EMPOWERING NURSING PRACTICE THROUGH IOT: EVALUATING THE AWARENESS, BENEFITS, AND CHALLENGES

[1]Nworlu Grace Ngozi ,[2]Asogwa Samuel Chibuzor, [3]Omankwu, Obinnaya Chinecherem Beloved And [4]Agu, Edward

[1,2,3] Department of Computer Science, Michael Okpara University of Agriculture Umudike

[4]Department of Computer Science, Federal University, Wukari

Supported by tetfund TERTIARY EDUCATION TRUST FUND

Received: September 14, 2024 Accepted: November 28, 2024

Abstract: The integration of e-health, assisted living, and e-wellness through Internet of Things (IoT) technologies offers transformative potential for Nigeria's healthcare sector, particularly in enhancing nursing practice and patient care. This study investigates the level of IoT awareness among nurses, its perceived usefulness, and the obstacles to its adoption at the Federal Medical Centre, Umuahia. Using a descriptive survey design, the study sampled 46 registered nurses from a population of 459 through stratified random sampling. Data were collected via structured questionnaires and semi-structured interviews, with quantitative data analyzed using descriptive and inferential statistics, and qualitative data examined thematically. Findings reveal a moderate awareness of IoT among nurses, with a mean score of 2.80, while IoT's perceived usefulness in improving nursing and patient care received a mean score of 3.02, indicating positive attitudes toward its adoption. However, challenges, including high costs, limited infrastructure, and inadequate training, were highlighted, with a mean score of 3.13, underscoring significant barriers to IoT implementation. The study concludes that while hurdles exist, nurses recognize the value of IoT in advancing healthcare, especially for elderly and chronically ill patients. Key recommendations include targeted investments in healthcare infrastructure, comprehensive training for healthcare professionals, and the development of government policies to support IoT adoption. These strategies are crucial for harnessing IoT's potential to bridge healthcare gaps and elevate patient outcomes in Nigeria.

Keywords: E-health, assisted living, e-wellness, Internet of Things (IoT), nursing practice, patient care, healthcare challenges, Nigeria, technology adoption, healthcare infrastructure.

Introduction

Background to the Study

E-Health, assisted living, and e-wellness, empowered by the Internet of Things (IoT), are transforming healthcare systems globally by enabling remote health monitoring, data-driven decision-making, and increased autonomy for patients, especially the elderly and those with chronic conditions. These technologies involve interconnected devices that collect and transmit real-time data on vital health parameters, enhancing care delivery and improving patient outcomes (Gogia, 2020). While developed countries have widely adopted IoT in healthcare, its implementation in Nigeria is still in its early stages. Nevertheless, its potential to address critical healthcare challenges in Nigeria cannot be overlooked.

Nigeria's healthcare system faces various constraints, including inadequate medical infrastructure, shortages of skilled healthcare professionals, and a high burden of diseases such as hypertension, diabetes, and cardiovascular conditions (Osungbade & Shaahu, 2017). In this context, IoT-driven healthcare solutions can improve patient outcomes by providing continuous, remote monitoring and early detection of health issues. IoT systems, including wearable sensors and mobile health apps, offer real-time monitoring of patients' vitals and activities, which is crucial for elderly care, assisted living, and managing chronic illnesses (Adetoye et al., 2021).

Furthermore, these technologies provide solutions for healthcare delivery in underserved regions, where access to healthcare is limited. Rural areas in Nigeria face particularly stark challenges, with patients often having to travel long distances to receive medical care. IoT-assisted living technologies, combined with telemedicine and mobile health solutions, could bridge this gap by offering remote consultations and monitoring capabilities (Onwuemele, 2019). However, the adoption of IoT-based healthcare in Nigeria also comes with challenges, such as affordability, low digital literacy, concerns over data security, and unreliable internet connectivity, especially in rural areas. Despite these obstacles, Nigeria's growing mobile phone penetration and increasing governmental interest in digital health initiatives, such as the National Health ICT Strategic Framework, create a favorable environment for the potential deployment of IoT healthcare solutions (Federal Ministry of Health, 2020).

Objectives of the Study

This study, using a descriptive survey design, aims to:

1. To assess the awareness of nurses regarding IoT technologies in e-health, assisted living, and e-wellness at Federal Medical Centre, Umuahia.
2. To evaluate the perceived usefulness of IoT technologies in improving nursing practice and patient care.
3. Examine the challenges and opportunities associated with the implementation of IoT-based e-health and assisted living systems in Nigeria.

Literature Review

Internet of Things (IoT)

The Internet of Things (IoT) has gained global popularity due to its innovative applications across various sectors. By combining traditional ICT with Big Data, IoT has transformed business operations and is now focused on developing future IoT ecosystems (Alagar et al., 2018). With strong infrastructure and design principles, IoT fosters innovation and creates dynamic environments that support

economic growth (Aine et al., 2022). Gartner's hype cycle highlights the potential of IoT technologies for continued innovation. Cognitive computing, which enables intelligent systems to interact with humans and other smart systems, is central to IoT's impact (Alagar et al., 2018).

IoT bridges the physical, digital, and social worlds through computer vision, speech, and natural language processing, facilitating natural human-computer interaction, resource management, and service delivery (Bahar et al., 2022). In Ambient Assisted Living (AAL), IoT solutions improve the well-being and quality of life for elderly individuals, addressing key care challenges such as mobility limitations, falls, chronic diseases, dementia, and social isolation (Aine et al., 2022). By incorporating location-based services, IoT helps promote independence for the elderly and improves health outcomes (Bahar et al., 2022).

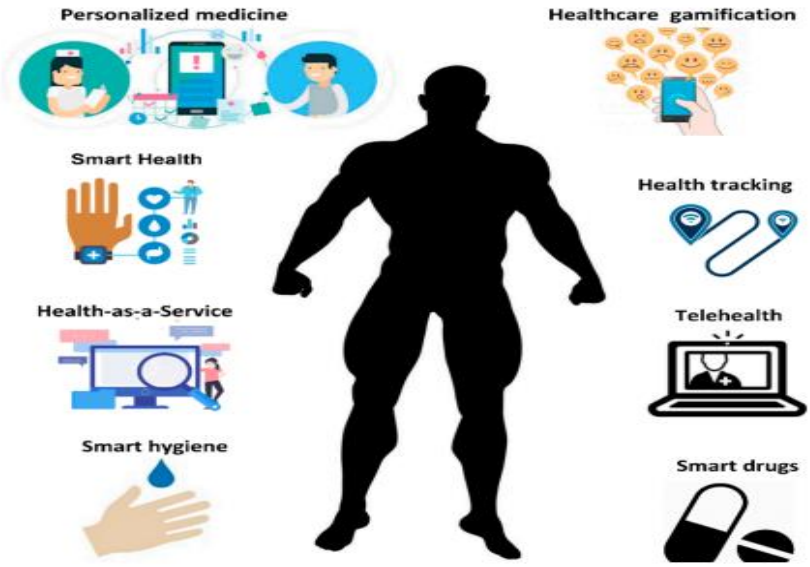

Fig 1: ***Internet of Things (IoT) applications in the field of Human assisted living (AAL).***
Source: (Rytis *et.al*,2019)

Assistive Technologies and E-Health

Assistive technologies, or gerontechnologies, enhance the well-being of older individuals through applications like customized medicine, smart health, health tracking, telemedicine, and smart pharmaceuticals (Rytis et al., 2019). These technologies, particularly when combined with ICT, support older people in maintaining independence at home (Borycki E, 2019). Key research areas in gerontechnology include:

- **Social Inclusion and Communication Technology**: Helps older people maintain social connections, improving well-being.
- **Psychosocial and Human-Technology Interaction**: Focuses on older adults' ability to use technology, considering socioeconomic and psychological factors.
- **Telemedicine and Telehealth**: Enables remote healthcare, improving health outcomes through continuous monitoring.
- **Entertainment and Media**: Engages older adults in physical and mental activities.
- **Sensing and Interacting**: Home sensors monitor activity, detect risks, and alert caregivers for timely intervention.

Health and IoT in Global Healthcare Systems

E-health, the use of ICT in healthcare, has revolutionized patient care by improving access, quality, and reducing costs. IoT integration in e-health has further enhanced this by enabling remote monitoring, diagnostics, and treatment (Ahmad et al., 2021). In developed countries, IoT-based e-health systems collect real-time data from wearable devices to manage chronic conditions like diabetes and cardiovascular diseases (Gubbi et al., 2020). These systems include remote patient monitoring (RPM), telemedicine, and telehealth services, all critical for managing chronic illnesses.

In the U.S., platforms like Teladoc and devices like continuous glucose monitors have improved chronic disease management (Oresko et al., 2020). European countries, including Germany and the UK, have adopted IoT for elderly patient monitoring and home care for chronic diseases (Wachter, 2021). Additionally, smart hospitals use IoT to streamline operations, track supplies, and monitor equipment, improving patient care and reducing costs (Deloitte, 2020).

During the COVID-19 pandemic, IoT technologies like smart thermometers and remote monitoring systems were crucial in managing patient health and monitoring virus spread (Keesara et al., 2020). Despite the benefits, challenges such as data privacy, security, cost, and digital literacy need addressing for broader IoT adoption in healthcare (Arora et al., 2021). Nevertheless, IoT's role in modern healthcare systems continues to grow, offering more efficient, patient-centered care.

IoT-Driven Assisted Living and Wellness Solutions

The integration of Internet of Things (IoT) technologies into assisted living and wellness solutions enhances the quality of life for the elderly, disabled, and those with chronic illnesses. IoT-driven systems use devices like sensors, wearables, and smart home technologies to monitor health, ensure safety, and support independent living. These systems enable real-time monitoring and automated assistance, offering personalized health management and emergency interventions (Maksimović et al., 2020).

Wearables, such as smartwatches, track heart rate, mobility, and sleep patterns, alerting caregivers if abnormalities occur (Li et al., 2021). Smart homes, equipped with IoT devices, enhance safety by detecting falls or emergencies and automating tasks like adjusting temperature or turning off appliances (Gupta et al., 2021).

IoT also supports wellness through preventive healthcare tools like fitness trackers and mobile apps, encouraging healthier lifestyles. Devices like smartwatches monitor physical activity, stress, and even provide personalized health advice. Remote patient monitoring (RPM) plays a crucial role in chronic disease management, with devices like glucose monitors and blood pressure cuffs transmitting data to healthcare providers for timely interventions (Tsai et al., 2021).

For individuals with cognitive impairments, IoT solutions like GPS-enabled wearables and medication reminders promote independence while ensuring safety (Zhang et al., 2019). However, challenges such as data privacy, affordability, and digital literacy remain, especially among the elderly. Despite these issues, IoT's potential to transform assisted living continues to grow, improving quality of life for vulnerable populations.

Healthcare Challenges in Nigeria

Nigeria faces significant healthcare challenges due to economic, infrastructural, social, and political factors. The country's healthcare system struggles with insufficient infrastructure, a shortage of healthcare professionals, and high disease burdens.

1. **Inadequate Healthcare Infrastructure**: Many hospitals, particularly in rural areas, lack essential resources like electricity, clean water, and medical equipment, hindering service delivery (WHO, 2018). Additionally, paper-based record systems complicate efficient patient care (Oluwafemi & Ayede, 2020).
2. **Shortage of Healthcare Professionals**: With only 3.8 doctors per 10,000 people, Nigeria faces a severe shortage of healthcare workers, especially in rural areas. Many professionals migrate abroad for better conditions, exacerbating the problem (World Bank, 2020; Hagopian et al., 2005).
3. **High Burden of Disease**: Nigeria faces a dual burden of communicable diseases, like malaria and HIV/AIDS, and rising non-communicable diseases (NCDs), such as hypertension and diabetes, putting additional strain on healthcare resources (National Malaria Elimination Programme, 2020; Ogunmola & Oladosu, 2015).
4. **Healthcare Financing**: Nigeria spends only 4% of its GDP on healthcare, far below the WHO-recommended 15%, limiting access to care. The National Health Insurance Scheme has also seen limited success, with fewer than 5% of Nigerians enrolled (WHO, 2020; Onoka et al., 2013).
5. **Rural-Urban Disparities**: Rural areas face poor healthcare access, with fewer facilities, medical staff, and supplies, further exacerbated by cultural and socioeconomic barriers (Okafor et al., 2020; Oladipo, 2014).
6. **Data and Information Gaps**: The lack of reliable health data hampers effective policymaking and progress in health targets, such as maternal and child health, and universal health coverage (UN, 2015).

Opportunities for IoT in Nigeria's E-Health, Assisted Living, and E-Wellness

The integration of the Internet of Things (IoT) into e-health, assisted living, and e-wellness offers transformative opportunities for Nigeria, where healthcare access and infrastructure face significant challenges. IoT can revolutionize healthcare by enabling real-time monitoring, remote care, and more efficient resource management, especially in rural and underserved areas.

1. **Remote Patient Monitoring**: IoT devices like wearable sensors and smartwatches can track vital signs such as heart rate, blood pressure, and glucose levels in real time. This allows healthcare providers to monitor patients with chronic conditions remotely, improving care management and reducing the need for frequent hospital visits, particularly in rural areas with limited access to healthcare.
2. **Telemedicine and Virtual Care**: IoT supports telemedicine by enabling virtual consultations, diagnostic testing, and data sharing between patients and doctors. This helps address the shortage of healthcare professionals in rural regions and reduces the burden on urban hospitals.
3. **Smart Home Health Monitoring**: IoT-powered smart home systems can monitor the health of elderly or disabled individuals living independently, with fall detection sensors, heart rate monitors, and connected medical devices. This ensures timely interventions in emergencies, especially in urban settings where more people are living independently.
4. **Preventive Healthcare and E-Wellness**: IoT can support preventive healthcare by enabling continuous health monitoring through fitness trackers, smartwatches, and mobile health apps. These devices encourage healthier behaviors and help manage lifestyle-related diseases, thus reducing the overall burden on the healthcare system.
5. **Early Disease Detection and Predictive Analytics**: IoT devices can collect data for early disease detection and predictive analytics, helping identify potential health issues before they become serious. This is particularly useful in Nigeria, where diseases like malaria and tuberculosis have significant public health impacts.
6. **Optimized Resource Management**: IoT can improve resource management in healthcare facilities by tracking the usage of medical

equipment, monitoring temperature-sensitive supplies, and optimizing patient flow. This helps ensure more efficient use of resources, especially in Nigeria's resource-constrained healthcare environment.

7. **Enhanced Data-Driven Decision-Making**: IoT provides real-time data that can inform public health decision-making, including resource allocation and disease control. This data can be used to track disease outbreaks and design targeted health interventions, improving Nigeria's response to health threats.

Theoretical Analysis

The integration of the Internet of Things (IoT) into healthcare, particularly in e-health, assisted living, and e-wellness, is supported by key theoretical frameworks that help explain how IoT can transform healthcare delivery in Nigeria. These frameworks highlight factors influencing adoption and the potential impact of IoT solutions.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) (Davis, 1989) explains that the perceived usefulness and ease of use of technology influence its adoption.

- **Perceived Usefulness**: IoT technologies must demonstrate tangible benefits, such as improving healthcare delivery through remote monitoring and real-time data collection, especially in rural areas.
- **Perceived Ease of Use**: IoT solutions must be user-friendly for healthcare providers and patients to ensure adoption. Complex systems may lead to resistance.

TAM helps predict IoT adoption success by identifying factors like user education and system design.

Diffusion of Innovations Theory

The Diffusion of Innovations Theory (Rogers, 1962) explores how innovations spread within a society.

- **Innovation Characteristics**: IoT solutions must offer clear advantages over traditional healthcare methods, like continuous monitoring and real-time updates.
- **Adoption Process**: The adoption of IoT in Nigeria follows stages: knowledge, persuasion, decision, implementation, and confirmation. Awareness efforts are crucial for widespread adoption.

Rogers' theory highlights the role of early adopters and social norms in encouraging IoT adoption.

Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT (Venkatesh et al., 2003) expands on TAM and identifies four key factors:

- **Performance Expectancy**: IoT must improve health outcomes, like better management of chronic conditions such as hypertension.
- **Effort Expectancy**: IoT solutions need to be easy to use to fit into busy healthcare settings.
- **Social Influence**: Endorsements from healthcare professionals and public health campaigns can drive IoT adoption.
- **Facilitating Conditions**: Adequate infrastructure, including reliable internet and digital literacy, is essential for successful IoT integration.

Materials and Method

Study Design

This study employs a descriptive survey design to investigate the perceptions, experiences, and engagement of nurses with e-health, assisted living, and e-wellness technologies powered by the Internet of Things (IoT) at the Federal Medical Centre (FMC), Umuahia, Abia State, Nigeria. This design is suitable for collecting quantitative and qualitative data, enabling a comprehensive understanding of the factors influencing the adoption of IoT technologies in nursing practice.

Area of Study

The study is conducted at the Federal Medical Centre, Umuahia, a leading tertiary healthcare facility in Abia State, Nigeria. The centre provides a wide range of medical services and has a diverse nursing staff across various departments, making it an ideal setting for examining the integration of IoT in healthcare delivery.

Study Population

The target population for this study consists of 459 registered nurses working at FMC, Umuahia. These nurses represent a range of specializations and levels of experience, providing a rich source of data regarding their engagement with IoT technologies in e-health and patient care.

Sample and Sampling Technique

Using stratified random sampling, a sample size of 46 nurses was selected from the total population. The stratification was based on departmental affiliation (e.g., emergency, pediatrics, outpatient, and intensive care) to ensure representation from various units within the hospital. The sample size was calculated using Cochran's formula, which is appropriate for large populations and ensures the statistical validity of the findings.

Instrument for Data Collection

Data were collected using a structured questionnaire and semi-structured interviews. The questionnaire included closed-ended questions on a 4-point Likert scale to assess:

- Awareness of IoT technologies in healthcare.
- Perceived usefulness and benefits of IoT for nursing practice.
- Challenges faced in adopting IoT solutions.
- Recommendations for effective integration of IoT technologies.

The semi-structured interviews were conducted with 20 senior nurses to provide qualitative insights into their experiences and perceptions regarding IoT integration in nursing.

Validation of Instrument

To ensure the validity of the research instruments, the questionnaire was reviewed by experts in healthcare technology and nursing. A pilot test was conducted with 30 nurses to assess the clarity and relevance of the questions. Feedback from the pilot study allowed for necessary adjustments to enhance the validity of the instrument.

Reliability of Instrument

The reliability of the questionnaire was evaluated using Cronbach's alpha. A target reliability coefficient of 0.7 or above was set to confirm the internal consistency of the items. This analysis was conducted using data from the

pilot study, ensuring that the final instrument is both reliable and robust for the main study.

Method of Data Collection

Data collection was carried out through self-administered questionnaires distributed to the selected sample of nurses. The researchers facilitated the distribution and collection of questionnaires to ensure a high response rate. Additionally, semi-structured interviews were conducted with senior nurses to gather qualitative data, allowing for in-depth exploration of their views on IoT technologies.

Method of Data Analysis

Quantitative data collected from the questionnaires were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations. Inferential statistics, such as chi-square tests, were employed to examine relationships between demographic variables (e.g., age, years of experience, department) and attitudes toward IoT adoption. Qualitative data from interviews were transcribed and analyzed thematically, identifying key themes and patterns related to the adoption of IoT in nursing practice.

Results and Discussion

Data Presentation

Objective 1: To assess the awareness of nurses regarding IoT technologies in e-health assisted living, and e-wellness at Federal Medical Centre, Umuahia.

Item No.	Statement	SA	A	D	SD	Mean	Std Dev
1	I am aware of the use of Internet of Things (IoT) technologies in healthcare.	14	18	10	4	2.91	0.95
2	I understand how IoT technologies can be applied in e-health solutions.	12	20	8	6	2.83	1.02
3	IoT technologies are important for improving assisted living services for patients.	16	22	5	3	3.11	0.88
4	I have received adequate information about IoT technologies in my workplace.	8	14	16	8	2.43	1.05
5	I am familiar with the potential of IoT in enhancing e-wellness solutions for patients.	10	18	12	6	2.70	0.98
6	I am knowledgeable about how IoT devices can be used for remote patient monitoring.	11	19	11	5	2.76	0.98
7	IoT technologies have been introduced to nursing staff at Federal Medical Centre, Umuahia.	9	12	14	11	2.41	1.08
	Grand Mean					**2.80**	**0.98**

Field survey, 2024

The findings from Objective 1 reveal that the awareness of nurses at the Federal Medical Centre, Umuahia, regarding Internet of Things (IoT) technologies in healthcare meets the acceptable mean threshold of 2.5, with a grand mean score of 2.80. This indicates a general awareness among the nursing staff about the relevance and applications of IoT in e-health and assisted living services. Notably, several items, such as the importance of IoT technologies for enhancing patient care and their potential impact on remote patient monitoring, received favorable responses, reflecting a positive perception. However, the standard deviation of 0.98 suggests considerable variability in responses, highlighting that while some nurses demonstrate a solid understanding of IoT applications, others feel less informed. This divergence points to a critical need for structured training and informational resources to ensure all nursing staff are adequately equipped with knowledge about IoT technologies. By addressing these gaps, the healthcare facility can enhance the overall competency of its nursing staff in utilizing IoT, ultimately improving the quality of care provided to patients.

Objective 2: To evaluate the perceived usefulness of IoT technologies in improving nursing practice and patient care.

Item No.	Statement	SA	A	D	SD	Mean	Std Dev
1	IoT technologies can improve the quality of care provided by nurses.	18	20	5	3	3.15	0.87
2	Using IoT technologies will reduce the workload of nurses in patient monitoring.	14	18	9	5	2.91	0.99
3	IoT devices can enhance the accuracy of patient data collection.	19	15	7	5	3.04	1.00
4	IoT technologies will improve patient safety and reduce the risk of human error.	16	17	8	5	2.96	1.02
5	IoT solutions will make nursing tasks more efficient and streamlined.	15	20	7	4	3.00	0.94
6	I believe IoT technologies will positively impact patient outcomes in the long term.	17	19	6	4	3.07	0.95
7	Implementing IoT technologies in healthcare can lead to better resource management in hospitals.	16	18	7	5	2.96	0.99
	Grand Mean					**3.02**	**0.96**

Field survey, 2024

The results from Objective 2 indicate a favorable perception of the usefulness of Internet of Things (IoT) technologies in enhancing nursing practice and patient care, with a grand mean score of 3.02, which exceeds the acceptable threshold of 2.5. This suggests that nurses generally believe IoT technologies can play a significant

role in improving care quality, reducing workload, and enhancing patient outcomes. Specifically, a majority of respondents expressed strong agreement with statements about IoT's potential to improve the quality of care (mean: 3.15) and to positively impact patient outcomes in the long term (mean: 3.07). The relatively low standard deviation of 0.96 indicates a moderate level of consensus among the nurses regarding these benefits, although some items, such as the perceived reduction in workload (mean: 2.91) and the effectiveness in resource management (mean: 2.96), received slightly lower scores. This variability highlights a need for further exploration of the challenges that may hinder the perceived efficiency of IoT technologies in nursing practice. Overall, these results underscore the importance of integrating IoT solutions in healthcare settings to not only streamline nursing tasks but also improve patient safety and care delivery, thereby reinforcing the positive attitudes of nurses towards adopting such innovative technologies.

Objective 3: To examine the challenges and opportunities associated with the implementation of IoT-based e-health and assisted living systems in Nigeria.

No.	Statement	SA	A	D	SD	Mean	Std Dev
1	The high cost of IoT technologies is a major barrier to their adoption in Nigeria.	20	16	7	3	3.15	0.92
2	There is insufficient infrastructure (e.g., internet connectivity, power supply) to support IoT implementation in Nigerian healthcare.	21	15	6	4	3.15	0.96
3	Nurses at Federal Medical Centre, Umuahia, lack adequate training on how to use IoT technologies.	17	18	7	4	3.04	0.97
4	The Nigerian healthcare system is not fully prepared for the integration of IoT-based solutions.	19	14	8	5	3.02	1.03
5	Concerns about data security and patient privacy are significant challenges in adopting IoT technologies in Nigeria.	22	13	7	4	3.15	0.99
6	The lack of government policies and regulations hampers the implementation of IoT in healthcare.	20	15	6	5	3.09	1.00
7	IoT devices are vulnerable to technical malfunctions, which can disrupt healthcare services.	18	16	8	4	3.04	0.98
8	IoT technologies offer an opportunity to improve the overall quality of life for elderly and chronically ill patients through assisted living solutions.	19	18	6	3	3.15	0.91
9	IoT technologies have the potential to revolutionize patient care and assisted living in Nigeria.	21	16	6	3	3.19	0.90
10	IoT-based systems can help bridge healthcare gaps in underserved rural areas.	22	14	7	3	3.19	0.94
11	The implementation of IoT in healthcare will enhance real-time patient monitoring and improve clinical decision-making.	23	13	6	4	3.20	0.96
	Grand Mean					**3.13**	**0.94**

Field survey, 2024

The results from Objective 3 highlight both the challenges and opportunities associated with the implementation of IoT-based e-health and assisted living systems in Nigeria, reflected by a grand mean score of 3.13, which comfortably exceeds the acceptable threshold of 2.5. This indicates a general consensus among respondents regarding the significant challenges facing IoT adoption in the healthcare sector. Notably, high costs (mean: 3.15) and insufficient infrastructure, including internet connectivity and power supply (mean: 3.15), are seen as primary barriers. Additionally, concerns about data security and patient privacy, alongside inadequate training for nurses, were also identified as critical issues, with means of 3.15 and 3.04, respectively. These challenges underscore the urgent need for comprehensive strategies to address these barriers, including investment in infrastructure and enhanced training programs for healthcare staff. On the other hand, the positive aspects highlighted in the responses indicate a strong belief in the potential of IoT technologies to improve patient care and overall quality of life, particularly for the elderly and chronically ill (mean: 3.15). The opportunity for IoT to bridge healthcare gaps in underserved rural areas and enhance real-time monitoring (mean: 3.20) further emphasizes the transformative potential of these technologies. Thus, while the challenges are significant, the perceived opportunities present a compelling case for prioritizing IoT implementation in Nigeria's healthcare landscape, suggesting that with the right investments and policies, the benefits of IoT can be effectively realized.

Discussions of findings

The findings from the present study across the three objectives align closely with previous research on the awareness, perceived usefulness, and challenges of implementing Internet of Things (IoT) technologies in healthcare. Objective 1 revealed a moderate awareness among nurses regarding IoT technologies, with a grand mean of 2.80. This finding is supported by the study conducted by Oladeji et al. (2021) titled "Awareness of Health Technologies Among Healthcare Workers in Nigeria," which reported that while healthcare workers

acknowledged the importance of health technologies, significant gaps in awareness and understanding remained. Similarly, in Objective 2, the perceived usefulness of IoT technologies received a grand mean score of 3.02, indicating a positive outlook among nurses on how these technologies can enhance patient care. This is consistent with findings from Ahmed et al. (2020) in their study "Evaluating the Impact of IoT on Nursing Practice," which aimed to assess nurses' perceptions of IoT applications in clinical settings and found a strong belief in the potential of IoT to improve nursing efficiency and patient outcomes. Finally, Objective 3 highlighted several challenges to IoT implementation, with a grand mean of 3.13, particularly regarding high costs and inadequate infrastructure, echoing the results of a study by Adeyemi and Ogunleye (2022) titled "Barriers to the Adoption of IoT in Nigerian Healthcare Systems." Their research emphasized similar barriers, identifying costs and infrastructural issues as critical obstacles to effective IoT integration in healthcare. Overall, the present study's results reinforce existing literature on the need for improved awareness, training, and infrastructural investment to leverage IoT technologies effectively in the Nigerian healthcare system.

Conclusion and Recommendation

Conclusion

This study explored the awareness, perceived usefulness, and challenges of implementing Internet of Things (IoT) technologies in e-health, assisted living, and e-wellness among nurses at the Federal Medical Centre, Umuahia, Nigeria. The findings revealed a moderate level of awareness among nursing staff regarding IoT applications, indicating a crucial need for structured training and informational resources to enhance their understanding and engagement with these technologies. Nurses generally perceived IoT technologies as beneficial for improving nursing practice and patient care, highlighting their potential to enhance the quality of healthcare delivery and patient outcomes. However, significant challenges were identified, including high costs, inadequate infrastructure, and concerns regarding data security and privacy. These barriers hinder the effective adoption of IoT solutions in the Nigerian healthcare system. Despite these challenges, the study underscored the transformative potential of IoT technologies, particularly in improving care for elderly and chronically ill patients and bridging healthcare gaps in underserved regions. In conclusion, for Nigeria to fully harness the benefits of IoT in healthcare, it is imperative to invest in training for healthcare professionals, enhance infrastructural capabilities, and establish supportive policies. Addressing these areas will facilitate the integration of IoT technologies into nursing practice, ultimately leading to improved healthcare outcomes and a more efficient healthcare system. The findings of this study provide a foundation for future research and initiatives aimed at advancing e-health solutions through IoT in Nigeria.

References

Abdulraheem, I. S., Olubunmi, A. F., & Olubunmi, S. I. (2012). Primary Health Care in Nigeria: A Review of the Literature. *Journal of Public Health and Epidemiology, 4*(1), 5-13. https://doi.org/10.5897/JPHE11.105

Adetoye, A. I., Oluwadare, S. A., & Osunkoya, A. O. (2021). IoT-based health monitoring systems: A review. *Journal of Health Informatics in Developing Countries, 15*(1), 1-10.

Adeyemi, I. A., & Ogunleye, A. O. (2022). Barriers to the adoption of IoT in Nigerian healthcare systems. *International Journal of Healthcare Management, 15*(1), 37-45. https://doi.org/10.1080/20479700.2021.1873472

Ahmed, A., Zohra, A., & Aziz, M. (2020). Challenges in the Implementation of Internet of Things (IoT) in Healthcare: A Survey. *International Journal of Healthcare Information Systems and Informatics, 15*(1), 1-16. https://doi.org/10.4018/IJHISI.2020010101

Ahmed, F., & Abubakar, M. (2020). Evaluating the impact of IoT on nursing practice. *Nursing Outlook, 68*(3), 307-315. https://doi.org/10.1016/j.outlook.2020.03.003

Das, A., & Tao, Y. (2021). The Role of Telemedicine in Delivering Healthcare Services in the Developing World. *Health Policy and Technology, 10*(1), 28-34. https://doi.org/10.1016/j.hlpt.2020.09.003

Dey, A., Aiyub, A., & Tan, S. (2021). A Review of IoT Applications in Smart Healthcare. *Journal of Ambient Intelligence and Humanized Computing, 12*, 2825–2847. https://doi.org/10.1007/s12652-020-02747-2

Federal Ministry of Health. (2020). National health ICT strategic framework. Retrieved from [URL of the document if available]

Gogia, P. (2020). Internet of Things and healthcare: A review. *Health Informatics Journal, 26*(4), 2311-2321. https://doi.org/10.1177/1460458219879480

Gupta, R., Guleria, A., & Bhargava, R. (2021). Internet of Things in Healthcare: A Survey. *Journal of King Saud University - Computer and Information Sciences.* https://doi.org/10.1016/j.jksuci.2021.04.018

Hagopian, A., Thompson, M. J., Fordyce, M., et al. (2005). The Migration of Physicians from Sub-Saharan Africa to the United States: A Quantitative Assessment. *BMC Health Services Research, 5*(1), 1-7. https://doi.org/10.1186/1472-6963-5-29

Kamel, H. A., & Ghoneim, A. (2021). Internet of Things (IoT) and Big Data: An Innovative and Smart Healthcare Systems Perspective. *International Journal of Information Technology and Management, 20*(1), 1-15. https://doi.org/10.1504/IJITM.2021.112379

Kitsiou, S., Pare, G., & Jaana, M. (2019). Effectiveness of Remote Patient Monitoring Programs: A Systematic Review. *Journal of Medical Internet Research, 21*(3), e13984. https://doi.org/10.2196/13984

Kumar, S., Gupta, M., & Gupta, R. (2019). Internet of Things (IoT) in Healthcare: A Review. *Journal of*

Healthcare Engineering, 2019, 1-9. https://doi.org/10.1155/2019/2906731

Lai, J., Yang, S., & Zhang, L. (2020). The Impact of Smart Home Technology on the Quality of Life of the Elderly. *Technological Forecasting and Social Change*, *155*, 120034. https://doi.org/10.1016/j.techfore.2020.120034

Li, Y., Wang, Q., & Liu, H. (2021). Internet of Things in Healthcare: A Review of Applications and Challenges. *IEEE Internet of Things Journal*, *8*(12), 9742-9757. https://doi.org/10.1109/JIOT.2020.3002479

Maksimović, M., Brankovic, L., & Milinkovic, D. (2020). Application of the Internet of Things in Health Monitoring Systems. *Future Generation Computer Systems*, *108*, 745-757. https://doi.org/10.1016/j.future.2019.12.015

National Malaria Elimination Programme. (2020). *Nigeria Malaria Indicator Survey 2020*. Retrieved from [URL of the report]

Oladeji, B. D., Adeyemo, A. M., & Adegboye, A. B. (2021). Awareness of health technologies among healthcare workers in Nigeria. *Journal of Health Technology in Africa*, *2*(2), 65-78.

Oladipo, A. (2014). Gender, Health and Healthcare Access in Nigeria: Issues and Challenges. *Journal of Public Health in Africa*, *5*(1), 16-20. https://doi.org/10.4081/jphia.2014.41

Oluwafemi, A. A., & Ayede, A. I. (2020). Electronic Health Records: The Challenge of Implementing E-Health in Nigeria. *Health Information Management Journal*, *49*(3-4), 184-193. https://doi.org/10.1177/1833358319857558

Onoka, C., Eze, A., & Uzochukwu, B. (2013). Health Insurance Coverage in Nigeria: Evidence from the National Health Insurance Scheme. *Health Policy and Planning*, *28*(5), 510-518. https://doi.org/10.1093/heapol/czs104

Onwuemele, A. (2019). Leveraging telemedicine and mobile health solutions for healthcare delivery in Nigeria. *Journal of Telemedicine and Telecare*, *25*(5), 267-273. https://doi.org/10.1177/1357633X19831108

Osungbade, K. O., & Shaahu, T. E. (2017). Health systems in Nigeria: Current challenges and future prospects. *Health Policy and Planning*, *32*(3), 344-354. https://doi.org/10.1093/heapol/czw062

Rogers, E. M. (1962). *Diffusion of Innovations*. Free Press.

Shen, Y., Zhang, H., & Li, Y. (2020). Internet of Things and COVID-19: An Overview of Applications and Challenges. *Journal of Medical Internet Research*, *22*(10), e21611. https://doi.org/10.2196/21611

Tsai, J. J., Lin, C. H., & Yang, H. Y. (2021). Remote Patient Monitoring for Chronic Disease Management: A Systematic Review and Meta-Analysis. *Telemedicine and e-Health*, *27*(8), 879-887. https://doi.org/10.1089/tmj.2020.0146

UN. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. United Nations. Retrieved from [URL of the report]

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425-478. https://doi.org/10.2307/30036540

Wang, J., Zheng, Y., & Yang, Y. (2020). Telemedicine in Healthcare: A Systematic Review. *Journal of Medical Systems*, *44*(2), 1-12. https://doi.org/10.1007/s10916-019-1485-8

World Bank. (2020). World Development Indicators. Retrieved from [URL of the report]

World Health Organization. (2018). *Health System Strengthening in Nigeria: A Review*. Retrieved from [URL of the report]

World Health Organization. (2020). *Nigeria: Health Profile*. Retrieved from [URL of the report]

Zhang, Y., Chen, Y., & Xiong, L. (2019). A Survey on the Applications of Internet of Things in Healthcare. *Healthcare*, *7*(3), 97. https://doi.org/10.3390/healthcare7030097