Smart Healthcare Information Technology for the Period 2019-2025" [12] specifies that digital technology is advancing rapidly and having a profound impact on all aspects of economic and social life worldwide. Revolutionary changes in science and breakthrough digital technologies are driving trends that demand significant changes in national economic and social structures, as well as management systems across various sectors. Digital transformation solutions support the smart healthcare model.

Decision No. 749/QD-TTg dated June 3, 2020, by the Prime Minister approved the "National Digital Transformation Program to 2025, with a vision to 2030" [13]. According to this decision, healthcare is one of the top eight priority areas for digital transformation. This underscores the government's significant expectations and attention toward public health care. Moreover, healthcare is identified as a "sector with social impact, closely related to people's daily lives, capable of rapid change in perception, delivering effective results, saving costs, and needing to prioritize digital transformation." Based on this, the Ministry of Health issued Decision No. 5316/QD-BYT dated December 22, 2020, on the "Approval of the Digital Transformation Program for Healthcare to 2025, with a vision to 2030" [14], outlining objectives for (i) developing digital government in healthcare, (ii) promoting social development in healthcare, (iii) maintaining indicators for disease prevention and health care, and (iv) implementing digital transformation in diagnosis and treatment. Figure 3 presents the framework for analyzing digital transformation in healthcare in Vietnam.
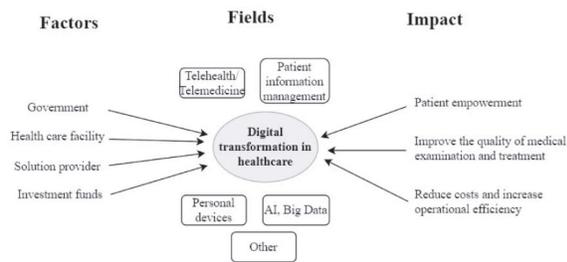
Figure 3. Framework for analyzing digital transformation in healthcare in Vietnam

Deploy Hospital Information Systems (HIS), Laboratory Information Systems (LIS), Radiology Information Systems/Picture Archiving and Communication Systems (RIS/PACS), and Electronic Medical Records (EMR) in compliance with both national and international standards. Ensure interoperability, data sharing, and integration, as well as seamless connectivity with all existing medical equipment in healthcare facilities (e.g., diagnostic machines, imaging devices, interactive screens, handheld devices, etc.) to enhance automation.

- Standardize Health ID: Use social insurance numbers or citizen identification numbers to create a unified Health ID and implement it nationwide.

- Develop "Smart Hospitals": Healthcare facilities should follow the Ministry of Health's Circular No. 54/2017/TT-BYT dated December 29, 2017, which establishes criteria for IT application in healthcare facilities. Develop a roadmap to achieve "smart hospital" status, meeting Level 6 of Circular 54 [15].

Implement Electronic Medical Records at all healthcare facilities according to the roadmap outlined in Circular No. 46/2018/TT-BYT dated December 28, 2018, by the Ministry of Health regarding Electronic Medical Records. This includes transitioning from paper-based medical records to electronic records and implementing

electronic payment systems for medical fees without the use of cash [16].

Implement remote consultation services in accordance with Official Letter No. 7946/BYT-KCB 2023, which provides guidelines for remote healthcare at primary healthcare levels [17]; Additionally, deploy a national electronic prescription management system at all public and private healthcare facilities across the country. Developing the application of AI in healthcare, prioritizing the following areas:

- Develop standards for connecting healthcare devices based on the Internet of Medical Things (IoMT) to build expert systems for clinical decision support;

- Develop a clinical decision support system that integrates closely and operates in real-time with electronic health records (EHR);

- Support medical imaging diagnosis and surgical assistance;

- Apply AI in specialized fields such as medical imaging, cardiology, respiratory medicine, orthopedics, oncology, pediatrics, etc;

- Healthcare facilities should build big data systems with fast analytical algorithms to support clinical decision-making based on AI;

- AI in traditional medicine.

3.2 Challenges of digital transformation in healthcare in Vietnam

3.2.1 Data security and privacy

One of the biggest challenges is the risk of loss or leakage of sensitive information. Digital healthcare systems store vast amounts of personal data, including medical records, test results, and patient contact information. If not adequately protected, this data can be stolen or misused, leading to serious consequences for both patients and healthcare facilities. According to a report

from IBM Security [18], the healthcare sector is a prime target for cyberattacks, with the average cost of a data breach reaching millions of dollars.

3.2.2 Human resources

One of the biggest challenges is the lack of technological skills among the healthcare workforces. Many current healthcare professionals are not adequately trained in digital tools and platforms. According to a report by the World Health Organization (WHO), "The lack of technological skills in the healthcare workforce can severely impact the effective implementation and use of new healthcare technologies" [19]. Current training programs may not fully meet the requirements for digital health transformation. Traditional medical training programs often do not include digital technology skills and healthcare data management. According to a report by the World Health Organization (WHO), "Health education systems in many countries, including Vietnam, still do not fully integrate information technology into the curriculum, leading to a shortage of essential digital skills" [20].

According to Professor Tran Diep Tuan, Chairman of the University Council of Ho Chi Minh City University of Medicine and Pharmacy, to upgrade the domestic healthcare system, the first step is to develop a modern medical education model that meets the needs of digital health transformation. The lack of technological skills could undermine the effectiveness of new healthcare systems, which directly affects the quality of patient care and safety.

3.2.3 Data reliability

Lack of trust in digital health is a significant barrier to its development. Patients, especially the elderly, often remain skeptical about the authenticity of information provided on digital health platforms. Additionally, concerns about data security and ownership of health information are major issues for patients. Since health data is highly sensitive and personal, patients are particularly concerned about how their data is collected, processed, and analyzed by service providers and/or third parties. Data breaches have occurred, and the concentration of personal information in national data repositories has led to public skepticism and a loss of trust in the government. Therefore, building trust in personal data security is essential to persuade the public to engage with the system. Public trust plays a crucial role in the success of technology [21]. This requires active involvement from the Department of Information Technology.

3.3 Digital transformation solutions for remote smart health models

Smart Telemedicine Model combines advanced technologies to provide remote healthcare services with higher accuracy and efficiency compared to traditional models. It includes key components such as smart health monitoring devices, AI and big data, online healthcare platforms, and EHR management. Wearable devices and remote diagnostic tools provide detailed, real-time health data, while AI supports diagnosis and treatment by analyzing health data and aiding decision-making (Wearable Technology in Healthcare, Artificial Intelligence in Healthcare). Big data helps predict health trends and personalize treatment (Big Data in Healthcare). Online healthcare platforms and EHR systems enable effective health monitoring and record management (Telemedicine Platforms, EHR). This model not only improves accuracy in diagnosis and treatment but also

enhances access to healthcare services, saving time and costs for both patients and doctors. By integrating modern technologies, smart telemedicine opens up new opportunities in health management and meets the increasing demands of patients and the global healthcare system.

User Health Monitoring System Using Smartwatches [22]: A new low-cost system has been proposed in Figure 4 to automatically detect health issues and alert healthcare professionals for timely intervention. The system integrates various smartwatches through cloud principles and provides the collected data to healthcare professionals to improve diagnostic decision-making. The system uses five supervised ML algorithms and the best-performing algorithm, artificial neural networks, with an accuracy of 99.5%, a recall rate of 99.5%, and an F1 score of 99.5%. This system aids doctors in managing their patients more easily, allows continuous monitoring of patients' health indicators, detects abnormal signs, and provides timely intervention. Interaction between patients, doctors, and family members becomes more convenient with this system.

Patient Activity Recognition and Posture Monitoring System [23]: The system proposed in Figure 5 uses continuous camera surveillance to monitor patient activities at home in real-time. The generated video stream is identified and labeled in real-time using the MediaPipe Pose framework and a Long Short-Term Memory (LSTM) network model trained and stored on a Raspberry Pi 4 device. If the patient's activity is deemed abnormal, indicating a potential health issue, the system will immediately send a warning message along with a snapshot of the abnormal activity to the patient's relatives via email and Telegram messaging app. Labeled videos are then stored on a virtual server on a regular schedule. Videos labeled as containing abnormal activity are stored on the server for a long term, while normal activity videos are retained for a short period and then deleted to save storage space. The algorithm for recognizing patient activities in real-time within the video and sending warning messages with images of abnormal activities to users is summarized and displayed.
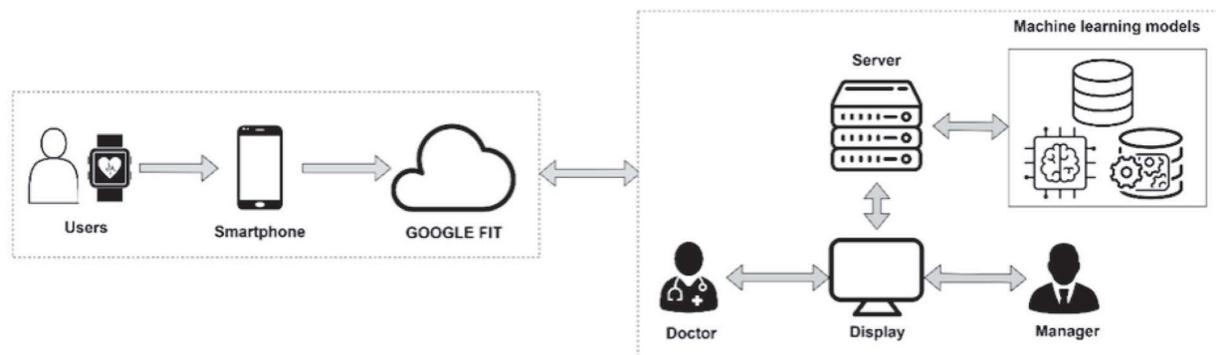

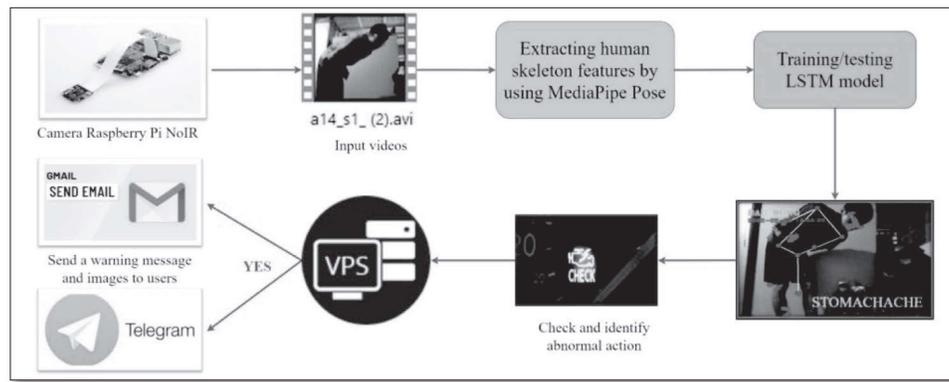**Figure 4. User health monitoring system using smartwatches**

Figure 5. Patient activity recognition and posture monitoring system

System for Remote Patient Activity Monitoring and Abnormal Alert Notification [24]: Figure 6 also proposes a real-time smart camera system for monitoring, recognizing, and alerting on abnormal patient activities from a distance. This system is cost-effective and easy to implement in practice. Specifically, it suggests a network model combining LSTM, MobileNetV2, and Raspberry Pi 4 for remote patient activity recognition. It provides a self-constructed dataset by collecting real-world data and reusing existing datasets. The system has been evaluated and tested with an accuracy exceeding 96%. With this system, if a patient's activity is identified as abnormal, indicating a potential health issue, the system will automatically send a warning message along with an image of the abnormal activity. This message will be sent to the patient's relatives via email and the Telegram messaging application.
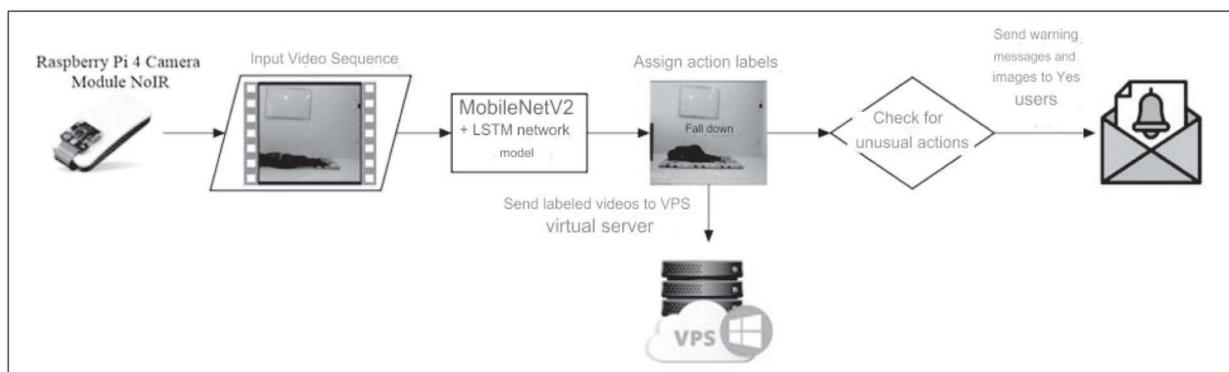

Figure 6. Remote patient activity monitoring system and abnormal alert notification

4. CONCLUSION AND RECOMMENDATIONS

In the context of rapid technological advancement, digital transformation in healthcare plays a crucial role in improving the quality of care and enhancing remote health monitoring, contributing to universal access to healthcare services. Digital transformation solutions not only increase the effectiveness of diagnostics and treatment but also expand the reach of healthcare services to remote areas with limited medical infrastructure. The smart telemedicine models proposed in this paper also contribute to advancing digital transformation, making remote health monitoring increasingly popular and developed. Increase Investment in

Technology Infrastructure: Healthcare facilities should invest heavily in IT infrastructure, including networks, servers, and data analytics tools, to ensure that remote healthcare solutions operate effectively and securely. Train the Workforce: To optimize the adoption of digital technology in healthcare, specialized training programs for healthcare staff on using digital tools and managing health data are essential. Training healthcare professionals for remote healthcare is a crucial factor in implementing and maintaining effective remote health systems. To ensure effective delivery of remote healthcare services, training programs should focus on equipping staff with the necessary skills and knowledge to work in a digital environment. Develop Regulations and Policies: Governments and healthcare organizations need to develop and update regulations and policies related to data security, privacy, and legal responsibilities in the use of remote healthcare services. Encourage Research and Development: Support research and development projects in the field of digital health to create new and more effective solutions for remote health monitoring and management. Expand the Use of Smart Technology: Integrate smart technologies such as AI, IoT, and big data into healthcare systems to enhance predictive capabilities and personalized treatment, thereby improving the quality of healthcare. Foster International Collaboration: Promote international cooperation to share experiences, technologies, and successful models from countries with effective remote healthcare implementations, aiming to learn from and apply these insights in the local context.

REFERENCES

[1] Marques, I. C. P., and Ferreira, J. J. M. (2020). Digital transformation in the area of health: systematic review of 45 years of evolution. *Health Technol*, *10*(3), 575–586. DOI: 10.1007/s12553-019-00402-8.

[2] Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., ... & Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and Vascular Neurology, 2*(4). https://svn.bmj.com/content/2/4/230.

[3] Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., & Thrun, S. (2017). Dermatologist-level classification of skin cancer with deep neural networks. *Nature, 542*(7639), 115–118.

[4] Thiện Nhân (2022). *Deployment of the first smart hospital project in Ninh Thuan*. https://thanhnien.vn/trien-khai-du-an-benh-vien-thong-minh-dau-tien-tai-ninh-thuan-1851419330.htm. Accessed: Aug. 16, 2024.

[5] *Telemedicine.* European Lung Foundation. https://europeanlung.org/wp-content/uploads/2021/01/telemedicine-vt.pdf. Accessed: Aug. 16, 2024.

[6] Trung, Q. H. (2021). Remote medicine - A new trend in modern medicine. *Vietnam Journal of Diabetes and Endocrinology*, *47*, 125–131. DOI: 10.47122/vjde.2021.47.17.

[7] Sood, S., Mbarika, V., Jugoo, S., Dookhy, R., Doarn, C. R., Prakash, N., & Merrell, R. C. (2007). What is telemedicine? A collection of 104 peer-reviewed perspectives and theoretical underpinnings. *Telemedicine and e-Health*, *13*(5), 573-590. DOI: 10.1089/tmj.2006.0073.

[8] Bashshur, R. L., Shannon, G. W., Smith, B. R., Alverson, D. C., Antoniotti, N., Barsan,

W. G., & Yellowlees, P. (2014). The Empirical Foundations of Telemedicine Interventions for Chronic Disease Management. *Telemedicine and e-Health*, *20*(9), 769-800. DOI: 10.1089/tmj.2014.9981.

[9] Mehta, N., and Pandit, A. (2018). Concurrence of big data analytics and healthcare: A systematic review. *International Journal of Medical Informatics*, *114*, 57-65. DOI: 10.1016/j.ijmedinf.2018.03.013.

[10] Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., & Thrun, S. (2017). Dermatologist–level classification of skin cancer with deep neural networks. *Nature*, *542*(7639), 115–118. DOI: 10.1038/nature21056.

[11] *Telemedicine: opportunities and developments in Member States: report on the second global survey on eHealth*. (2010). WHO Global Observatory for eHealth, p. 93.

[12] Ministry of Health. (2019). *Decision on the application and development of smart healthcare information technology* (Number 4888/QD-BYT), October 18,2019. https://thuvienphapluat.vn/van-ban/Cong-nghe-thong-tin/Quyet-dinh-4888-QD-BYT-2019-ung-dung-va-phat-trien-cong-nghe-thong- tin-y-te-thong-minh-426995.aspx. Accessed: Aug. 13, 2024.

[13] Government of Vietnam. (2020). *Decision approving the National Digital Transformation Program* (Number 749/QD-TTg), June 3, 2020.https://thuvienphapluat.vn/van-ban/Cong-nghe-thong-tin/Quyet-dinh-749-

QD-TTg-2020-phe-duyet-Chuong-trinh-Chuyen-doi-so-quoc- gia-444136.aspx. Accessed: Aug. 13, 2024.

[14] Ministry of Health. (2020). *Decision approving the digital transformation program for healthcare until 2025* (Number 5316/QD-BYT), December 22, 2020. https://thuvienphapluat.vn/van-ban/The-thao-Y-te/Quyet-dinh-5316-QD-BYT-2020-phe-duyet-chuong-trinh-chuyen-doi-so-y- te-den-2025-460152.aspx. Accessed: Aug. 13, 2024

[15] Ministry of Health. (2017). *Circular on the criteria for applying information technology at healthcare facilities* (Number 54/2017/TT-BYT), December 29, 2017. https://thuvienphapluat.vn/van-ban/Cong-nghe-thong-tin/Thong-tu-54-2017-TT-BYT-Bo-tieu-chi-ung-dung-cong-nghe-thong-news-tai-cac-co-so-kham-chua-benh-373292.aspx. Accessed: Aug. 13, 2024

[16] Ministry of Health. (2018). *Circular on the use and management of electronic medical records* (Number 46/2018/TT-BYT), December 28, 2018. https://thuvienphapluat.vn/van-ban/Cong-nghe-thong-tin/Thong-tu-46-2018-TT-BYT-su-dung-va-quan-ly-ho-so-benh- an-dien-tu-391438.aspx. Accessed: Aug. 13, 2024

[17] Ministry of Health. (2023). *Official letter on remote diagnosis and treatment at primary healthcare levels* (Number 7946/BYT-KCB), December 12, 2023. https://luatvietnam.vn/y-te/cong-van-7946-byt-kcb-2023-huong-dan-kham-chua-benh-tu-xa-tai-tuyen-y-te-co-so-282484-d6.html. Accessed: Aug. 16, 2024.

[18] *Cost of a Data Breach Report 2021.* (2021). IBM Security. https://info.techdata.com/rs/946-OMQ-360/images/Cost_of_a_Data_Breach_Report_2021.pdf. Accessed: Aug. 16, 2024.

[19] *Global strategy on digital health 2020-2025.* World Health Organization https://www.who.int/publications/i/item/9789240020924. Accessed: Aug. 16, 2024.

[20] *Digital education for building health workforce capacity.* World Health Organization. https://www.who.int/publications/i/item/9789240000476. Accessed: Aug. 17, 2024.

[21] Shah, T., et al. (2019). Information-sharing in health and social care: Lessons from a socio-technical initiative. *Public Money & Management*, 39(5), 359–363. DOI: 10.1080/09540962.2019.1583891.

[22] Doan Thanh Nghi (2023). A novel low-cost system for remote health monitoring using smartwatches. *Indian Journal of Computer Science and Engineering, 14*(3), 429-443. DOI: 10.21817/indjcse/2023/v14i3/231403068.

[23] Doan Thanh Nghi (2022). An Efficient Patient Activity Recognition using LSTM Network and High-Fidelity Body Pose Tracking. *International Journal of Advanced Computer Science and Applications*, 13(8). DOI: 10.14569/IJACSA.2022.0130827.

[24] Nghi, D. T., Triet, N. T. H., and An, T. T. (2021). Smart camera system for remote patient activity monitoring. *In Proceedings of the 14th National Conference on Fundamental and Applied Information Technology Research*. Hochiminh City, Vietnam: Publishing House for Natural Sciences and Technology. DOI: 10.15625/vap.2021.0049.