Journal of Technology Research (JTR)
Volume 5, Issue 1, (2025), pp 001-010, ISSN 3005-639X

The Internet of Things Applications: Its Effects, Roles, and Implications in Libyan Healthcare System

Khaled M. Ben Hamed*[1], Nahed F. Farah[1]

[1]Mobile Computing Department, Faculty of Information Technology, University of Tripoli, Libya.
*Corresponding author email: k.benhamed@uot.edu.ly

Received: 02-05-2025 | Accepted: 27-05-2025 | Available online: 01-06-2025 | DOI:10.26629/jtr.2025.01

ABSTRACT

Libya is more shifting to digital transformation. Using Ubiquitous Computing (Ubicomp) by Integrating Internet of Things (IoT) technologies and mobile computing (MC) in the Libyan healthcare system (LHS) represents a transform shift with tangible benefits. Merging IoT, which brings connectivity of the network and their devices, low-power consumption, Miniaturization, and biosensors with mobile computing, which brings remote health monitoring, real-time locating, personalized healthcare, better patient-doctor interaction. This merger will have dramatic improvement by enabling patients, devices, doctors, sensors, health providers, and supply chains to communicate and interact with each other seamlessly and autonomously, without requiring explicit human intervention.

This paper presents some of the innovations in IoT technologies on a global scale. Based on our previous works, the authors discuss the roles, effects, and implications of IoT technologies inclusion in the digital transformation of LHS. Also, the authors aim to inspire healthcare providers, policymakers, and researchers in Libya to collaborate in developing and using IoT in their digital transformations of LHS.

Keywords: Ubiquitous computing, Mobile computing, Edge computing, IoT, Real-time system, Health informatics, assistive technology, Cloud.

تطبيقات إنترنت الأشياء: آثارها وأدوارها وتداعياتها على نظام الرعاية الصحية الليبي

خالد بن حامد[1]، ناهد فرح[1]

[1]قسم الحوسبة المتنقلة، كلية تقنية المعلومات، جامعة طرابلس، ليبيا.

ملخـــــــص البحـــــــث

تسعى ليبيا وبجدية نحو التحول الرقمي، وسيُحدث استخدام الحوسبة الشاملة **(Ubicomp)** من خلال دمج تقنيات إنترنت الأشياء **(IoT)** والحوسبة المتنقلة **(MC)** في النظام الصحي الليبي تحولاً ملموساً وذو فوائد جمة. إن دمج إنترنت الأشياء الذي يتيح اتصال أجهزة الاستشعار الحيوية بالشبكة وباستهلاك منخفض للطاقة، مع الحوسبة المتنقلة التي تتيح رصد الحالة الصحية عن بعد، وتحديد المواقع في الوقت الفعلي، وتقديم الرعاية الصحية الشخصية، وتحسين التفاعل المريض والطبيب. من المتوقع أن يحقق تحسيناً كبيراً في نظام الرعاية الصحية في ليبيا، حيث سيُمكن المرضى والأجهزة والأطباء وأجهزة الاستشعار ومقدمي الخدمات الصحية من التواصل والتفاعل بسلاسة واستقلالية، دون الحاجة إلى تدخل بشري صريح.

تم استخدام منهجية بحثية تكامل فيها المنهج الوصفي والتحليلي والاستقرائي مع التجريبي؛ وذلك لتقديم رؤية شاملة عن دور تقنيات إنترنت الأشياء في التحول الرقمي للنظام الصحي حيث تستعرض هذه الورقة بعضاً من الابتكارات العالمية في تقنيات إنترنت الأشياء، استنادا إلى أبحاثنا السابقة. وتُناقش دور هذه التقنيات في التحول الرقمي للنظام الصحي الليبي، و تحلل أثارها بدءًا من تحسين كفاءة الرعاية الصحية إلى تقديم حلول مبتكرة لرصد الحالات الصحية وإدارة الأمراض المزمنة وغيره، مع تسليط الضوء على تداعياتها المُحتملة. ويهدف المؤلفون من خلال جُملة من التوصيات التي خلصت لها هذه الورقة إلى تحفيز وإلهام مقدمي الرعاية الصحية وصُناع القرار والبُحاث في ليبيا للتعاون الفعّال لتوظيف تقنيات إنترنت الأشياء في تطوير النظام الصحي الليبي؛ مما يُعزز تحقيق التحول الرقمي وتبني سياسات داعمة لنجاح هذا التحول.

الكلمات الدالة: ي الحوسبة الشاملة، الحوسبة المتنقلة، الحوسبة الطرفية، إنترنت الأشياء، نظام الوقت الحقيقي، المعلوماتية الصحية، التكنولوجيا المساعدة، الحوسبة السحابية.

1. INTRODUCTION

In 1988, computer scientist Mark Weiser first coined the term "*Ubiquitous Computing*" [1]. Weiser published two short memos titled "*Ubiquitous Computing #1*" and "*Ubiquitous Computing #2*." In these memos, he outlined his vision of a future in which computing, as we knew it, would no longer be done by desktop computers. Instead, Mark envisioned computing moving into our everyday environments, where context-aware services would be provided to users ubiquitously (anywhere, anytime). In contrast to desktop computing, *Ubicomp* would mean that people no longer have to interact directly with their computers to perform certain tasks because the objects around them use artificial intelligence (AI) and machine learning (ML) to understand their needs and proactively respond to them [2]. In 1999, Kevin Ashton invented the term "*Internet of Things*" by expanded on the same concept and specified the advancements of mobile technologies, such as mobile devices wearable devices that would potentially realize the *Ubicomp* as envisioned by Weiser [3]. In addition, the term got popular with an ITU report in 2005 called "*The Internet of Things*" [4].

In 2023, there were more than 15.9 billion connected IoT devices and the number is expected to double to 32.1 billion by 2030 [5]. This means almost every object around us such as streetlights, thermostats, refrigerator, TV, cars, elevators, even garbage baskets—is connected to the Internet. This positions the IoT as a key factor of digital transformation for a societal transformation that promises to change the way we interact with our surroundings. The *LHS* can benefit greatly from this growth.

IoT technologies involves the interconnection of various of themes including distributed computing, mobile computing, location-aware computing, mobile networking, sensor networks, human–computer interaction, context-aware, and AI. Via the Internet, those themes communicate with each other and share data resulting in a creation of smart environment.

Currently, the Libyan healthcare system is not using IoT technologies to improve patient care and outcomes. As a consequence, limiting the opportunities for remote monitoring, personalized treatment plans, and efficient **healthcare delivery**. Whereas the IoT is currently being used in Europe, China, Far East Asia and reshaping societies [6]. As such, it is crucial for *LHS* to stay abreast of the latest developments in this field and explore the ways in which IoT can be leveraged for positive change in the digital transformation of *LHS*.

The positive effects of using IoT in *LHS* are as follows:

- **Cost reduction:** The IoT can sharply reduce healthcare cost by streamlining processes, automating routine tasks, and decreasing the need for expensive interventions while enhancing healthcare.

- **Enhances patient care:** by enabling real-time data collection, accurate documentation, and monitoring. Thereby improving response times, patient outcomes, and future data analysis.
- **Doctor-patient interaction:** by providing real–time, location-aware, continuous communications with patients through mobile apps and IoT-connected devices. Therefore, providing better personal patient care, and health data share.

Overall, using IoT in *LHS* requires collaborations healthcare providers, patients, policymakers, and researchers to constantly address the effects, roles, and implications associated with its usage.

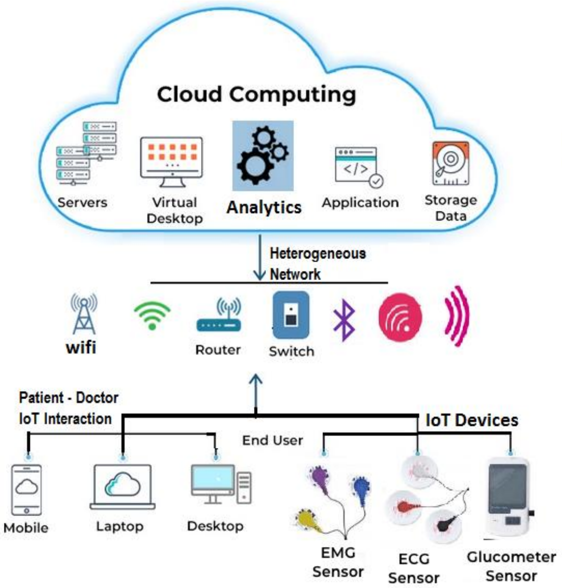

Fig 1. IOT main themes.

As shown in Fig 1, the main IoT themes including AI, sensors and actuators, human–computer interaction, machine–machine interaction, cloud, heterogeneous communication media, diverse computing, and security. Next, the authors discuss based on our experiments the effects, roles, and implications of grouping particularly mobile computing with IoT themes in the *LHS* services.

2. IOT TECHNOLOGIES IN HEALTHCARE

2.1. Sensors and Actuators

Sensors such as heart rate monitors, blood pressure sensors, glucose sensors, temperature sensors, and motion sensors, are vital for remote patient monitoring, chronic disease management, and real-time health evaluations. Also, Actuators such as infusion pumps, robotic surgery systems, automated medication dispensers, and adjustable hospital beds, convert sensor signals into physical actions, thereby improving patient care and operational efficiency [7]. Table 1 presents the most frequently utilized sensors in healthcare systems. Apart from these various healthcare sensor technologies, researchers continue creating more cutting-edge sensors to detect vital physical signs. Some of these biosensors can be incorporated in the digital transformations *LHS*.

For instance, we used in our experiments some sensers such as *EMG*, *MAX30102*, M1 DHT22, pp11bh1750 and *GY-906*. These sensers were connected to mobile apps to facilitate in obtaining results and sending them in real-time to the cloud seamlessly and autonomously without interventions of the patient or/and service providers. The effect of these IOT mobile healthcare apps may prove to be a key in monitoring patients' conditions and enabling rapid intervention in emergency and critical situations.

2.2. Communications

Heterogenous communication technologies such as *Bluetooth*, *Zigbee*, *NFC*, *Wi-Fi*, and cellular networks are fundamental component of IoT to enable a seamless and a real-time data sharing between sensors, medical equipment, computing, data analytics using AI, security, patients, and healthcare providers [8].

Table 1. Provides Sensors are an essential component of IoT devices [23-27].

Sensor type	Product Name	Vital physical signs	Observations
Skin electrodes	*EMG	Electromyography	Muscle activity *
	*MAX30102	Electrocardiography	Heart rate, heart rate variability *
Woven metal electrodes	SN-PH0-14	Galvanic skin response	Skin electrical conductivity
Infrared	IR Sensors	Blood flow and pressure	Measure heat radiation
Accelerometer	ADXL345	Activity, mobility and fall	Body posture, limb movement
Electrochemical		Activity, and mobility	Sweat analysis, bimolecular analysis
Glucose meter	Accu-Check Guide Dexcom G6	Blood glucose	Amount of glucose in the blood for glucose monitoring
Piezoelectric	Keyestudio	Respiration	Breathing rate, physical activity, inspiration and expiration
Cuff pressure sensor	BMP180	Blood pressure	Status of the cardiovascular system, Hypertension
Temperature sensor	* GY-906 Sensor	Temperature	Skin temperature, health state *
Scalp-placed electrodes	Electroencephalo graphy (EEG)	Electroencephalogram	Electrical activity of the brain, brain potential
Sphygmomano meter	Sunrom	Blood pressure	Blood pressure
The galvanic skin response	empatica e4	Activity and mobility	Monitor sweating

analytics using AI, security, patients, and healthcare providers [8].

For example, we used *Bluetooth* and *Wi-Fi* connectivity while developing a mobile health app to track the spread of Covid-19 pandemic in Libya using social networking project [9]. This app tracks the spread of Covid-19 among the app users while they are in social gatherings using *Bluetooth* connectivity. In addition, the *Wi-Fi* connectivity facilitates the efficient exchange of real-time data and information on the number of infected people and their locations with healthcare providers using the cloud. This mobile health app enables the transmission of information related to the spread of the Covid-19 pandemic in surrounding communities in real-time. The positive rule of this mobile health app is it allowed patients, healthcare providers, policymakers, and researchers to be better informed of their personal health and the accelerating rate of the spread of the pandemic.

One of the implications of using IoT mHealth apps in Libya is that only the 4G network is available. As shown in Table-2, 1G started the first mobile calls. 2G and 3G period provided faster data-transmission speeds which paved the way for video calling and mobile internet access. Also, the term "mobile broadband" was first applied to 3G cellular technology. 4G supports mobile web access like 3G does and also gaming services, HD mobile TV, video conferencing, 3D TV, and other features

Table 2. Shows differences and comparisons of 1g to 6g technologies.

Generation	release	services	technologies	speed	bandwidth	milestone
1G	1980s	voice	amps, nmt, tacs	2kbps	30 khz	first mobile calls
2G	1990s	voice, sms, slow data	gsm, cdma	9.2–100 kbps	200 khz	sms introduced roaming
3G	2000s	voice, video call, mms	wcdma, cdma2000	2 - 21 mbps	5 mhz	speed in mbps
4G	2010s	voice, high speed data, IoT	lte	10 mbps – 1gbps	1.4mhz - 20mhz	allip, volte, IoT
5G	2020s	fast data, massive IoT, low latency application	nr	>1 gbps	100mhz - 1ghz	very high speed data low latency, mmwave
6G	2030s	ultra fast data, holographic call	?	~100 gbps	1100ghz - 100ghz	terra hertz frequency, hugh bandwith

that demand high speeds. This because the max speeds of a 4G network when the device is moving is 100 Mbps and up to 1 Gbps for low-mobility communication such as when the caller is stationary or walking [10].

However, the 5G network promises significantly faster data rates, higher connection density, much lower latency, and energy savings [11]. By covering three main verticals namely, Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC), and Ultra Reliable Low Latency Communications (URLLC) to support a wide variety of use cases such as IoT, AR/VR, and self-driving cars. One of the key advantages of 5G networks is availability of a vast number of IPs that facilitate the support rapid expansions of connected devices on IoT [12].

In Libya, networks services provider offers 4G services but has struggled with network congestions, leading poor internet quality. Currently, the Libyan Communications Authority organizes workshops aimed to transition from Internet Protocol (IPv4) to the Internet Protocol (IPv6) in Libya. As IP is a fundamental component of the IoT, enabling devices to communicate with each other over a network. From IoT communication prospective, IPv6 has a greater address space than IPv4, which is required for expanding the IP Connected Devices in IoT.

As shown in Table 3, IPv6 has 128 bit IP Address rather and IPv4 has a 32-bit Address. This transition in Libya, IPv6 has several of the key advantages over IPv4. If Libya moves quickly in transition from IPv4 to IPv6, will set the first step for Libya in one of the fastest-growing industries, namely IoT industries, paves the way for Libyan entrepreneurs looking to start a business in IoT mHealth systems developments industry.

2.3. Computing

Computing in IoT plays a pivotal role in real-time processing and managing different types of information and analyzing data intelligently. Computing in the IoT is divided into three themes:

Table 3. Comparisons between of ipv4 and ipv6 addresses.

Categories	IPv4	IPv6
Bit IP No.	32-bit	128 bit
Space	4.29×10^{9}	3.4×10^{38}
Representation	Decimal	Hexadecimal
Format	4 fields separated by (.)	8 fields separated by (:)
Example	**Ex.** 34.52.66.20	**Ex.** 1233:0330:4438:ABE3:A2F3:1234:1010:B1A2

- **Mobile computing:** it represents personal portable devices such as phones and mobile medical devices that are used to provide healthcare to patients during quarantine to prevent the spread of a pandemic, such as Covid-19 pandemic [13][14].
- **Cloud computing:** it uses the provision of computing services - including large numbers of servers, huge storage capacities, highly reliable and available databases, networks, software, AI, and data analytics, All of which helps in making informed, innovative, and fast decisions and insights at low prices [15].
- **Edge computing:** it is task is mainly performing some of the processing and analytic near the data source itself rather than o cloud for the purpose of improving performance in data transmission. Traditionally, IoT devices transmit data directly to cloud servers for time consuming processing tasks and data analytics. Edge computing plays a pivotal role in the IoT in healthcare, offering significant performance enhancement in real-time data processing tasks and reduce network latency in data transmission between IoT devices and mobile apps on one side and cloud servers on the other side. In this context, edge computing addresses the challenges posed by network latency and the need for fast response times when dealing with a life-threatening situations during medical care [16].

2.4. Security and Privacy

Numerous threats might target mobile computing when integrated with IoT in Libyan healthcare system. This caused by various biosensors and mobile devices used by patients, various, mobile and heterogeneous networks and IoT devices used in communications. In our previous work we categorize attacks according to the IoT system components they aim to target [17].

- **Device**: for instance use of radio frequency (RF) jamming and side channel attacks.
- **Software**: Indirect Attacks (SQL Injection), malware injection, buffer overflow, and software update incidents fall under this category.
- **Networks and Related Equipment**: There are four types of network attacks: botnets, cloud computing, man-in-the-middle (MITM), and denial of service (DoS).
- **Data**: Data leakage, ransom ware, cloud data leakage, fake data injection, and mis-configuration are some of the subcategories of data attacks, which are threats that target data during storage, transport, or processing [18].
- **Misuse**: These attacks target other individuals or institutes by taking advantage of Libyan healthcare system resources.

One key implication in Libyan Healthcare System is a scenario of a cyber-security attack causing a partial system shutdown that might be life threaten a patient.

2.5. Mobile Interaction

The usage of mobile health apps can influence communication and relationships between patients and providers positively, by fostering a collaborative environment, facilitating personal-centred healthcare [19]. These applications serve as a bridge, enabling smooth interaction and information exchange:

- **Improved Communication:** Mobile health apps facilitate easy communication between patients and healthcare providers.
- **sharing real-time Information:** Patients can access health records, treatment plans, and educational resources, promoting active healthcare involvement.
- **Enhanced Engagement:** Regular check-ins and reminders encourage active health management, promoting better adherence to treatment plans.
- **Personalized Care:** Providers can use collected data for personalized care approaches.
- **Building Trust:** Consistent communication strengthens patient-doctor trust, enhancing overall healthcare outcome.

2.6 Artificial Intelligence (AL)

The IoT and AI can work together to bring significant improvements the Libyan healthcare system through innovative and entrepreneurial ideas to healthcare outputs. The following presents the positive role and effect when they collaborate to enhance Libyan healthcare system:

- **Location-aware healthcare:** Connected devices such as smart devices and medical devices with mobile apps can be used to remotely monitor patients' health conditions and send real-time alerts to doctors when any abnormal changes occur. This reduces the hassle on Libyan healthcare facilities and patients in remote areas.
- **Disease Prediction and Spread:** AI can analyze data of any pandemic spread in the Libyan society. In our previous work [9]. A various parameters are defined to cover wide range of aspects related to current pandemic. These aspects covers existing the technologies (Cloud, Bluetooth, Mobile Device), governments (Support, Use, Enforcement), and app users (Health, Social, Privacy).
- **Healthcare Resource Management:** AI can analyze data to determine how to use and time healthcare resources more effectively in real-time especially in case of disasters such as previous Covid-19 pandemic spread or Darneh city Denial Storm.
- **Training and Education:** AI applications can used train and educate for Libya doctors and nurses on emergency situations handling, provide new medications treatments to enhance their skills and enabling them to deliver better healthcare.
- **Real-Time Continuous Monitoring:** Wearable devices and IoT sensors continuously monitor patients in real time and send data to doctors constantly[20][21]. Thus, this makes an early detection and diagnosis of medical cases. Based on our previous work, it is very vital especially when patient shows vital signs such as heart attack. In such scenarios the care giver at home will notice the case in instant and the healthcare provide will start monitoring the patient in real-time enabling doctors to care for the patient without delay in the Libyan healthcare facilities.
- **Disease Prediction and Spread:** AI can analyze data sent from sensors and connected devices to predict disease outbreaks and identify areas most at

risk, allowing Libyan healthcare system to take preventive measures early on.

- **Society Engagement Service:** AI can socially vigorously participate as a mentor using multimedia awareness initiatives. In our previous work, we designed social mobile cloud app. This app allows mobile users to make text, voice, and video call to each other. One of the users can be AI-Agent user representing the Libyan healthcare system. The AI-Agent key task is to be eagerly, highly spirited, and helpful mentor to Libyan society.

3. CONCLUSIONS

In conclusion, Libya public and private healthcare systems is facing numerous key problems such as steep healthcare costs, shortage of doctors, and lack of access to healthcare, weak health information system, lack sufficient health literacy, and high cost of private healthcare services. Nevertheless, Libya is planning to eagerly implement digital transformation in its healthcare system to tackle existing problems. The authors aim to motivate the Libyan policy makers to include mobile computing and IoT technologies in their digital transformations of *LHS*. The embracement of mobile computing IoT in digital transformations of *LHS*s has many benefits, the most important of which are:

- **Improvement in Public Health awareness in consequence of lack sufficient health literacy:** IoT applications are keys to enhancing public health awareness by enabling better monitoring and management of health conditions, which can lead to improved health outcomes.
- **Remote Training and Management:** IoT technologies facilitate remote training of healthcare staff and global healthcare management, making healthcare services more accessible, especially in remote areas.
- **Enhanced Synergies between public and private healthcare providers:** The integration of AI-Agent, mobile computing and IoT improves collaboration between healthcare providers in Libya as well as with foreign advanced healthcare facilities in developed countries.
- **Disease Prevention and Management:** IoT applications play a crucial role in the research, application, and prevention of diseases and pandemics, vaccinations, supply chains, and personal patient monitoring, .
- **Remote, Accessibility, and Equity due to lack of access to healthcare:** We emphasize that IoT technology must accessible through mobile apps ensure that benefits reach all members of the society.
- **Support for Sustainable Development Goals (SDGs):** The implementation of mobile IoT in healthcare aligns with various SDGs, contributing to broader goals such as improving health, and promoting sustainable practices.
- **Investing in mobile computing and IoT will shrink the steep healthcare costs:** The vast majority of Libyan populations own mobile phones connected to the internet. Thus, the Libyan healthcare systems can utilize on this to lower healthcare costs while enhancing healthcare services.

4. RECOMMENDATIONS

Finally, the authors explored the effects, roles, and implications developing IoT apps in *LHS*. We, support for Libyan sustainable development goals (SDGs) by the following recommendations:

- **Digital transformation of *LHS*:** The integration of mobile computing with IoT with existing healthcare systems requires.

- **Encourage Libyans entrepreneurs:** It is time encourage and increase the public awareness of the importance of entrepreneurship to start investing in the mobile computing and IoT healthcare industries. Since the adventure does not require large capital to start-up. On the other hand, it requires innovative ideas to approaches the problems and challenges in the Libyan health sector. Plus, mobile computing and IoT is very lucrative.
- **Teamwork spirit:** invite the healthcare providers, policymakers, and researchers in Libya as well as public engagements to join forces in developing and using IoT in their Digital transformations of *LHS*.
- **Transition from IPv4 to IPv6:** support this communication infrastructure transition which will pave the way for Libyan entrepreneurs looking to start a business in this industry.
- **Research and development:** Need for intensify research and development to explore the effectiveness of IoT apps, development innovative solutions to build robust *LHS*, as well as security issues.

5. REFERENCES

1. M. Weiser, "Hot topics-ubiquitous computing," in Computer, vol. 26, no. 10, pp. 71-72, Oct. 1993, doi: 10.1109/2.237456.

2. Kramp, T., van Kranenburg, R., Lange, S. “Introduction to the Internet of Things”. In: Bassi, A., et al. Enabling Things to Talk. Springer, Berlin, Heidelberg. (2013) https://doi.org/10.1007/978-3-642-40403-0_1

3. Stefan Poslad, “Ubiquitous Computing: Smart Devices, Environments and Interactions”, first edition 2009, John Wiley & Sons,Ltd. ISBN: 978-0-470-03560-3.

4. ITU Internet Reports. The Internet of Things (Ed. 2005). November 2005.

5. Lionel Sujay Vailshery “Number of IoT connections worldwide 2022-2033”, Sep 11, 2024

6. European Union, 2024 - Shaping Europe’s digital future, “The Internet of Things in European healthcare”, https://digital-strategy.ec.europa.eu/en/policies/internet-things-european-healthcare (https://digital-strategy.ec.europa.eu/en) - PDF generated on 19/12/2024

7. P. Dhivya, V. G. Karthiga, S. Vinotha, S. Saravanakumar, T. Abinith and T. Varunsri, "*Advanced Sensing and Actuation Health Monitoring Robot*," 2024 5th International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2024, pp. 177-183, doi: 10.1109/ICESC60852.2024.10689853.

8. A. Soomro and R. Schmitt, "A framework for mobile healthcare applications over heterogeneous networks," 2011 IEEE 13th International Conference on e-Health Networking, *Applications and Services*, Columbia, MO, USA, 2011, pp. 70-73, doi: 10.1109/HEALTH.2011.6026789.

9. K. M. Ben Hamed and A. Baryun, "Designing a mobile app to trace Covid-19 using social networks," *2021 IEEE 1st International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering MI-STA*, Tripoli, Libya, 2021, pp. 276-281, doi: 10.1109/MI-STA52233.2021.9464486.

10. B. A. Kumar and P. T. Rao, "Overview of advances in communication technologies," 2015 13th International Conference on Electromagnetic Interference and Compatibility (INCEMIC), Visakhapatnam, India, 2015, pp. 102-106, doi: 10.1109/INCEMIC.2015.8055856.

11. M. Goswami, N. Panda, S. Mohanty and P. K. Pattnaik, "*Machine Learning Techniques and Routing Protocols in 5G and 6G Mobile Network Communication System - An Overview*," 2023 7th International Conference on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India, 2023, pp. 1094-1101, doi: 10.1109/ICOEI56765.2023.10125697.

12. B. Mohanta, P. Das and S. Patnaik, "*Healthcare 5.0: A Paradigm Shift in Digital Healthcare System Using Artificial*

Intelligence, IOT and 5G Communication," *2019 International Conference on Applied Machine Learning (ICAML)*, Bhubaneswar, India, 2019, pp. 191-196, doi: 10.1109/ICAML48257.2019.00044.

13. Bonyan Qudah, Karen Luetsch, " *The influence of mobile health applications on patient - healthcare provider relationships: A systematic, narrative review*", Patient Education and Counseling, Volume 102, Issue 6,2019, Pages 1080-1089, ISSN 0738-3991, https://doi.org/10.1016/j.pec.2019.01.021

14. N. Almtireen, H. Altaha, A. Alissa, M. Ryalat and H. Elmoaqet, "*AI-Driven Mobile App for Personalized Health Monitoring*," 2024 22nd International Conference on Research and Education in Mechatronics (REM), Amman, Jordan, 2024, pp. 338-342, doi: 10.1109/REM63063.2024.10735595.

15. Sarangi AK, Mohapatra AG, Mishra TC, Keswani B. Healthcare 40: "*A Voyag Computing With IOT, Cloud Computing, Big Data, and Machine Learning*". In: T ed. Fog Computing For Healthcare 4.0 Environments: Technical, Societal, and Fr plications. Cham: Springer; 2021:177-210.

16. Y. Dash and P. Jajoria, "Fog Computing: Applications in Smart Healthcare," 2023 3rd International Conference on Advancement in Electronics & Communication Engineering (AECE), GHAZIABAD, India, 2023, pp. 903-909, doi: 10.1109/AECE59614.2023.10428418.

17. N. F. Farah, A. M. Sllame and O. M. Sleik, "Analyzing the Networking Infrastructure and Security Issues of Agriculture Smart Systems Based on Internet of Things Technology" , 2024 The First Scientific Conference on Engineering Applications (ICEA'2024), Engineering Academy ,Tajoura, Libya, 2024

18. A. Majeed and S. O. Hwang, "A Comprehensive Analysis of Privacy Protection Techniques Developed for COVID-19 Pandemic," in *IEEE Access*, vol. 9, pp. 164159-164187, 2021, doi: 10.1109/ACCESS.2021.3130610.

19. Y. A. Alshehhi, B. Philip, M. Abdelrazek and A. Bonti, "*Needs and Challenges of Personal Data Visualisations in Mobile Health Apps: User Survey*," 2023 IEEE International Conference on Big Data and Smart Computing (BigComp), Jeju, Korea, Republic of, 2023, pp. 295-297, doi: 10.1109/BigComp57234.2023.00058.

20. Li JD, Ma Q, Chan AH, *Man SS. Health monitoring through wearable technologies for older adults: smart wearables acceptance model*. Appl Ergon. 2019;75:162-169.

21. I. d. M. B. Filho, G. Aquino, R. S. Malaquias, G. Girão and S. R. M. Melo, "*An IoT-Based Healthcare Platform for Patients in ICU Beds During the COVID-19 Outbreak*," in IEEE Access, vol. 9, pp. 27262-27277, 2021, doi: 10.1109/ACCESS.2021.3058448.

22. Li S, Ma Z, Cao ZL, Pan LJ, Shi Y. "Advanced Wearable Microfluidic Sensors for Health- care Monitoring. Small. 2020;16(9):e1903822.

23. Bhavin M, Tanwar S, Sharma N, Tyagi S, Kumar N. Blockchain and quantum blind signature-based hybrid scheme for healthcare 5.0 applications. J Inf Secur Appl. 2021;56:102673.

24. Javaid M, Haleem A, Singh RP, Rab S, Suman R. Significance of sensors for industry 4.0: roles, capabilities, and applications. Sensors Int. 2021;2:100110.

25. Hatamie A, Angizi S, Kumar S. Review Textile Based Chemical and Physical Sensors for Healthcare Monitoring. J Electrochem Soc. 2020;167(3):037546.

26. Dian FJ, Vahidnia R, Rahmati A. Wearables and the Internet of Things (IoT), Applications, Opportunities, and Challenges: a Survey. IEEE Access. 2020;8:69200-69211.

27. Ali F, El-Sappagh S, Islam SMR. An intelligent healthcare monitoring framework using wearable sensors and social networking data. Futur Gener Comput Syst. 2021;114:23-43.