IJECBE (2024), **2**, **4**, 557–574
Received (28 October 2024) / Revised (22 November 2024)
Accepted (21 December 2024) / Published (30 December 2024)
https://doi.org/10.62146/ijecbe.v2i4.86
https://ijecbe.ui.ac.id
ISSN 3026-5258

International Journal of Electrical, Computer and Biomedical Engineering

RESEARCH ARTICLE

An Analytical Review on Emerging Future Network Technologies in Healthcare: Issues, Challenges and Prospects for the Future

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Abstract

This review research article covers in detail healthcare issues and problems related to emerging network technologies, including 5G, satellite communication, and body area networks. The main target is to provide readings that are preliminary so as to get a more rapid in-depth exploitation of this area through which the existing landscape can be figured out and related areas in which further research and probing can be done. This review focuses on core components such as security and privacy, transmission performance, regulatory issues, coexistence issues, and standardization, and explores the issues of securing patient data and confidentiality and measures of performance which play a critical role in healthcare application. Identifying key challenges and matured areas in the review, the review points out researchers to confirmed areas where more efforts are required, like robust security protocols, more innovative regulatory solutions, and new interoperability standards. In this way this study corroborates the need for ongoing innovation and research in healthcare network technologies that will eventually result in an improved quality of healthcare delivery and, hence, an improved result for the patient.

Keywords: Healthcare Network Technology, 5G and Beyond, Data Security and Privacy, Regulatory Compliance, Interoperability Standards

1. Introduction

Network technology has importance in the health sector since it enhances communication, coordination, and, therefore, efficiency within the healthcare sector. For the treatment and care of patients, several kinds of networks are important, which include clinical decision-making tools, physician partnership networks, telehealth networks, and integrated healthcare data access to better the outcomes. [1]. The healthcare service developed its sustainability in the attainment of development goals, mainly in the wake of the COVID-19 crisis, through the advancement of health, the prevention of diseases, and support for the involvement of patients through the incorporation of Information Communication Technology in Care [2], [3]. More so, healthcare networks diminish fragmented care; enhance collaboration between healthcare providers; and increase patient satisfaction. A good instance is the implementation of the ARGI Respiratory Health Programme, which acts as a model of care because of the well-defined roles and matters regarding objectives, team support, and commitment to receiving feedback and review during both the design and implementation phases of the system [4].

Healthcare technology management staff have the mandate of providing reports on adverse reactions of medical equipment. This acts in the best interest of the specific patient by enhancing safety in the patient and improving the devices themselves [5].

Important among the current trends in network technology is the rapid development of 5G wireless communication, the embedding of satellite networks in 5G ecosystems, and, finally, the advancement of Body Area Networks (BANs). 5G technology has offered new offerings through, for example, Radio Cognitive (RC) for Internet of Things (IoT) applications.

Additionally, satellite communication networks are being investigated to improve terrestrial networks. However, these satellite networks are facing difficulties in integrating with future 5G systems due to limitations in proprietary hardware. Furthermore, the advancement of extraterrestrial networks, such as satellites, unmanned aerial vehicles (UAVs), and highaltitude platforms (HAPs) [6], is essential for establishing connections in remote regions and facilitating services like high-speed internet and disaster response. There is a growing emphasis on low Earth orbit (LEO) satellite constellations to achieve worldwide internet coverage [6].

These patterns demonstrate the varied and interrelated characteristics of contemporary network technologies, which provide improved connectivity and delivery of services. Therefore, the aim of this review article is to provide some initial readings which will support more in-depth research in healthcare domain of the healthcare issues and challenges with respect to new network technologies. This article intends to have researchers with a summarized idea of the present scenario and identified areas requiring further research. The review includes various important aspects of healthcare network technology, such as security, privacy, transmission performance, regulatory issues, coexistence, and standardization. In concrete terms, it assesses the means and technologies employed to ensure patient data security, addresses issues related to patient privacy and permission, and considers performance metrics such as latency, bandwidth, and dependability and their influence on healthcare applications.

Furthermore, it also addresses the adherence to healthcare-related regulations, data sovereignty issues and the impact of cross-border data transfer. The review also covers integration and interoperability of new technological solutions with existing healthcare systems and devices, handling coexistence in a shared networking environment, and the review of the existing current standards as well as identification of gaps and a discussion about the need for new standards to facilitate the development of new healthcare network technologies.

2. Review Of Literature

Technological breakthroughs in network technology have been stimulated by the need to respond to increasing requirements and constraints. There has been a call to reform the architecture of the Internet, which is seemingly ossified, leading to activities in post-IP networking and investigation of other protocols [7]. Innovations such as software-defined networking (SDN) and network function virtualization (NFV) [8] are bringing a change in the degree of network flexibility. The emergence of the internet of Things is again increasing in the number of devices interconnecting the IoT, driving new traffic patterns and resource requirements. Developments in distributed computer network server systems are providing safe data access with minimal bandwidth utilization, which in turn, is facilitating the performance of non-traditional activities such as using intellectual property rights as cash over electronic exchange platforms. All these developments collectively strive to resolve the intricacies of current networks, support mission-critical applications, and exploit artificial intelligence to improve computing capabilities [8].

2.1 5G and Beyond: Benefits and Challenges

Advancement from 5G to beyond 5G enables the realization of the following advantages: high speed, low latency, and optimal connectivity. 5G systems, with its enhanced mobile broadband (eMBB), massive machine-type communication (mMTC), and ultra-reliable low latency communications (URLLC) [9] features, provide low latency communication for applications such as smart factories and self-driving cars [9]. Millimetre wave and multi-connectivity technologies enhance system performance by offering reliable low latency communication at varying mobility. This is a critical requirement for delivering next-generation services. To facilitate the development of mission-critical applications, beyond 5G systems should provide ultra-reliable and low latency communication with acceptable end-to-end delay and the probability of losing packets [10]. Besides this, newly proposed schemes, such as Edge Peering, aim to bring the latency of end-to-end communications down by routing end-to-end communications through edge networks for optimal routing paths that improve overall connection and performance [10]. Issues that plague the implementation of 5G include high infrastructure costs and associated technical limitations. Of the two, infrastructure costs are more worrying as the 5G launch is becoming more expensive because of the rapidly growing frequency loss affecting coverage [11].

Technical restrictions include hardware/device issues, security concerns, limited use cases, financial challenges, and the absence of a competent workforce among telecom carriers in India [12]. Additionally, improvements in wireless technologies like massive multi-input multioutput (mMIMO) are seen as possible options to expand channel capacity and spectral efficiency for 5G and beyond networks, answering the requirement for improved network performance and satisfying user needs [13]. These concerns illustrate the complexity and multidimensional nature of issues that need to be addressed for the effective deployment and evolution of 5G networks.

2.2 Satellite Communication: Advantages and Issues

Satellite communication offers major advantages in terms of wide coverage and access to remote places. Satellites positioned in preset orbits enable worldwide communication services, circumventing the limits of terrestrial infrastructure [14]. By employing free space light for communication between satellites, coverage range and communication bandwidth limits can be overcome, boosting the system's capabilities [15]. Additionally, satellite communication systems can enable multichannel phone services, two-way video transmission, and automatic signal intensity modifications, ensuring reliable and high-quality communication in diverse settings, including remote working regions. These properties make satellite communication Real-time connectivity is crucial for businesses in sectors such as telecommuting, media, oil and gas, government, and emergency response, as it is vital for their operations and safety. [16]. Overall, satellite communication technology plays a significant role in providing extensive coverage and facilitating communication in remote and challenging situations.

Satellite communication confronts issues relating to latency, cost, and regulatory barriers. Latency, governed by satellite orbits, is a major component in real-time network services [17]. While satellite communication gives worldwide coverage, it has shortcomings compared to terrestrial systems, leading to cost issues and the need for faster, higher-quality communication methods [18]. Regulatory developments currently allow for the integration of higher network layers The aim is to improve efficiency in satellites networks for communication by utilizing software-defined technology to optimize resource use, radio spectrum allocation, and reduce latency. [14]. Additionally, the dynamic landscape of satellite communication necessitates updated cybersecurity techniques to address the rising sophistication of cyber threats. Overcoming these problems will be important to fully realize the potential of ubiquitous satellite communications [19].

2.3 Body-Area Networks (BANs): Applications and Challenges

BANs are used in health-monitoring wearables and implanted devices for health monitoring, military purposes, athletic and fitness monitoring, access control, and search and rescue missions [20]. These networks make use of small wearable patch antennas designed for the 2.45 GHz ISM band to make them flexible and suitable for biomedical setups[21]. The reliability of WBANs is being improved with congestion management techniques, making the performance characteristics (like latency, throughput, and packet loss) closer to their conceivable ideal values. Detailed investigations are also made related to the assessment of different aspects: WBAN architectures, communication protocols, security needs, antenna designs, energy harvesting technologies and wearable sensor innovation, etc., which highlight the critical importance of energy management and energy-efficient harvesting mechanisms in WBANs. [22].

BANs face challenges related to power consumption and data security. The dynamic network environment and the blocking effects due to the frequent in-body movements are two major problems that arise in WBANs [23], [24]. In this regard, new power-aware communication protocols, such as Tuatara, have been developed to be used to make real-time power adjustments according to the channel state for saved energy and increased reliability [25]. On the other hand, data security in BANs is significantly important; it assures sensitive health information is secure and is not accessed by an unauthorized person nor compromised. Several security methods have been proposed, including encryption, access control, and secure communication protocols, to enhance the data security in WBANs [26]. These protocols are aimed at ensuring secrecy, privacy, and data integrity to build user trust and to follow privacy legislation.

2.4 Integrity and Confidentiality of Health Data

The assurance of these two factors including confidentiality and integrity of sensitive health care data—is widely crucial in the health care sector. Some applied secure health data encryption techniques include enhanced Quaternion Based Neural Networks, Hybrid Cloud Patterns, and integrated transformation algorithms, such as ITPKLEIN-EHO [27]. Such strategies involve encrypting data using cryptographic methods, storing secret keys on blockchain for safe access, and leveraging chaotic maps for generating highly unpredictable keys. Secure data storage is done through procedures like classifying data, encryption, key management, and secure key communication protocols[28]. By implementing these powerful methods of encryption and secure storage practices, healthcare organizations can protect patient confidentiality, make sure data integrity, and prevent unauthorized gain of access to susceptible medical information, ultimately enhancing the overall security of health data in cloud environments.

2.4.1 Major Healthcare Facilities Attacks

A. Trick-bot: The Trickbot malware is manufactured by the Wizard Spider cybercriminal a criminal group. Trickbot is also known by various ways, such as UNC1878 or Team 9 [29]. These hacker groups primarily attack hospitals, healthcare facilities, and public sector companies in the United States. Trickbot includes a kind of tool known as anchor-DNS that functions just like botnet, offering backdoor access to compromised machines and utilizes that access to spread the malware across fresh systems. Trickbot employs four basic tactics for dropping its malware: spear phishing, secondary payloads, exploiting network vulnerabilities, and malvertising.

B. R.Y.U.K Ransomware: The RYUK ransomware is mainly used by hackers to gain monetary rewards. A distinct criminal group has spread RYUK ransomware in about 400 healthcare facilities across the United States [30]. In 2020, RYUK was the third most prevalent ransomware attack. The Federal Bureau of Investigation (FBI) has reported that victims paid around $61m in ransoms in order to recover their stolen information. The RYUK ransomware works through a multi-stage method. First, it tries to eliminate all files and backup information. It then makes shadow copies of the files and tries to turn off any safety features on the device that was infected. In the second stage, RYUK disables the built-in Windows Automated Startup Repair feature. Moving to the third level, it adjusts the boot status criteria to overlook failure.

In the final phase, RYUK posts a message on the the target's screen requiring them to provide a ransom price for restoring their data. The message further tells the victim not to switch off their smartphone. Files named RyukReadMe.html or RyukReadMe.txt [31]. are generated on the target's desktop, offering a contact email from which the ransom payment needs to be transferred. This kind of ransomware attack is not novel - a similar occurrence occurred in 2017 through the WannaCry virus and impacted roughly 40% of healthcare companies [31].

2.4.2 Mitigation Strategies: Firewalls, Intrusion Detection Systems

Healthcare facilities confront increasing cybersecurity vulnerabilities, especially with the surge in cyberattacks targeting sensitive health data. To prevent these risks, deploying effective cybersecurity measures like firewalls and intrusion detection systems is vital. Additionally, the use of machine learning technology can assist detect and prevent criminal actions within electronic health records (EHR) systems, preserving the security, integrity, and availability of patient data [32]. Furthermore, a risk transference-based system architecture can boost security by shifting sensitive data outside the system boundary to data repositories with strong security measures, lowering the chance of unauthorized access and data breaches.

2.5 Transmission Performance and Reliability

In real-time telemedicine applications, the transmission performance and dependability of health data are critical. Various network technologies, such as point-to-point radiofrequency transceiver, satellite communication, IoT networks prioritizing data packets, and intelligent channel selection [33]. play a vital role in lowering latency. Bandwidth requirements differ across healthcare applications, with solutions like effective routing processes, secure data transmission, and energy-efficient models aiding in optimizing bandwidth utilization. Reliability is crucial in healthcare, with approaches including redundant systems, QoS protocols, automatic data caching, and intelligent channel selection preserving the quality and validity of delivered health data [34]. These innovations jointly improve the efficiency, security, and availability of health information transfer in applications related to telemedicine.

2.6 Regulatory Issues and Data Sovereignty

Health data governance and regulatory compliance, including but not limited to the GDPR, and Health Insurance Portability and Accountability Act (HIPAA), raise major concerns in the health care industry [35], [36]. Problems related to the quality of data, security, harmonization, and compliance with the policy are essential for addressing the regulatory barrier and ensuring that health data in use are of proper quality for research and decision-making [37]. Difficulties such as data sovereignty arise when data is stored and processed across borders. Thus, it needs measures to address regulations governing the location of data and controls in multiple jurisdictions. For instance, the European Health Data Space in planning attempts to harmonize multiple data governance regulations across Member States. Technologies that implement access control, cryptography, data de-identification, and privacy-preserving distributed data mining[38] may be useful for the protection of health data and harmonization with disparate regulatory frameworks.

2.7 Health Data Cross-Border Data Transfer Challenges and Solutions

Cross-border health data sharing includes legal interoperability, ethical issues, and technical limits [39]. The European Health Data Space (EHDS) is trying to facilitate sharing across Europe, but such obstacles as trust, concerns with privacy, and various rules of states make this interchange yet not seamless. For overcoming these problems, a model of legal interoperability for eHealth services has been described that is based on data protection, transparency, and liability [40]. Some initiatives, such as the eHealth Digital Service Infrastructure (eHDSI), are aiming at presenting the opportunity of continuing care for individuals traveling within the EU, where one of the key issues is the importance of harmonized international standards for optimal transmission of information [41]. This has several implications for global health collaborations, assisting in important research, improving patient care, and the development of telehealth projects worldwide.

2.8 Coexistence and Interoperability

The integration of novel technology with legacy health systems brings its own set of challenges due to lack of interoperability, among other issues, pertinent to data compatibility issues [42]. Success stories in integration with the new technology call for shared specifications and standardized data formats, such as HL7 and FHIR, to allow seamless data flow [43]. Existing standards face inadequacies in addressing the huge magnitude of health data, thus leading to the development of new standards to enhance better interoperability, scalability, and handling capabilities. The demand for strong data stewardship, governance models, and new techniques for dealing with the difficulties in interoperability is extremely important for the enhancement of decision-making in public health and the maintenance of data integrity.

2.9 Device and Network Coexistence

Managing interference in densely populated health device networks requires advanced techniques for resource allocation and coexistence management. Research highlights the challenges posed by dynamic interference in Wireless Body Area Networks (WBANs) due to human mobility, emphasizing the need for interference mitigation protocols and dynamic coexistence management mechanisms [44]. The integration of wireless technologies like Wi-Fi and Bluetooth in medical environments further complicates coexistence, necessitating adaptive coexistence mechanisms based on probabilistic packet scheduling with Quality-of- Service (QoS) provision. Additionally, the emergence of Medical Body Area Networks (MBANs) underscores the importance of interference management techniques for coexistence with other radio systems, suggesting methods like gateway-to-gateway coordination to enhance reliability and Quality of Service for MBANs [45]. These insights inform the development of strategies for efficient resource allocation and interference management in densely populated health device networks.

2.10 Application Scenarios

Telemedicine technology, have evolved to permit distant consultations, presenting issues in delivering appropriate care, maintaining relationships, and protecting privacy. Remote monitoring, employs wearables and IoT devices for health tracking, boosting early identification and decision-making in cardiovascular diseases. Data management concerns, underscore the significance of aligning mandates with evidence-based medical practices. Emergency services networks, play a significant role in disaster response by providing telemedical services for on-site medical workers. To assure quality and dependability in these cases, concerns such as network optimization for QoS and CoS, as discussed in[46], are crucial for effective telemedicine applications, especially in critical situations where reliability and low latency are paramount.

2.11 Matured/Saturated Areas

In the world of science and technology, the concept of saturation is complex. From a qualitative research standpoint, saturation is often mistaken as a strict endpoint, signalling completeness without necessarily reflecting actual exhaustiveness [47]. Significant advancement in healthcare technology has been documented in several domains. The integration of technology like artificial intelligence (AI), the Internet of Things (IoT), wearable devices, telemedicine, robotics, and big data analytics has changed patient care, diagnosis, and treatment [48], [49]. Electronic Health Records (EHRs) have eased information sharing among healthcare professionals, boosting real-time decision-making and patient outcomes. Medical imaging technologies such as X-rays, CT scans, and MRI have increased illness diagnosis and treatment accuracy[50]. Telemedicine has enabled remote patient care, notably aiding underserved rural populations. The application of AI and machine learning has showed promise in saving clinicians' time, boosting diagnostic procedures, and forecasting health crises[48]. These improvements not only improve healthcare quality but also lead to cost reduction and increased efficiency in healthcare delivery.

2.12 Future Trends, predictive Analysis and Personalized Healthcare

Big data and AI play a vital role in anticipating health trends by leveraging massive datasets and advanced analytics approaches. Successful implementations include employing AI for disease forecasting for fields like cancer, neurology, and cardiology [51], as well as in recognizing and combating the COVID-19 pandemic through predictive analysis, drug development, and vaccine manufacture [52]. Additionally, the combination of big data, AI, and IoT has led to enhanced community and population health outcomes by employing machinelearning algorithms on standardized healthcare data sets [53]. Furthermore, the combination of big data analytics and AI has enabled accurate chronic illness outbreak prediction, with a multimodal disease severity assessment method exceeding traditional prediction algorithms in terms of precision as well as speed [54]. Overall, these examples highlight how big data and AI applications are transforming healthcare by forecasting health trends and improving patient outcomes.

2.13 Future Trends in Healthcare Network Technologies

The rapid transition of healthcare technology is very much influenced by breakthroughs in artificial intelligence, network technologies, and next-generation communication systems. These innovations are changing healthcare delivery, enhancing quality, access, and efficiency. The following sections discuss the major aspects of this transition[55]. While application of healthcare technology in combination with already existing communication infrastructure, such as 4G networks and IoT, has greatly enhanced patient care with path-breaking applications such as wearable devices and diagnoses through AI. Yet, most of these systems still face issues related to speed, reliability, and integration, more so in critical healthcare applications[56].

2.13.1 Future Trends

Ultra-Reliable Low-Latency Communication—URLLC-5G and ultimately 6G networks will provide ultra-reliable, low-latency communication important for precision and immediacy in real-time remote surgeries. AI-Powered Systems: Artificial intelligence will become even more important in healthcare, using AI to develop predictive diagnoses and personalized treatment strategies. AI, with its ability to go through huge amounts of information and identify patterns, will enhance the clinician's predictive abilities in forecasting the course of a disease and the outcome of treatment.

Quantum Communication—Quantum technology promises to ensure inherently safe, unbreakable encryption of sensitive patient data. This will become crucial in protecting the information about personal health in the increasing tide of data sharing across the networks.

6G Networks—The advent of 6G networks will bring unparalleled speed, bandwidth, and edge intelligence in healthcare applications. This enables technology such as augmented reality (AR) and virtual reality for surgeries, remote consultations, and medical training.

Advanced IoT—Next-generation IoT devices will deliver non-stop real-time monitoring of patients with minimum human interference. Such gadgets will capture and send data across to healthcare providers for the continuous monitoring of chronic diseases and quick intervention in case of emergencies.

As it is depicted in the figure 01, above, the flowchart is initiated with Current State, which signifies the prevailing technology such as 4G, IoT, and basic AI applications in health. Transition Phase: In this phase, it includes 5G technology, AI-based diagnostics, cloud computing technology that is in action for data management, wearable gadgets, facilitating real-time health monitoring.

These future trends are supposed to be the upcoming innovations that are going to include Ultra-Reliable Low-Latency Communication, AI-driven systems, Quantum Communication, 6G Networks, and Advanced IoT. Elaborating on the Key Innovations phase, it describes various uses these technologies can have in healthcare, including AR and VR for surgical procedures, predictive diagnostics, and routine monitoring of patients. The Human Element positions these breakthroughs as instrumental in realizing better patient, health professional, and carer outcomes arising from improved monitoring and diagnosis. All of these are linked to some functions around healthcare-in predictive diagnosis, real-time monitoring, and remote procedures-at

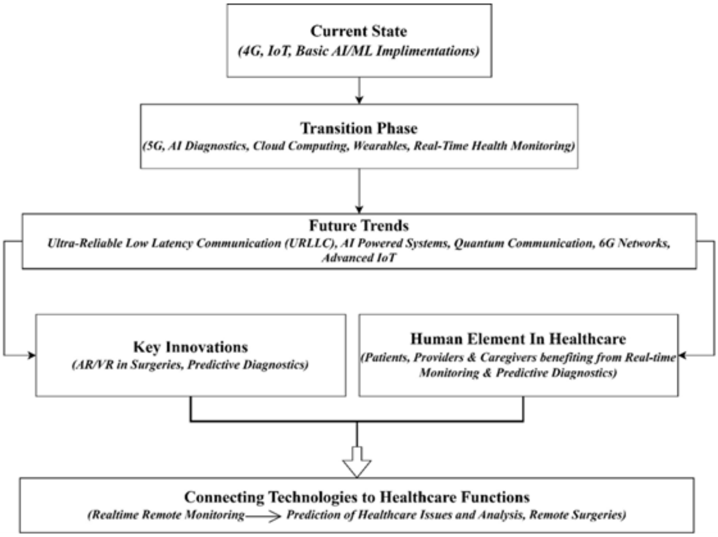

Figure 1. Explaining the current state, transition phase and future trends in the healthcare technology

the end of the flowchart, thus giving a holistic perspective on the growing healthcare landscape.

3. Graphical Analysis

The analysis was performed using advanced network tool NS3 and results obtained from various sources are given below with the graphical representation.

3.1 Latency Comparison

This plot in figure 01, compares latency among 5G, Low Earth Orbit satellites, and Body Area Networks and illustrates the very different capabilities and trade-offs possible with these technologies in various applications. 5G technology is designed for ultra-reliable low-latency communication (URLLC) with average latency at 10 milliseconds. 5G technology will ideally serve applications that require a near-instant response, such as driverless vehicles, virtual reality, and industrial automation. Maintaining such low latency requires a dense network of small cells, especially in metro areas, which increases the implementation complexity and cost further. Latency in the case of LEO satellites is around 30ms, which is much lower as compared to traditional geo-stationary satellites at 500-600ms. Improvement in latency is because of proximity to Earth operating at altitudes that range from 200 to 2,000 kilometres. While not as fast as 5G, LEO satellites play an important role in connecting those remote or underdeveloped locations where terrestrial infrastructure is minim [57] al. Their ability to supply moderate latency allows them to be useful for maritime and aviation communication, among other latency-tolerant applications. On the other hand, the latency is much lower for BANs, averaging only about 5 milliseconds due to their short-range and real-time communication capability. This makes BANs vital in areas such as medical monitoring and wearable devices, where instantaneous data transfer could be related to the health and safety of the patients. However, because they are dependent upon closeness to base devices or gateways, their operational range is very limited; employment in actual settings would thus also be very restricted.

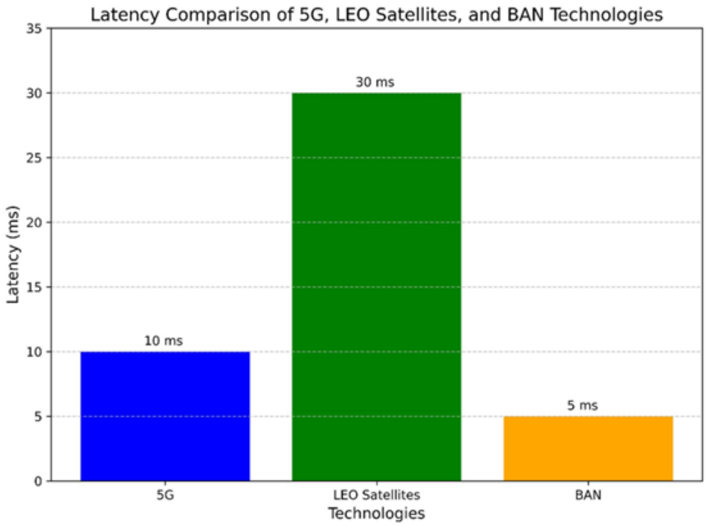

Figure 2. Shows the graphical representation of the Latency

3.2 Data Transmission Speed

The graph in figure 02 illustrates the data transmission velocities of 5G, satellite, and BAN networks. 5G is very fast, running at 1000 mbps, while satellite and BAN are behind at 100 mbps and 10 mbps, respectively. This grand difference in their speeds demonstrates the advantages of 5G in bandwidth-intensive applications such as streaming and online gaming. The data will help businesses and consumers choose the best network based on their needs and required data transmission speeds. From the figure 02 these conclusions can be drawn: 5G Technology has the edge over all previous technologies with a very high transmission speed of 1000 Mbps, which would be extremely ideal for bandwidth-intensive operations like real-time streaming, online gaming, and virtual/augmented reality applications. Higher speeds in this regard come in handy in ensuring smooth data flow with minimum buffering or interruptions. While satellite networks serve exemplary functions in wide-area geographic coverage, they offer data transmission speeds of 100 Mbps, which is lower than 5G and hence may not be useful for high-bandwidth applications; this speed is acceptable for light internet browsing and remote communications. On the contrary, body area networks, or BANs, represent the lowest transmission speed of 10 Mbps, which, while adequate for low-power medical or IoT devices, limits the usefulness of such networks for operations that rely heavily on data.

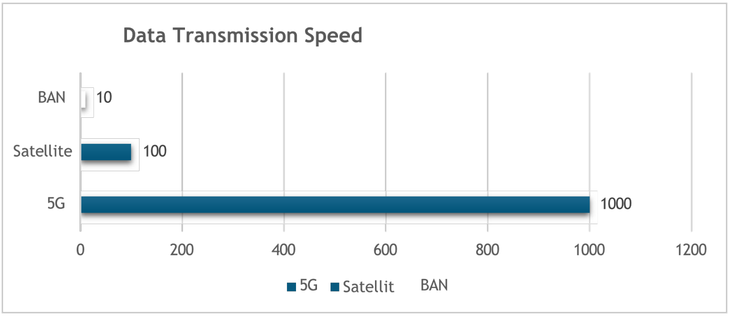

Figure 3. Graphical representation of the Data Transmission Speed

3.3 Security Breach Frequency

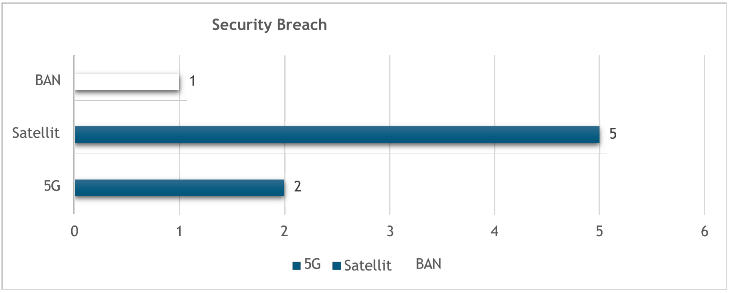

Figure 4. Shows the breaches/month for the major network technologies associated with healthcare sector. It can be seen that on monthly basis 5G technology faces 2 security breaches per month while 5 and 1 breach per month is faced encountered by Satellite network and BAN respectively (potential threat vectors to 5G infrastructure, 2021)

4. Discussion

The future network technologies are refolding the healthcare industry in forms of medical service delivery, management, and outcomes. The challenges posed by these emergent technologies will be severe integration and implementation issues. Technologies like 5G and 6G, advanced IoT, and AI systems do have great potential for patient care, but their integration requires robust methodologies–especially for connectivity, interoperability, security, and accessibility as it can be seen in the figure 03.

One of the key focuses is on the way how satellite networks will be integrated into future 5G systems. Satellite networks can be a critical element in extending healthcare coverage to areas where it is impossible to lay terrestrial networks. In establishing seamless communication between the satellite and 5G networks, efforts must overcome latency, bandwidth, and synchronization challenges. Specific solutions may include establishing hybrid network architecture, developing adaptive routing protocols, and incorporating edge computing capabilities, thereby reducing these issues. It is also important that collaboration between the satellite service providers and telecom operators has been done to build standardized protocols for interoperability.

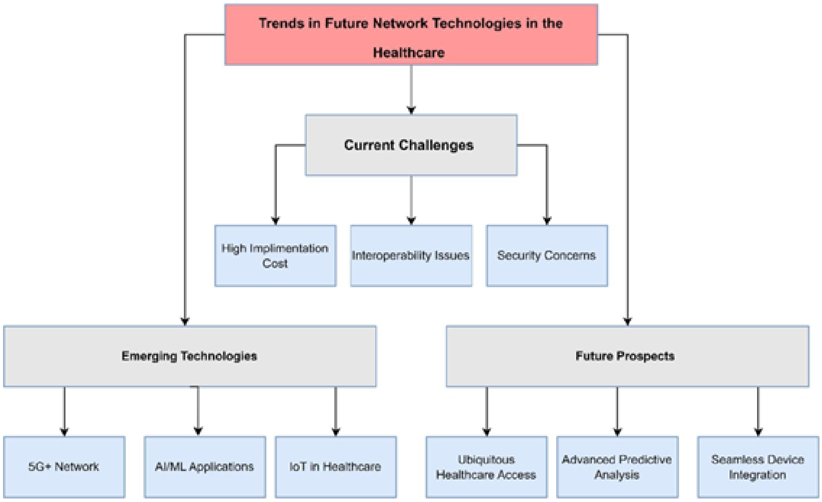

Figure 5. Explaining the overall trends in the Future network technology as depicted above

Additionally, one more such innovative feature is in the domain of BANs: this holds tremendous promise and another significant use case in the care and observation of patients in the clinical environment. BAN offers a network of medical sensors deployed on or within the human body that may observe vital signs and transmit data in real-time to the healthcare provider. It allows preventive treatments, reducing hospital readmissions and enhancing outcomes of patients. Clinical BANs facilitate precision medicine by adjusting treatment methods with evidence related to patient-specific data. However, their widespread adoption requires considerations of energy economy, data security, and compatibility to ensure the continuity of reliability in patient safety.

So, data sovereignty remains a quite serious issue with healthcare systems increasingly using worldwide cloud services for storage and processing of data. Hence, Meeting compliance requirements of various healthcare legislation across the globe, such as HIPAA in the United States, GDPR in Europe, and similar frameworks in other countries. Certain developments or plans in this regard revolve around multi-cloud strategies that enable healthcare firms to store sensitive data in a way compliant with local regulations but still provide access to analytics capabilities at a global scale. Further, new ways of anonymizing and encrypting data combined with blockchain-based architectures for sharing data can further help to maintain sovereignty while ensuring the integrity and availability of the data.

While these technologies hold great promise, the question of equitable access is really one of limitation. Satellite-5G integration and BAN development must reach rural and poor areas, lest the health disparities be further increased. Both the government and the commercial players ought to join hands in supporting the application of the above technologies to the underprivileged areas.

Moreover, healthcare providers and patients should be taught the effective use of these technologies in order for their application to be successful. Intuitive designs, easier interfaces, and cross-training programs facilitate overcoming resistance to change and allow the technologies to achieve their maximum potential.

5. Recommendations

Many important, targeted and specific stretegies are required that can be adopted to address these challenges and leverage the potential afforded by new network technologies in healthcare. First, addressing the integration problems between satellite networks and any future 5G systems calls for a multi-faceted approach. Hybrid network models that combine satellite and terrestrial infrastructure must be developed to balance bandwidth with lower latency. The application of adaptive algorithms for the dynamic management of networks, and edge computing for localized data processing, might further enhance integration.

Considering the application in body area networks, their scope could be extended in patient care only if quite a few technical and operational issues were addressed. First, energy-efficient solutions for the BAN devices have to be developed to allow for prolonged battery life and better practical use. Further, strong cyber-security processes would be ensured in order to protect sensitive patient information carried by BANs. The interoperability protocols would also be required for connecting to more general systems.

Federated learning or other forms of distributed data storage models, where analytics take place locally within healthcare organizations but are internationally coordinated, might be an effective remedy for issues of data sovereignty. This would ensure the applicability of regional legislation while at least partially realizing some of the benefits of cross-border data sharing. Blockchain technology may also play a very important role by offering secure and immutable protocols for cross-border sharing, raising both trust and compliance across countries.

In addition, it has to be equitably distributed, developing technology. Installation of such technologies in rural and underserved areas should be financed and resourced by the governments and international organizations. Collaboration between the public and private sectors would be a good example for cheap access and the infrastructural development that needs to go with it. Training programs for healthcare providers and end-users should aim at confidence and skill growth in implementing these technologies.

6. CONCLUSION

This review has offered a complete review of the essential components of healthcare network technology, concentrating on concerns and challenges such as cybersecurity, interoperability and implementation cost related with new trends such as 5G, satellite communication, and body-area networks. Key considerations include security procedures to secure patient data, privacy concerns connected to patient confidentiality, and performance indicators including latency, bandwidth, and reliability. Additionally, we considered regulatory compliance, data sovereignty, and cross-border data transfer issues, as well as the coexistence and interoperability of new technologies with existing healthcare systems. Standardization issues were emphasized, identifying gaps and suggesting new standards to assist developments. Our analysis suggests that security and privacy, data sovereignty, regulatory compliance, and integration of future technologies require additional contributions, whereas basic encryption techniques and components of telemedicine are quite established. Future research should develop better security protocols, privacy-preserving technologies, new solutions for regulatory problems, and continuing investigation of AI and IoT integration with healthcare networks. Standardization efforts must be expanded to keep pace with technological improvements. Continued innovation and research are crucial for tackling developing difficulties and advancing healthcare delivery, and researchers are encouraged to examine these gaps to contribute to more secure, efficient, and interoperable healthcare systems, ultimately improving patient outcomes worldwide.

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