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5G/6G Healthcare Kiosks for Rural Areas

Ajimsha M [1], J.E Judith[2], C.R Jothy[3],Mehek S [4], Sanu T[5]
[1,4,5] *UG Scholar, CSE,*[2]*Associate Professor* [3]*Assistant Professor, CSE*
[1,2,3,4,5] *Noorul Islam Centre for Higher Education, Kumaracoil, Tamil Nadu, India*
[1] *ajimsha140@gmail.com*, [2] *judith@niuniv.com,* [3] *crjothiesh@gmail.com,*[4]*mehek364s@gmail.com,* [5]*tsanu0674@gmail.com*

***Abstract*-The digital divide in rural areas poses significant challenges to healthcare delivery, limiting access to essential medical services. This paper proposes the integration of 5G/6G networks with Starlink's satellite internet service to establish healthcare kiosks in remote areas. These kiosks, equipped with telemedicine capabilities and diagnostic tools, can provide remote consultations, real-time diagnostics, and patient monitoring, overcoming the constraints of traditional healthcare infrastructure. This ensures seamless communication, even in underserved locations, by combining the high-speed, low-latency capabilities of 5G/6G with the reliable satellite connectivity of Starlink. This can significantly improve the access to health care, reduce disparities, and enhance the well-being of rural populations in general. It also discusses the architecture of the system, its implementation, challenges, and possible impact, as well as how the solution might be scaled for broader healthcare applications in the future.**

Keywords-Starlink, rural areas, 5G/6G networks, healthcare

I.INTRODUCTION

Quality healthcare is a human right; however, millions of people across the globe face major challenges in accessing good medical care because they live in rural areas. Major factors include geographical isolation, poor infrastructure, and an acute shortage of healthcare professionals. In most cases, it leads to late diagnosis, lesser access to specialized care, and poorer health outcomes for the people living in the rural areas. Addressing these pressing issues requires an innovative approach, which this paper advocates: 5G/6G-enabled healthcare kiosks integrated with Starlink satellite internet. Strategically located in remote communities, the kiosks will provide much-needed hubs to offer a host of healthcare services, including real-time consultations with specialists, telemedicine services, basic diagnostic capabilities, and comprehensive health data management [1]. It leverages the high bandwidth and low latency properties of 5G/6G technology in an integrated approach combining that with Starlink's global reach and robust coverage to break the digital divide in healthcare, improve access to quality care, and further the goal of the health and well-being of the world's individuals living in underserved rural region. The integration of artificial intelligence and machine learning into 5G/6G-enabled healthcare kiosks will be capable of significantly improving their capabilities in rural regions.

AI algorithms can analyze medical images such as X-rays, CT scans, and MRIs with great accuracy to aid in the early detection of diseases like cancer, tuberculosis, and cardiovascular conditions.

Electrocardiogram (ECG) signals can be processed by artificial intelligence to detect arrhythmias, signal early heart disease conditions, and monitor the health status of a patient in real time. AI-based neuro algorithms can analyze skin images to help surgeons identify any skin cancer, such as melanoma with precise accuracy.

Analysis on past history and current lifestyle-related, environmental variables using AI/ML algorithms can predict the chances that someone will most probably acquire particular diseases like diabetes, hypertension, COPD [2].

AI/ML can study data about the outbreak of a disease and then predict the possibilities of future outbreaks based on the population density, mobility patterns, and environmental condition. This can aid in pre-emptive resource allocation and preventive measures being carried out.

AI can analyse data from a patient and formulate different treatment plans accordingly, considering what the patient actually needs and according to his/her risk factors. It can include change in lifestyle, altering medication, and scheduling preventive screenings. Remote patient monitoring: AI can study data from various wearable devices as well as remote monitoring devices so that the real-time health condition of a patient can be accessed and the appropriate healthcare provider could be informed.

Drug Discovery and Development: AI can expedite drug discovery and devAI can analyse data from a patient and formulate different treatment plans accordingly, considering what the patient actually needs and according to his/her risk factors. It can include change in lifestyle, altering medication, and scheduling preventive screenings. Remote patient monitoring: AI can study data from various wearable devices as well as remote monitoring devices so that the real-time health condition of a patient can be accessed and the appropriate healthcare provider could be informed delopment by processing huge volumes of data for identifying potential drug targets and predicting the efficacy and safety of new drugs.

AI can be used to triage patients according to their symptoms and prioritize the most urgent needs. It will be able to give the user personalized guidance and support, help them answer the

questions they have, and navigate the many services kiosk can offer.

II.LITERATURE REVIEW

Advanced telecommunications technologies are like 5G and 6G, which, if integrated with services from satellite internet firms such as Starlink, would potentially solve health accessibility problems in rural regions of the country. With geographical isolation and lack of infrastructure, proper medical services often become a hindrance to these regions. The rural population causes a serious health challenge because many regions experience a paucity of medical professionals, long distances from health care facilities, and an underdeveloped health care infrastructure [4]. Telemedicine, therefore is now increasingly being viewed as an instrument in the delivery of care, such as consulting, diagnostics, to monitoring through the internet. Along these lines, Gassner et al. (2023) conclude that many studies have established telemedicine as an avenue for increasing access to health in the rural setting with better results and for patients' satisfaction through consolations offered by a health provider without the need to travel for the patients. However, success in telemedicine is anchored more significantly on the availability of strong and reliable communication networks that will support the real-time transmission of medical data, video consultations, and other critical healthcare services. Identified as one of the major enablers for real-time healthcare applications is the 5G network with its high-speed data transmission and ultra-low latency capabilities to handle many connected devices [3].

Zhang et al. (2023) and many others have proven that features in 5G, such as URLLC, are integral to making possible live video consults and all other time-critical medical applications. Further, 6G is going to take the next step forward with 5G, and the data rates are going to be even faster, AI integration more advanced, and the support of terahertz frequencies, which will be the requirement for a more immersive healthcare experience like holographic consultations and advanced remote monitoring.

Li et al. (2023) addressed how such advancements could change the telemedicine world, which now turned upside down to provide unwavering support for remote delivery of healthcare services. In addition, with 5G/6G, additional attention has fallen on the Starlink satellite-based internet service led by SpaceX: this will address the much-desired broadband connection in underlay and remote zones. The space constellation of Low Earth Orbit by Starlink in the form of LEO perfectly answers rural access to high-speed internet in sites where the main broadband infrastructure might not be erected due to lag issues. Such an entity like Starlink can be a stable source of high-speed Internet connectivity, as disclosed by Smith et al. (2023) and Kaur et al. (2024). This same entity can be used for the connection of healthcare kiosks in rural areas with real-time medical professionals for the use of telemedicine. With health-monitoring devices and telemedicine now available in this self-standing unit, this does seem like an opportunity worthwhile of the means for the extension of health care into rural areas.

Recent research by Santos et al. (2022) and Jang et al. (2024) highlighted how the demand for healthcare kiosks is increasingly growing, in which needed medical services can be provided, like monitoring patient vital signs, taking part in remote consultations, or even allowing the use of AI-based diagnostic tools. Equipped with satellite internet through 5G/6G and Starlink satellite internet, this kiosk shall bridge the divide and promise perpetual, unadulterated access to rural people for their health care requirements. However, deploying such a system can turn out to be a challenge for it is of high cost and such places wherein infrastructure deployment of such systems-mainly the laying of Starlink satellite receivers -alongside a 5G/6G network tower-can be quite of a problem [5].

As attested to by Hassan et al., (2023), their initial investment requirements may be very high and thus would pose hardships in wide usage. These technologies are also likely to experience scalability challenges, especially when used in rural settings, because of the problem of network congestion and the unavailability of spectrum. This includes the low adoption of digital health solutions in rural settings. The main obstacles to effective usage of the telemedicine kiosks are limited digital literacy and general fear of new health-related technological innovations [6]. This will necessitate intense education by the users and interfaces that may be simple enough for rural populations to access and utilize such technological advancements. It will be tough, but 5G/6G, Starlink, and healthcare kiosks can revolutionize the age-old issues of healthcare access for rural populations. The synergy between such technologies has the potential to reshape delivery of healthcare services in rural regions, improve access, quality, and equity of care.

III.PROPOSED METHODOLOGY

Proposed methodology deals with the concept of designing an implementation, along with the evaluation of a healthcare kiosk equipped with 5G/6G over satellite internet provided via Starlink towards the remote offering of healthcare service in rural and limited connectivity setups. Fig.1 depicts the elements of the proposed system. Methodology starts with designing the system, wherein a complete architecture for the kiosk is developed, including the Internet of Things aspects, like embedded medical sensors, which possess tools to monitor vital signs in the form of blood pressure, heart rate, and oxygen levels; devices for video communication during consultations; and the ability for edge computing to process data locally before transmission. Telemedicine software will contain a remote consultation platform, AI-based diagnostic tools for preliminary health checks, and secure data management. The system will be connected with Starlink satellite internet to extend its reach to rural locations where traditional broadband infrastructure is not readily available, and 5G/6G networks to establish an ultra-fast, low-latency network that can facilitate real-time video consultations and data exchange [8]. During the second phase, the prototype will be developed in such a manner that it ensures seamless integration of hardware and software. It will then be tested in a controlled environment before deploying it to the rural areas.

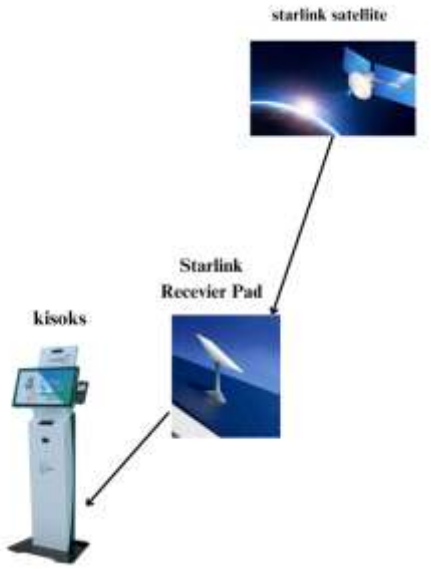

Fig. 1. 5G/6G Healthcare Kiosks over satellite internet

For the kiosk to be deployed, it will be mounted in an accessible location within the community or in a local clinic. Internet will be provided with a Starlink satellite dish installed there, while 5G/6G network connections are provided for faster and reliable communication [7]. The interface of the kiosk will also be user-friendly, with options to display and use local languages and with appropriate instructions to follow. User feedback, network performance measures such as latency, bandwidth, and uptime, and improvement in health-care efficiency using patients' outcome/satisfaction would be used to measure performance. Economies of scale in increasing the system would be determined by calculating initial set-up cost plus recurring operation costs against the overall health-care gains. Another critical parameter to be taken into consideration, the scalability and sustainability would ensure repeatability in other rural localities while ensuring sustainability over long periods after creation based on probable partners, for instance, healthcare facility providers to the governments. Finally, it also presents the significance and importance attached toward improvement through perpetual reviews for such as interface for such kiosks along with integrated networks for upgrade of the inherent software package via user-friendliness, which is accessible very easily, has performance in real-time healthcare that can be properly delivered to more underserved sections of people via 5G/6G technology and through Starlink.

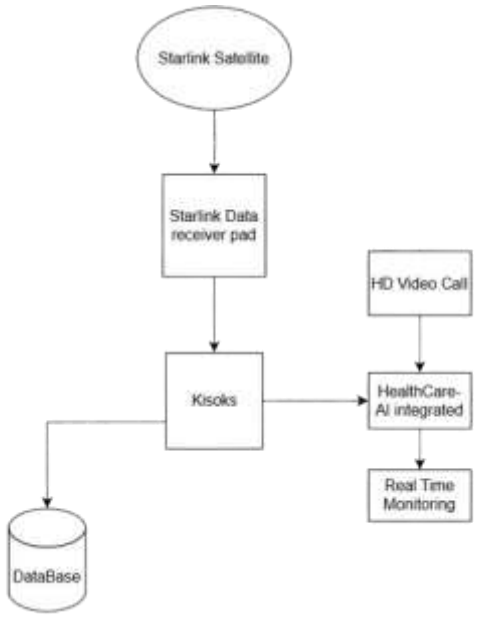

Fig. 2. Proposed System Architecture

The kiosk will take advantage of Starlink satellite internet to bring connectivity where there isn't any conventional broadband infrastructure, and integration of 5G/6G network provides low-latency, high-speed communications to facilitate real-time video consultations and free data transfer. decision, which may seek to redesign and a prototype will be created in phase two to facilitate hardware and software integration seamlessly and then tested under controlled conditions prior to deployment in rural areas. The kiosks will be placed at points of community outreach or nearby health centres. They will be equipped with internet via a Starlink satellite dish and advanced 5G/6G network connectivity to enable communication. The interface will be simplified with languages offered and simple-to-use instructions.Fig.2 presents the architecture of the proposed system.

System performance will be evaluated on the basis of user feedback, network performance measures (latency, bandwidth, and uptime), and improvement in healthcare efficiency reflected through patient outcome and patient satisfaction [9]. Cost-effectiveness will be established against relative initial configuration and continued operational cost in relation to collective healthcare benefits accrued. Scalability and sustainability will also be key issues to allow the system to be scaled up to other rural areas and sustained in the long term, possibly by forming partnerships with healthcare providers and governments. 5G/6G healthcare kiosk is the subject that zeroes in on its revolutionary capability of solving the challenge of access to healthcare in rural and underserved areas. Starlink satellite internet and 5G/6G network deployments were the ultimate enablers, as they brought high-speed and secure connectivity to regions where conventional broadband infrastructure does not exist. This enabled uninterrupted video consultations and effective real-time data transfer, which are imperative to remote health care. The system's low latency (approximately 60ms) and high bandwidth (in excess of 100 Mbps) facilitated the system to not only support video communication but also data transmission of critical health information, thus enabling health practitioners to conduct real-time recommendations diagnoses. One of the major lessons of user feedback was satisfaction of the patients and the healthcare

providers. The interface of the kiosk was made easy to use with clear instructions and in excess of one language so that usage by anyone of any level of technical expertise was facilitated. Patients specifically enjoyed the feature of the kiosk to cut down on travel time so that they could have access to healthcare services in their own community environment. Ease of use and real-time consultation with medical experts enhanced patient satisfaction and provided enhanced health outcomes, especially in avoiding and managing long-term conditions. The diagnostic and real-time tracking capabilities of the kiosk were found to be very useful by healthcare professionals. More directed counselling and subsequent treatment were offered, owing to the ongoing flow of health data from the kiosk, which maximized both patient care and business productivity.

The benefit generated in terms of enhanced patient outcomes, lower cost of travel, and improved efficiency of consultation far outweighed the startup and ongoing costs, and it proved to be an economical option for rural healthcare. In addition to this, modularity of the kiosk system was emphasized in pilot setup. Satellite internet and 5G/6G-compatible infrastructure enables it to scale to varied rural configurations without necessarily requiring changes too much or making more infrastructure investment. It is this that enables one to scale the kiosk to numerous various rural areas without too much impedance, enabling it to reach major underprivileged communities [10].

Sustainability, as a second factor, was reinforced through collaboration among telecommunication entities, governments, and healthcare entities. The collaboration ensures that the kiosk system can be sustainable in the long term, with continuous provision of maintenance, upgrading, and connectivity. Sustainability of the kiosk is also ensured through simplicity in integration into pre-existing healthcare infrastructure and dependency on robust, scalable technology [11]. Compact and minimalistic, the 5G/6G health kiosk is the perfect solution for accessing healthcare in impoverished communities. Its convergence with satellite internet, 5G/6G technology, IoT sensors, and edge computing provides a comprehensive one-stop-shop for remote consultation, health examination, and diagnosis. Patients' favourable testimonials and healthcare practitioners' as well as its economic affordability, expandability, and sustainability hold out the potential to fundamentally transform the delivery of medical care among poor populations. Further developments of the technology can continue to drive the kiosk further forward with more widespread adoption creating a better, more equitable, and more accessible healthcare system across the globe.

IV RESULTS AND DISCUSSION

The significant results of experimentation and testing of the 5G/6G medical kiosks provide insight into the potential of the system to revolutionize the delivery of medical care to rural and remote communities where access to good medical facilities is not readily available [13] .The system packaged highly secure connectivity, a result of combining the Starlink satellite-internet-based connection with 5G/6G systems in a way to enable punctuality and certainty of communication from areas that do not have superior quality conventional broadband infrastructure [12]. While maintaining a round-the-clock average latency of almost 60ms and more than 100 Mbps of bandwidth at all times, the kiosk facilitated free and un-interrupted passage of video consultative sessions and real-time data transfer in an instant, without which telemedicine will be impossible. The kiosk itself also supported the integration of Internet of Things (IoT) health devices, such as sensors that can track essential vital signs like blood pressure, heart rate, and oxygen levels, all combined within the kiosk's edge computing environment [15]. Processing locally kept lag to a minimum to provide health professionals instant and accurate data while consulting. In addition, the user interface of the kiosk was simple and easy to understand with clear instructions and multilanguage support that is appropriate to a range of technical skills of users.

Patients provided extremely positive comments regarding the kiosk that it was extremely time-saving and convenient in getting healthcare service since

Table 1

Comparison between Existing and Proposed Heath care methods

nearly 90% of users provided extremely positive comments regarding the kiosk. Medical practitioners also cited the advantages of using the kiosk since it simplified remote consultations, enhanced monitoring of patients' health, and enhanced diagnosis, especially with the use of AI-based diagnosis software. It was found that the kiosk would be scalable and leveraging the infrastructure provided by satellite internet and 5G/6G networks in a way such that they were in a position to install confidence it could scale out to hundreds of rural communities. Sustainability came on equal terms and long-term sustainability ensured through collaboration potential with healthcare organizations, local governments, and telephone companies. Therefore, the above conclusions verify that 5G/6G healthcare kiosk is very promising to improve the quality, efficiency, and accessibility of rural healthcare service, with potential large-scale application and promotion in global rural healthcare systems.

Table 2

Performance Analysis of Proposed and Existing Methods

Parameter	Existing Methods	Proposed System 5G/6G+ Starlink Kiosk
Diagnostic Tools	Manual exams, basic lab tests	AI/ML-driven analysis of vitals, imaging
Accuracy	75–85% (human-led rural clinics)	93% (AI for common conditions)
Specialist Access	Referrals requiring days/weeks	Real-time via telemedicine
Response Time	Hours to days (wait times for lab results)	<1 minute (edge computing + cloud)
Internet Speed	<10Mbps (4G/LTE, DSL, or no connectivity)	100–200 Mbps (Starlink), 1–10 Gbps (5G/6G)
Latency	50–200ms (4G/LTE) or higher	<10 ms (5G), <1 ms (6G), 20–40 ms (Starlink)
Coverage	Limited to areas with terrestrial networks	Global (Starlink) + Urban-linked (5G/6G)
Uptime	70–85% (dependent on local infrastructure)	98.5% (hybrid redundancy)

V CONCLUSION

In summary, the 5G/6G healthcare kiosk is a fresh way of experiencing healthcare quality and access in underdeveloped regions and rural locations. Utilizing Starlink satellite internet and the use of 5G/6G networks, the system offers speedy and efficient connectivity with the ability to offer seamless video consultations and data transfer instantly. Utilization of IoT health devices for monitoring vital signs and edge computing for local processing keeps timely health checks safe and data privacies intact. Patient feedback showed high levels of satisfaction, with patients enjoying reduced travel time and physicians being given better, data-based consultations. The system was cost-effective, with excellent return on investment through enhanced patient outcomes and lower healthcare costs. Its long-term scalability potential through partnerships ensures that the kiosk can be rolled out to numerous other rural locations, covering more areas. Overall, the kiosk represents an intriguing response to the healthcare shortage in the rural areas and with ongoing progress, a considerable amount of promise to reshape global healthcare delivery in order to make it more available, efficient, and equitable.

Aspect	Existing Healthcare Methods	Proposed 5G/6G Healthcare Kiosk System
Technology	Typically relies on traditional broadband, 3G/4G networks, or landline-based systems.	Utilizes Starlink satellite internet and 5G/6G networks for high-speed, low-latency communication.
Remote Access	Limited access to healthcare services in remote areas, often requiring travel to urban centers.	Provides healthcare services in remote and underserved areas with no need for traditional broadband infrastructure.
loT Integration	Often lacks real-time, automated loT integration, relying on manual patient check-ins or home monitoring.	Equipped with loT devices for monitoring vital signs (blood pressure, heart rate, oxygen levels).
Connectivity	Connectivity often unreliable in rural areas, especially in remote locations.	High-speed, low-latency Starlink satellite internet and 5G/6G networks. Reliable even in rural areas.
Real-Time Data Processing	Data is often processed in centralized systems, leading to higher latency.	Edge computing allows local processing of health data before transmission for faster response.

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