ISSN: 2182-2069 / E-ISSN: 2182-2077

Healthcare Monitoring-based Internet of Things (IOT)

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Received: July 15, 2024; Revised: August 23, 2024; Accepted: September 25, 2024; Published: November 30, 2024

Abstract

Remote health care is needed when direct medical monitoring is unavailable. Modern technology provides several ways to make patient access simpler. In particular, cloud, IoT, and data mining technologies have been successful in health care and medicine. This method identifies illnesses using data collected from two groups of patients, a male group and a female group where data are based on the heart rate, systolic blood pressure, and body temperature parameters. The three classifier types use the collected data: the naïve Bayes, support vector machine (SVM), and the J48. These three classification methods were considered to measure the classification accuracy using the proposed healthcare IOT-based monitoring system. The Precision, Recall, and F-measure evaluation measurements were used to quantify the obtained accuracy results of the two groups. The obtained results showed excellent classification results of 0.96, 0.99, and 0.98 for the naïve Bayes classifier to the male group that outperformed the results of the other two classifiers for the precision, recall, and f-measure, respectively. As for the female group, similar results have been obtained. In conclusion: The use of the Internet of Things in the proposed system makes it accurate and easy to use remotely by patients.

Keywords: Classification, Healthcare, IoT, Monitoring, Naïve Bayes, SVM.

1 Introduction

Technology in the healthcare sector extends the ways of providing healthcare to patients, developing treatments, and improving the work of healthcare facilities in general. There has been significant improvement in the fields of electronic health records (Negro-Calduch et al., 2021), telemedicine (Haleem et al., 2021; Rahaim et al., 2024), and diagnostic methods (Ali et al., 2020; Venigandla, 2022; bAmeer et al., 2022).

Journal of Internet Services and Information Security (JISIS), volume: 14, number: 4 (November), pp. 347-359.
DOI: *10.58346/JISIS.2024.I4.021*

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Among the clear developments, the importance of adopting electronic health records emerges as one of the most influential transformations in the healthcare field (Negro-Calduch et al., 2021; Shah & Khan, 2020; Al-Ja'afari et al., 2018) as electronic records serve as an alternative to the traditional paper-based system previously adopted, thus providing a comprehensive medical view of the patient's health condition. These records include comprehensive details of the case, such as medical history, diagnostic results, prescriptions, immunization records, allergies, x-rays, and laboratory results, thus facilitating the process of accessing patient information efficiently and easily.

Digital transformation to electronic health records has provided some improvements (Huang et al., 2020; Abdul Kareem et al., 2022). These include increasing the accuracy and completeness of patient records and thus reducing common errors such as poor handwriting, which affects the understanding of notes or overlap between files. In addition, health records provide immediate access to patient data, which supports rapid decision-making among healthcare professionals (Kodric et al., 2021). In addition, it allows patients easy access to personal health information (Sofiene et al., 2023). Telemedicine or telehealth uses technology to deliver health services remotely (Bokolo, 2021). This includes different methods of communication, such as video conferencing and mobile applications. Telemedicine has become widespread to address the distance problem and difficulty in reaching specialists for convenient health care services. One of the advantages of telemedicine is the ease of access to health care for people living in rural areas who lack services (Achenbach, 2020; Haque et al., 2022). Patients can talk to doctors from their homes without having to travel and in emergencies by obtaining quick consultations, which may sometimes save lives.

This paper presents an IoT-based patient health monitoring system using advanced algorithms (Boopathy et al., 2024).

The paper is organized as follows: In the second section, an overview of the use of IoT in healthcare is presented. In the third section, the methodology of the main components of the system is presented. The results are presented in the fifth section, and the conclusions are presented in the fifth section (Abdulmahdi et al., 2023).

2 Literature Review

This section presents the most important academic works on using the Internet of Things in healthcare, leading to many improvements, especially in diagnosing artificial intelligence and robotics (Odilov et al., 2024).

Developments in the field of disease detection help increase accuracy and early detection of diseases, magnetic resonance imaging, and computed tomography (Hussain et al., 2022). Science is evolving as the focus has been on using genetics and genomics to increase the accuracy of treatments. Genetic markers can predict diseases better and lead to increased success of treatments, thus making treatments more effective and reducing side effects (MacRitchie et al., 2020).

Artificial intelligence and machine learning significantly impact the healthcare sector's development (Hamilton et al., 2021; Qayyum et al., 2023; Rubinger et al., 2023; Santosh & Gaur, 2022). They help analyze large data at high speed and thus help doctors make better predictions (Alowais et al., 2023). Machine learning can analyze disease progression based on patient data patterns (Kumar et al., 2023). It can also help predict disease outbreaks and manage resources based on patient outcomes. AI systems provide healthcare through faster and more accurate decision-making. Individualized treatments can be suggested for each patient based on genetic information and medical history, improving outcomes and reducing unnecessary treatments (Ahmed et al., 2020; Khan et al., 2020).

Robots have evolved in surgery and have become more common (Kyrarini et al., 2021). Robots assist in performing surgeries and provide greater precision, smaller wounds, and less harm to the patient, including delicate surgeries such as cardiac (Iacob et al., 2024). These systems give surgeons greater precision in complex operations (Negrín et al., 2021). These robots also perform patient care, rehabilitation, medication delivery, and patient transport, assist in administering treatment, and contribute effectively to reducing the workload of healthcare workers and improving services to patients (Gillespie et al., 2021; Kanji et al., 2021). These technologies come with challenges such as ethical questions, data security, privacy, and following the rules set by regulatory bodies. Ethical issues in the use of AI arise in cases of errors and negative outcomes. The difficulty of understanding AI also appears in the aspect of transparency (Saraswat et al., 2022). Data security and privacy are very important, especially since EHRs and telemedicine involve sharing sensitive patient information digitally. Strong security measures, encryption, and compliance with rules like the Health Insurance Portability and Accountability Act (HIPAA) are essential to protect patient data (Humphrey, 2021; Marks & Haupt, 2023; Moore & Frye, 2020).

It is also crucial to understand and follow the complex regulations in healthcare when developing and using these technologies. These rules are essential for both innovation and patient care. Whether discussing medical devices, health information systems, or telemedicine platforms, all must comply with local, national, and international laws. Regulations cover everything from protecting patient data to ensuring that medical devices are safe before they are available. Not following these rules can lead to legal and financial problems, so it is important for everyone involved to know and follow them (Miller, 2023).

In the United States, HIPAA sets strict rules on handling patient health information, with heavy penalties for violations, including fines and criminal charges for serious neglect (Neelima et al., 2024). The General Data Protection Regulation (GDPR) in the European Union applies to all industries, including healthcare. It requires explicit consent for data collection, fast notifications of data breaches, and appointment of Data Protection Officers (Hansen et al., 2021). GDPR violations can result in huge fines, especially for healthcare companies serving European patients (Daigle & Khan, 2020).

Regarding medical devices, manufacturers must go through tough approval processes. For example, the U.S. Food and Drug Administration (FDA) ensures that medical devices are safe and effective before being sold. There is a significant risk of violating these rules, such as the U.S. Food and Drug Administration’s recall of implantable defibrillators in 2019 due to cybersecurity concerns (Benjamens et al., 2020; Darrow et al., 2021). Standards from groups such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) remain important, especially for companies looking to enter the market, and failure to do so could result in exclusion from the market (Darrow et al., 2021).

Despite their widespread popularity, telemedicine services need to be improved. Telemedicine technologies allow doctors and patients to connect remotely for consultations, monitoring, and diagnosis, but they come with challenges such as licensing, reimbursement, and practicing medicine across borders. Legal expertise in regulations and policies is crucial for telemedicine providers to avoid legal and financial issues (Nittari et al., 2020). Navigating healthcare regulations requires teamwork between healthcare providers, technology developers, regulatory agencies, and legal experts. Chief Compliance Officers (CCOs) have a key role in ensuring compliance. They must keep up with new regulations, identify risks of non-compliance, and create strategies to reduce these risks. Regular training, internal audits, and open communication with regulatory bodies are essential for staying compliant (Herrin, 2021).

Data protection is a major concern with IoT technology (Lee & Ahmed, 2021). IoT devices collect many types of data, each needing a different level of security. While some data, like temperature readings, may not need strong protection, more sensitive data, like GPS coordinates, require strict security measures. Ensuring that external systems are trusted through authentication and authorization is important. The data collection system must also protect it to maintain trust and security (Shahid et al., 2022).

Technology has become a major force in transforming healthcare. It improves diagnostic accuracy, supports predictive analytics, and personalizes medicine. However, we must address ethical, security, and regulatory challenges to benefit from these advancements fully. New technologies such as 5G, IoT, blockchain, augmented and virtual reality, 3D printing, and predictive healthcare will push the healthcare industry towards more accessible, efficient, and patient-focused care.

IoT plays a big role in this transformation, as connected devices, sensors, and data analytics are changing how healthcare is delivered. Integrating IoT into patient care improves healthcare quality, reduces costs, and improves patient outcomes. This paper discusses the key benefits of patient health monitoring and the components of an IoT-based system while addressing challenges such as data security and interoperability. Healthcare has tremendous potential, and new technologies such as robotics and artificial intelligence continue to innovate healthcare services.

3 Methodology

This section presents an overview of the proposed IoT-based patient health monitoring system. Each part is explained clearly and understandably. The proposed system provides IoT-based healthcare and monitoring, continuously tracking the patient's vital signs. The general design is shown in Figure 1. The sensors are connected to microcontrollers, the data is processed and sent to the central server via Wi-Fi, and a user-friendly interface has been created that allows real-time monitoring and control via Blynk. The system consists of sensors that collect patient data, microcontrollers (Arduino UNO), a Wi-Fi module (ESP8266), a cloud server, and a Blynk platform. These parts are important for the system to operate and monitor health data accurately and promptly, and to ensure that the data is analyzed without problems. Arduino UNO is the main controller and is popular because it is low-cost and easy to use. It communicates with different sensors to collect data about the patient's health, processes it, and sends it further, making it ideal for rapid development and testing and suitable for integration with the Internet of Things. The NodeMCU ESP8266 board is commonly used because it has built-in Wi-Fi. It is compatible with the Arduino IDE and is easy to program. It sends data from the microcontroller to the cloud computing system, thus ensuring that the data is sent securely and available for real-time monitoring.

At the system's core are a pulse oximeter and an MAX30100 heart rate monitor that senses heart rate and blood oxygen levels using LEDs and a photodetector. Data is collected precisely, then processed by the Arduino UNO and sent to the cloud. The ESP-01 Wi-Fi module wirelessly transmits the sensor data to the central cloud monitoring system. To further facilitate the system’s ease of use, a graphical interface has been created by Blynk that helps in managing and monitoring IoT devices. This interface increases the system's efficiency by allowing caregivers to check on patients remotely.

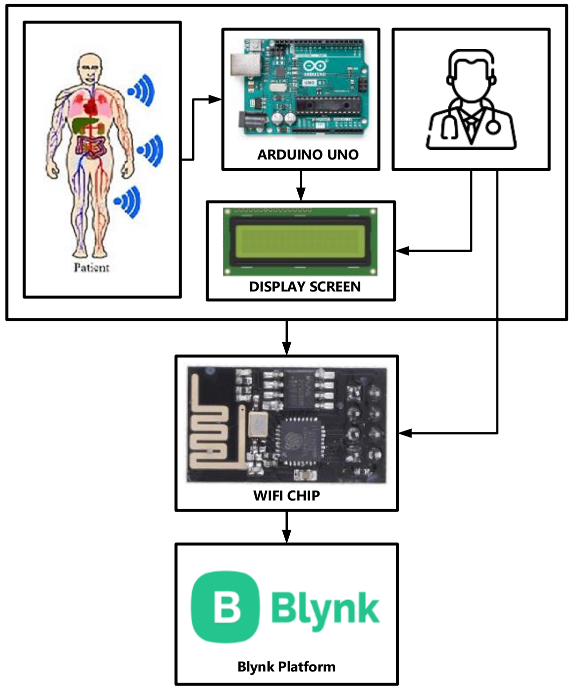

Figure 1: The Overall System Architecture

Figure 2 shows the process flow of the IoT-based health monitoring system. First, sensors are placed on the patient to gather health data, such as heart rate, blood oxygen levels, and body temperature. The microcontroller processes this information to create meaningful data. The system then checks the data to assess the patient's health. If it detects an emergency, the system will automatically alert emergency services.

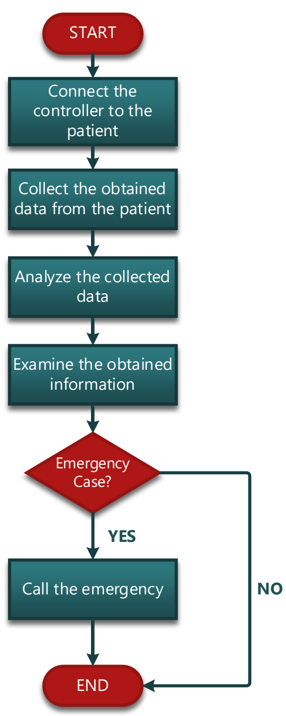

Figure 2: The Flowchart of the System

The implementation involves integrating all components as described. The sensors collect vital signs from the patient, which the Arduino UNO processes. The processed data is transmitted to the central server via the NodeMCU ESP8266 and displayed on the Blynk platform for real-time monitoring.

4 Results

The test results for Group A (Male Group) demonstrated the accuracy, precision, and recall measures of the proposed healthcare IoT-based monitoring system using different classification methods. The performance metrics are shown in Table 1. The Naive Bayesian classifier achieved the highest classification accuracy, outperforming the J48 and SVM techniques. This superior performance is attributed to the Naive Bayesian model's computational efficiency and lower training time.

Table 1: Results for Group A – Accuracy, Precision and recall

Classification Method	**Accuracy (%)**	**Precision**	**Recall**
Naive Bayesian	95.2	0.93	0.94
J48	90.7	0.89	0.88
SVM	92.3	0.91	0.9

The test results for Group B (Female Group) were conducted similarly to Group A. The results, presented in Table 2, showed comparable performance, confirming the robustness of the Naive Bayesian classifier across different demographic groups.

Table 2: Results for Group B – Accuracy, Precision and recall

Classification Method	**Accuracy (%)**	**Precision**	**Recall**
Naive Bayesian	94.8	0.92	0.93
J48	91.1	0.90	0.89
SVM	92.0	0.90	0.91

The following images illustrate the test results after configuring all components of the proposed design:

Right-Hand Monitoring: Figure 3 (left) shows the patient’s health monitoring device experimenting with a sample using the index finger of the right hand. The result appears on the mobile phone using Internet of Things technology and shows the heart rate as 87, the blood oxygen percentage as 98, and the body temperature as 33°C. This real-time experiment demonstrates the seamless integration of IoT technology in health monitoring, providing instant feedback and enabling rapid assessment of the individual's health status.

Left-Hand Monitoring: Figure 3 (right) shows the device being tested on the index finger of the left hand. The values and results are consistent with the previous test, showing a heart rate of 87 bpm, blood oxygen percentage of 98%, and body temperature of 32°C. This consistency highlights the reliability of the device.

Figure 3: Left: Sample Using the Index Finger of the Right Hand. Right: Blood Oxygen Percentage is 98, and the Body Temperature is 32

Chronic Heart Disease Monitoring: The device was tested on a sample of individuals suffering from chronic heart disease. The findings from this test (depicted in figure 6) revealed a significant difference in the heart rate, averaging 65 beats per minute, compared to the previous samples. This result underscores the device's ability to effectively detect variations in health conditions. The Oxygen Level in the Blood is 90, and The Body Temperature is 31 shown in Figure 4.

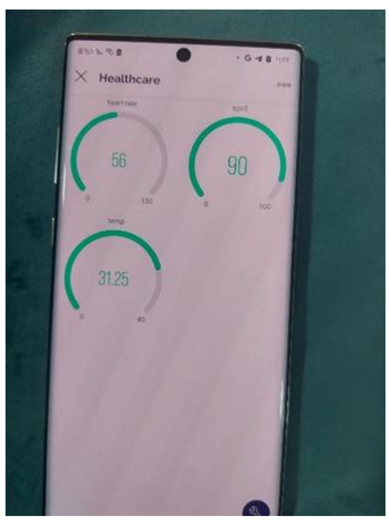

Figure 4: The Oxygen Level in the Blood is 90, and The Body Temperature is 31

These results indicate the effectiveness and reliability of the IoT-based patient healthcare monitoring system. The system allows for prompt monitoring of the patient's vital signs and alerting about emergencies, thus improving care and response speed. Based on the data collected from the sensors, the proposed system was further evaluated using Naive Bayesian, J48, and SVM. The accuracy evaluation included adjustments for systolic blood pressure, temperature, and heart rate. Figures 5 and 6 illustrate the performance measures for both male and female groups, respectively.

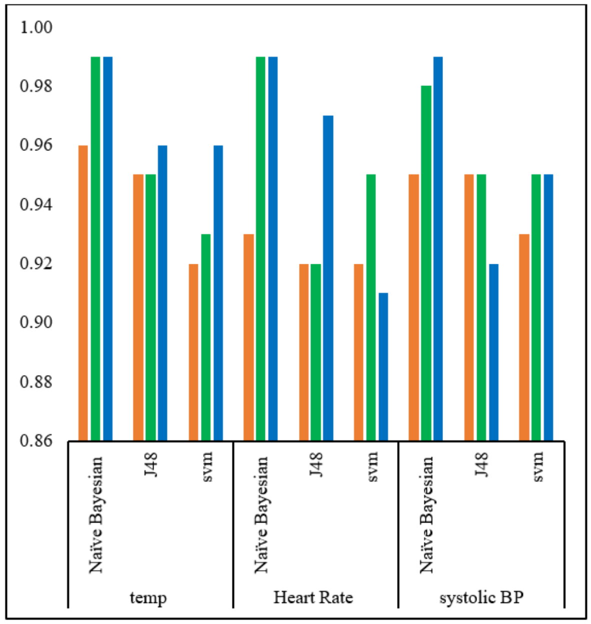

Figure 5: The Performance Measures Using the Three Collected Data from the Sensors for the Male Group

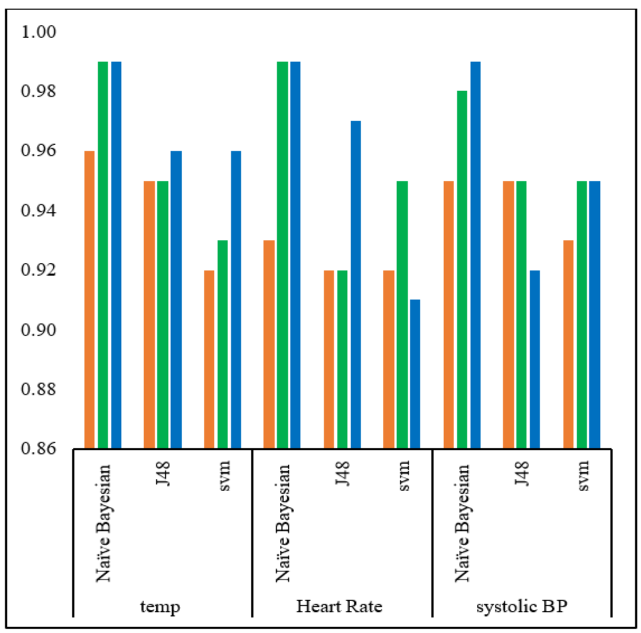

Figure 6: The Performance Measures Using the Three Collected Data from the Sensors for the Female Group

5 Discussion

The development of monitoring systems using the Internet of Things has improved the work of hospitals and patient care. This connection allows for continuous patient monitoring and faster data exchange. Both are essential for patient safety and increased interaction with the attending physician.

In real-time, IoT devices monitor vital signs such as heart rate, temperature, blood pressure, and blood sugar and send data wirelessly. The system was tested using three classifiers: Naive Bayesian, J48, and SVM. The Naive Bayesian classifier showed good performance and thus proved its efficiency in analyzing data collected from IoT sensors.

Naive Bayesian, J48, and SVM were chosen for their efficiency in dealing with medical data. The naive Bayesian classifier is known for its simplicity and is ideal for real-time systems. This makes it suitable for reading sensor data such as heart rate or temperature independent of each other.

J48 was chosen because it provides easy-to-understand decision rules and is therefore useful in medical settings where the reasons behind the predictions are shown. At the same time, SVM works well in dealing with complex and accurate data. K-Nearest Neighbors (KNN) has yet to be tested due to its complexity and slowness and, thus, is not ideal for real-time work.

6 Conclusion

The medical sector has greatly developed due to digital transformation and modern technologies. With the continued development, the need to use the Internet of Things technologies increases. The proliferation of portable medical devices, applications, and mobile health services has revolutionized healthcare delivery and the development of medical services. Modern methods such as artificial intelligence and robotics led to the discovery of new treatment methods and the ease of exchanging medical information over the Internet. This development has increased the accuracy of medical work, especially in achieving effective treatment results. Mobile devices and wireless networks have already been introduced to hospitals in the Middle East and North Africa, and the use of smart health devices has been activated. The spread of modern technologies in hospitals has led doctors and medical service providers to adopt modern methods, thus making them largely dispense with paper and replace it with mobile devices linked to Wi-Fi networks. The proposed work utilized a suite of sensors, including temperature, heart rate, and blood oxygen level sensors, to continuously monitor patients' health. The data collected by these sensors was periodically measured and transmitted to a computer platform and a mobile application. This system enabled accurate and effective remote monitoring of patient's conditions. Healthcare providers could monitor the measured data via the application and computer, allowing immediate action in response to abnormal changes in temperature, heartbeat, or blood oxygen levels.

Thanks to IoT technology, this project facilitated continuous and detailed patient health monitoring, significantly enhancing the chances of early detection of any health issues requiring immediate attention. This continuous monitoring capability improved patient care and supported proactive healthcare management, contributing to better health outcomes.

References

[1] Abdul Kareem, A. H., Ahmed, B. M., & Abdul-Rahaim, L. A. (2022). Design and Implementation of Humidity and Temperature Automation and Monitoring for Public Building Comfortable Climate Based on Cloud Platform. *Przeglad Elektrotechniczny*, *98*(4), 94. https://doi.org/10.15199/48.2022.04.21

[2] Abdulmahdi, M., Ali, A. H., Abdul-Rahaim, L. A., & Alhasani, A. T. (2023, July). IoT System of Medical Equipment Monitoring and Ambulance Tracking. In *2023 6th International Conference on Engineering Technology and its Applications (IICETA)* (pp. 571-574). IEEE. https://doi.org/10.1109/IICETA57613.2023.10351201

[3] Achenbach, S. J. (2020). *Telemedicine: benefits, challenges, and its great potential*. Health L. & Pol'y Brief, *14*, 1.

[4] Ahmed, Z., Mohamed, K., Zeeshan, S., & Dong, X. (2020). Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine. *Database*, *2020*, baaa010. https://doi.org/10.1093/database/baaa010

[5] Ali, A. M. E. E. R., Alrubei, M. O. H. A. M. M. E. D., Hassan, L. M., Al-Ja'afari, M., & Abdulwahed, S. (2020). Diabetes classification based on KNN. *IIUM Engineering Journal*, *21*(1), 175-181. https://doi.org/10.31436/iiumej.v21i1.1206

[6] Al-Ja'afari, M. A. M., Ali, A. H., Abdulwahed, S. H., Al-Rikabi, H., & Fakhruldeen, H. F. (2018). A Novel Algorithm for Sun Tracking System Based on Image Processing. *Journal of Engineering and Applied Sciences,13*(21), 9213-9217. https://doi.org/10.3923/jeasci.2018.9213.9217

[7] Alowais, S. A., Alghamdi, S. S., Alsuhebany, N., Alqahtani, T., Alshaya, A. I., Almohareb, S. N., & Albekairy, A. M. (2023). Revolutionizing healthcare: the role of artificial intelligence in clinical practice. *BMC medical education*, *23*(1), 689. https://doi.org/10.1186/s12909-023-04698-z

[8] bAmeer, H. A., Mohammedali, M. A., Abdul-Rahaim, L. A., & Al-Kharsan, I. H. (2022, May). Design of Surgical Arm Robot Based on Cloud Computing. In *2022 5th International Conference on Engineering Technology and its Applications (IICETA)* (pp. 289-293). IEEE. https://doi.org/10.1109/IICETA54559.2022.9888457

[9] Benjamens, S., Dhunnoo, P., & Meskó, B. (2020). The state of artificial intelligence-based FDA-approved medical devices and algorithms: an online database. *NPJ digital medicine*, *3*(1), 118. https://doi.org/10.1038/s41746-020-00324-0

[10] Bokolo, A. J. (2021). Application of telemedicine and eHealth technology for clinical services in response to COVID-19 pandemic. *Health and technology*, *11*(2), 359-366. https://doi.org/10.1007/s12553-020-00516-4

[11] Boopathy, E. V., Appa, M. A. Y., Pragadeswaran, S., Raja, D. K., Gowtham, M., Kishore, R., & Vissnuvardhan, K. (2024). A Data Driven Approach through IOMT based Patient Healthcare Monitoring System. *Archives for Technical Sciences, 2*(31), 9-15. http://dx.doi.org/10.70102/afts.2024.1631.009

[12] Daigle, B., & Khan, M. (2020). The EU general data protection regulation: an analysis of enforcement trends by eu data protection authorities. *J. Int'l Com. & Econ.*, 1.

[13] Darrow, J. J., Avorn, J., & Kesselheim, A. S. (2021). FDA regulation and approval of medical devices: 1976-2020. *Jama*, *326*(5), 420-432. https://doi.org/10.1001/jama.2021.11171

[14] Gillespie, B. M., Gillespie, J., Boorman, R. J., Granqvist, K., Stranne, J., & Erichsen-Andersson, A. (2021). The impact of robotic-assisted surgery on team performance: a systematic mixed studies review. *Human factors*, *63*(8), 1352-1379. https://doi.org/10.1177/0018720820928624

[15] Haleem, A., Javaid, M., Singh, R. P., & Suman, R. (2021). Telemedicine for healthcare: Capabilities, features, barriers, and applications. *Sensors international*, *2*, 100117. https://doi.org/10.1016/j.sintl.2021.100117

[16] Hamilton, A. J., Strauss, A. T., Martinez, D. A., Hinson, J. S., Levin, S., Lin, G., & Klein, E. Y. (2021). Machine learning and artificial intelligence: applications in healthcare epidemiology. *Antimicrobial Stewardship & Healthcare Epidemiology*, *1*(1), e28. https://doi.org/10.1017/ash.2021.192

[17] Hansen, J., Wilson, P., Verhoeven, E., Kroneman, M., Kirwan, M., Verheij, R., & van Veen, E. B. (2021). Assessment of the EU Member States' rules on health data in the light of GDPR. https://doi.org/10.2818/546193

[18] Haque, M. M. A., Jahan, Y., Khair, Z., Moriyama, M., Rahman, M. M., Sarker, M. H. R., & Hawlader, M. D. H. (2022). Perceptions about telemedicine among populations with chronic diseases amid COVID-19: data from a cross-sectional survey. *International journal of environmental research and public health*, *19*(7), 4250. https://doi.org/10.3390/ijerph19074250

[19] Herrin, B. S. (2021). What Your Compliance Officer Is-And Is Not. *J. Health Care L. & Pol'y*, *24*, 139.

[20] Huang, C., Koppel, R., McGreevey III, J. D., Craven, C. K., & Schreiber, R. (2020). Transitions from one electronic health record to another: challenges, pitfalls, and recommendations. *Applied clinical informatics*, *11*(05), 742-754. https://doi.org/10.1055/s-0040-1718535

[21] Humphrey, B. A. (2021). *Data privacy vs. innovation: A quantitative analysis of artificial intelligence in healthcare and its impact on HIPAA regarding the privacy and security of protected health information*. Robert Morris University.

[22] Hussain, S., Mubeen, I., Ullah, N., Shah, S. S. U. D., Khan, B. A., Zahoor, M., ... & Sultan, M. A. (2022). Modern diagnostic imaging technique applications and risk factors in the medical field: a review. *BioMed research international*, *2022*(1), 5164970. https://doi.org/10.1155/2022/5164970

[23] Iacob, E. R., Iacob, R., Ghenciu, L. A., Popoiu, T. A., Stoicescu, E. R., & Popoiu, C. M. (2024). Small Scale, High Precision: Robotic Surgery in Neonatal and Pediatric Patients—A Narrative Review. *Children*, *11*(3), 270. https://doi.org/10.3390/children11030270

[24] Kanji, F., Catchpole, K., Choi, E., Alfred, M., Cohen, K., Shouhed, D., & Cohen, T. (2021). Work-system interventions in robotic-assisted surgery: a systematic review exploring the gap between challenges and solutions. *Surgical endoscopy*, *35*, 1976-1989. https://doi.org/10.1007/s00464-020-08231-x

[25] Khan, O., Badhiwala, J. H., Grasso, G., & Fehlings, M. G. (2020). Use of machine learning and artificial intelligence to drive personalized medicine approaches for spine care. *World neurosurgery*, *140*, 512-518. https://doi.org/10.1016/j.wneu.2020.04.022

[26] Kodric, Z., Vrhovec, S., & Jelovcan, L. (2021). Securing edge-enabled smart healthcare systems with blockchain: A systematic literature review. *Journal of Internet Services and Information Security*, *11*(4), 19-32. https://doi.org/10.22667/JISIS.2021.11.30.019

[27] Kumar, K., Kumar, P., Deb, D., Unguresan, M. L., & Muresan, V. (2023, January). Artificial intelligence and machine learning based intervention in medical infrastructure: a review and future trends. In *Healthcare*, *11*(2), 207. https://doi.org/10.3390/healthcare11020207

[28] Kyrarini, M., Lygerakis, F., Rajavenkatanarayanan, A., Sevastopoulos, C., Nambiappan, H. R., Chaitanya, K. K., & Makedon, F. (2021). A survey of robots in healthcare. *Technologies*, *9*(1), 8. https://doi.org/10.3390/technologies9010008

[29] Lee, C., & Ahmed, G. (2021). Improving IoT privacy, data protection and security concerns. *International Journal of Technology, Innovation and Management (IJTIM)*, *1*(1), 18-33. https://doi.org/10.54489/ijtim.v1i1.12

[30] MacRitchie, N., Frleta-Gilchrist, M., Sugiyama, A., Lawton, T., McInnes, I. B., & Maffia, P. (2020). Molecular imaging of inflammation-Current and emerging technologies for diagnosis and treatment. *Pharmacology & Therapeutics*, *211*, 107550. https://doi.org/10.1016/j.pharmthera.2020.107550

[31] Marks, M., & Haupt, C. E. (2023). AI chatbots, health privacy, and challenges to HIPAA compliance. *Jama*. https://doi.org/10.1001/jama.2023.9458

[32] Miller, T. (2023). Artificial Intelligence in Healthcare Renders Privacy Artificial Under the Current Regulatory Scheme. *Houston Journal of Health Law & Policy*.

[33] Moore, W., & Frye, S. (2020). Review of HIPAA, part 2: limitations, rights, violations, and role for the imaging technologist. *Journal of nuclear medicine technology*, *48*(1), 17-23. https://doi.org/10.2967/jnmt.119.227827

[34] Neelima, S., Govindaraj, M., Subramani, D. K., ALkhayyat, A., & Mohan, D. C. (2024). Factors influencing data utilization and performance of health management information systems: A case study. *Indian Journal of Information Sources and Services*, *14*(2), 146-152. https://doi.org/10.51983/ijiss-2024.14.2.21

[35] Negrín, R., Ferrer, G., Iñiguez, M., Duboy, J., Saavedra, M., Larraín, N. R., & Barahona, M. (2021). Robotic-assisted surgery in medial unicompartmental knee arthroplasty: does it improve the precision of the surgery and its clinical outcomes? Systematic review. *Journal of Robotic Surgery*, *15*(2), 165-177. https://doi.org/10.1007/s11701-020-01162-8

[36] Negro-Calduch, E., Azzopardi-Muscat, N., Krishnamurthy, R. S., & Novillo-Ortiz, D. (2021). Technological progress in electronic health record system optimization: Systematic review of systematic literature reviews. *International journal of medical informatics*, *152*, 104507. https://doi.org/10.1016/j.ijmedinf.2021.104507

[37] Nittari, G., Khuman, R., Baldoni, S., Pallotta, G., Battineni, G., Sirignano, A., & Ricci, G. (2020). Telemedicine practice: review of the current ethical and legal challenges. *Telemedicine and e-Health*, *26*(12), 1427-1437. https://doi.org/10.1089/tmj.2019.0158

[38] Odilov, B. A., Madraimov, A., Yusupov, O. Y., Karimov, N. R., Alimova, R., Yakhshieva, Z. Z., & Akhunov, S. A. (2024). Utilizing Deep Learning and the Internet of Things to Monitor the Health of Aquatic Ecosystems to Conserve Biodiversity. *Natural and Engineering Sciences*, *9*(1), 72-83. https://doi.org/10.28978/nesciences.1491795

[39] Qayyum, M. U., Sherani, A. M. K., Khan, M., & Hussain, H. K. (2023). Revolutionizing Healthcare: The Transformative Impact of Artificial Intelligence in Medicine. *BIN: Bulletin of Informatics*, *1*(2), 71-83.

[40] Rahaim, L. A. A., Hasan, D. S., & Ali, A. H. (2024). Smart Cars Parking Systems of Big Cities based on the Internet of Things. *Journal of Internet Services and Information Security (JISIS), 14*(3), 380-392. https://doi.org/10.58346/JISIS.2024.I3.023

[41] Rubinger, L., Gazendam, A., Ekhtiari, S., & Bhandari, M. (2023). Machine learning and artificial intelligence in research and healthcare. *Injury*, *54*, S69-S73. https://doi.org/10.1016/j.injury.2022.01.046

[42] Santosh, K. C., & Gaur, L. (2022). *Artificial intelligence and machine learning in public healthcare: Opportunities and societal impact*. Springer Nature.

[43] Saraswat, D., Bhattacharya, P., Verma, A., Prasad, V. K., Tanwar, S., Sharma, G., & Sharma, R. (2022). Explainable AI for healthcare 5.0: opportunities and challenges. *IEEE Access*, *10*, 84486-84517. https://doi.org/10.1109/ACCESS.2022.3197671

[44] Shah, S. M., & Khan, R. A. (2020). Secondary use of electronic health record: Opportunities and challenges. *IEEE Access*, *8*, 136947-136965. https://doi.org/10.1109/ACCESS.2020.3011099

[45] Shahid, J., Ahmad, R., Kiani, A. K., Ahmad, T., Saeed, S., & Almuhaideb, A. M. (2022). Data protection and privacy of the internet of healthcare things (IoHTs). *Applied Sciences*, *12*(4), 1927. https://doi.org/10.3390/app12041927

[46] Sofiene, M., Souhir, C., Yousef, A., & Abdulrahman, A. (2023). Blockchain Technology in Enhancing Health Care Ecosystem for Sustainable Development. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, *14*(3), 240-252. https://doi.org/10.58346/JOWUA.2023.I3.018

[47] Venigandla, K. (2022). Integrating RPA with AI and ML for Enhanced Diagnostic Accuracy in Healthcare. *Power System Technology*, *46*(2), 33-42.

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