



Revolutionizing Healthcare Access: Exploring the Potential of Telehealth Kiosks

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5.1 Introduction

An important norm for a civilized society is to ensure that each of its members has access to affordable and good quality healthcare. It ensures improvement in the health status of the population resulting in improvement in the economy of the nation. However, there are inherent problems in the healthcare (e.g., inadequate infrastructure, high prevalence of unqualified medical quacks) which hinders the provision of proper health services especially in isolated and rural areas. The shortage of healthcare workers, coupled with a large number of patients, results in long waiting times for treatment. This coupled with high cost of private healthcare services eventually forces many patients to stop therapy for chronic diseases.

The shortage of health staff is higher in developing nations including India. According to a recent World Health Organization (WHO) report, India will need at least 1.8 million additional physicians, nurses, and midwives by 2030 in order to reach the benchmark of 44.5 health professionals per 10,000 people [1]. However, at the current growth rates, the projected density of the skilled health personnel is not expected to change by 2030.

There is a significant difference in the availability of healthcare workers and facilities, first between urban and rural locations and second between the public and

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private sectors. About 33% of the country's health professionals reside in rural areas which account for 66% of the country's overall population. The majority of health staff is employed in private sector, which provides for 60% of inpatient and 70% of outpatient care [2]. This increases the cost of healthcare. Given the shortage of professionals in India, particularly in auxiliary public institutions, there is a significant discrepancy in health services offered by the private and public sectors. In community health facilities across India, there is a deficit of 79% for surgeons, 70% for gynecologists, and 78% for pediatricians [3]. Needless to say, there is a vast difference between the need and supply of healthcare services in India.

Telemedicine is a viable option to narrow down these service delivery gaps and provide medical treatment even during epidemics. We have developed a telehealth clinic that serves both as comprehensive diagnostic lab and a hub for specialist consultation. It includes artificial intelligence (AI) technology for real-time data management. Our telemedicine kiosks have the potential to help in achieving the Sustainable Development Goal 3 (SDG3) of ensuring healthy lives, promoting well-being for all, and generating employment opportunities. By leveraging telemedicine and telehealth kiosks, we can bridge the gap in healthcare service delivery, bring healthcare services closer to communities, and improve access to quality healthcare. Our kiosk has the potential to revolutionize healthcare delivery, making it more efficient, affordable, and inclusive.

According to the information provided by the National Medical Commission (NMC), there are 13,08,009 doctors registered with the state medical councils and the National Medical Commission as of June 2022. The doctor (both practicing allopathic medicine and 6.5 lakh AYUSH doctors practicing traditional medicine) to patient ratio in our country is 1:834, which is better than the WHO standard of 1:1000 [4]. More than 75% of the healthcare infrastructure is concentrated in metro cities, where only 27% of the country's population resides. Accordingly, approximately 73% of the Indian population which resides in rural areas does not have access to even basic medical facilities. There is a lack of approximately 3000 doctors in primary health centers which has increased by more than 200% in the last decade [5]. Most of the doctors are employed in private sector, which is not affordable for common population of India [6]. In rural India, only 11% of subcenters, 13% of primary health centers (PHCs), and 16% of community health centers (CHCs) meet the Indian Public Health Standards (IPHS). In 2019, 9.6% of the 24,855 PHCs in India had no doctors, 38.4% were without laboratory technician, and 23.9% were without pharmacist [7, 8]. There are only 1.5 hospital beds per 1000 population.

India is facing a lot of healthcare-related challenges. Changing lifestyles and environment has led to a rise in various communicable (CDs; tuberculosis, leprosy, HIV) and noncommunicable diseases (NCDs; cardiovascular illnesses, chronic respiratory diseases, cancers, and diabetes). The WHO hopes to eliminate tuberculosis only by the year 2050 due mainly to lack of doctors, infrastructure, and other paramedical staff who can actually handle this dreadful disease [9]. According to the International Diabetes Federation (IDF), worldwide 537 million individuals suffer from diabetes, a number which is set to increase to 783 million by 2045. These numbers underscore the need to implement cost-effective measures for care of diabetes [10].

Communicable diseases (CDs) account for 26% of annual deaths in the world and 30% of 1.49 billion disability-adjusted life years (DALYs) which are lost annually. India, being a developing country suffers the most due to morbidity and mortality created by CDs [11]. However, NCDs are not far behind. A recent report released by the India State-Level Disease Burden Initiative shows that three of the top five leading causes of DALYs lost in India were NCDs: coronary artery disease, chronic lung diseases, and stroke. It is estimated that India is likely to lose \$4.58 trillion before 2030 due to NCDs [12]. Our telehealth kiosk has the potential to effectively manage NCDs and CDs through early detection, appropriate management, treatment adherence, and better compliance with reduced carbon footprint and enhanced social stability, without putting any extra burden on the patients and the state.

5.2 History of Telehealth Kiosks

Telemedicine has been used for decades, with origins in the twentieth century [13]. The best-known telemedicine program, the Extension for Community Healthcare Outcomes (ECHO), was developed by the University of New Mexico Healthcare Center for managing hepatitis C and helped to deliver specialty medical care [14]. Telemedicine has been utilized by the US military for several years. The Walter Reed National Medical Center offers chronic pain consultations to remote military training force (MTF) since 2009. In recent years, telemedicine is being used to treat mental health issues (including opioid-use related problems) in people residing in remote areas [15, 16].

With the rise of the COVID-19 pandemic, telemedicine became very popular. The clinicians and patients adapted to a novel way of medical care. During the pandemic, telemedicine provided a connection between patients and clinicians while maintaining social distancing and avoiding infection transmission [17]. Whether telemedicine will continue in the post-pandemic world depends on many factors. Some of these factors are related to patients, some to the consultants and their practices, and some are related to money reimbursements.

Health kiosks can be installed anywhere. Another example of telehealth kiosks includes health point, a community-based touchscreen kiosk developed and evaluated in Glasgow in 1989 [18]. Nicholas et al. [19, 20] provided data regarding the utility of touchscreen health kiosks located throughout the United Kingdom. They examined the use of a sample of 20 kiosks over three and half years and identified four patterns of use over time. These were a declining pattern, a stable pattern, an increasing pattern, and a no-trend pattern. Porter et al. [2004] [21] developed an asthma kiosk designed to address five critical issues for patient-centered technology to promote guideline-based care in the emergency department (ED). These issues included the following: (i) Develop front-end interface for patient-driven data capture that fits physical and logistical challenges of the ED setting; (ii) implement an interface that is neutral to patient's technology-based experience or medical expertise; (iii) create an architecture for the display and capture of medication data for asthma; (iv) implement a rules-based approach to link parent-derived data to "Best

Practice Guidelines Recommendations” in pediatric asthma; and (v) create output that encourages “activated and informed” patients and “prepared and proactive” providers. Some kiosks such as Wellpoint also included blood pressure, body fat, and body mass index measurements. These have been installed in occupational health settings [22]. Recently, a study on the “Retail Outlet Health Kiosk Hypertension Trial (ROKHYT)” supported the use of text-messaging intervention to improve control of hypertension [23]. In another study, a card-based telehealth kiosk system implemented in a community setting reduced the costs of installing and maintaining individual systems. However, most of the studies on telehealth kiosks have addressed user acceptance of telehealth systems in the context of home residences, and there is a lack of data on their use in community-based systems [24].

Despite successes in efforts to integrate HIV (human immunodeficiency virus) testing into medical kiosks, challenges remain. Kiosk-facilitated self-testing is one novel approach to improve HIV testing. One study recruited emergency department patients, aged between 18 and 64 years, to evaluate the use of tablet-based kiosks to guide the patients to conduct their own point-of-care HIV tests followed by the standard-of-care HIV tests by healthcare workers. Both tests were OraQuick Advance tests. The results showed that patients were comfortable using HIV-testing kiosk [25, 26]. Another study evaluated the role of kiosk as an automated patient history intake device (APHID). Here, the authors used an approach to assess the utility of patient-facing medication reconciliation and allergy review (MRAR) kiosk [27]. Still later, kiosks were developed and used to support self-management strategies for chronic kidney disease [28] and to promote sexual health and prevent sexually transmitted infections and unwanted pregnancies [29]. One study evaluated the efficacy of Guangdong Second Provincial General Hospital’s Digital Health Kiosk program, wherein Dingbei telemedicine platform was used to connect rural clinicians to physicians in upper-level health facilities. They reported that the use of telemedicine resulted in better healthcare utilization, more patient satisfaction, decreased out-of-pocket costs, and improved health outcomes [30]. Still later, teleophthalmology was found to give promising results in the diagnosis and management of ophthalmological diseases. Remidio, a proprietary, offline, smartphone-based, automated system of analysis of retinal images can be used to detect referable diabetic retinopathy (RDR) through images taken by a minimally trained healthcare worker with Remidio non-mydratic fundus (a smartphone-based, non-mydratic retinal camera) on phone [31, 32].

Two smart walk-in clinics have been prepared by the Center for Innovation and Bio-Design (CIBioD), namely Health Kiosk 101 and Health Kiosk 201, which have systems such as 12-lead electrocardiography, spirometer, blood pressure, body mass index, and weight measurements, rapid strip-based tests, hemoglobinometer, biochemistry analysis, vision assessment, pulse oximeter, digital stethoscope, body temperature measurement, height sensor, otoscope, urine strip test, glucose meter, and dermascope (Fig. 5.1).

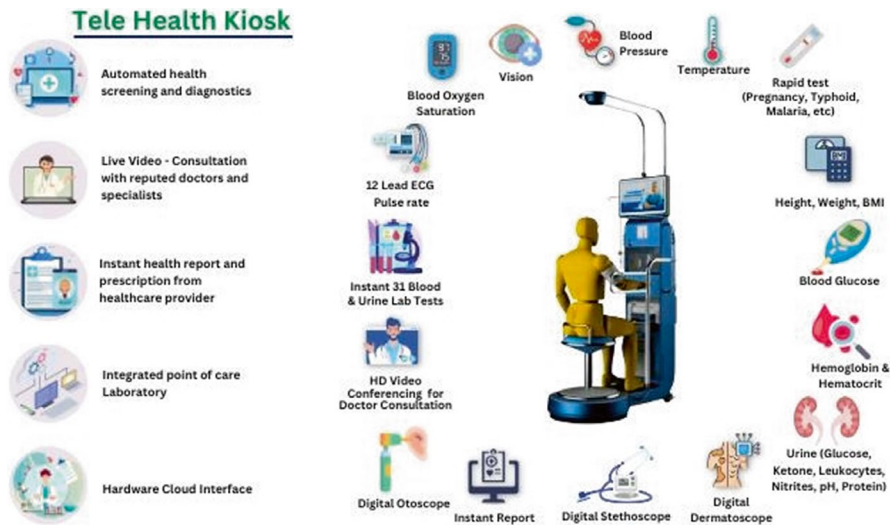


Fig. 5.1 Representation of telehealth kiosk developed by CIBioD

5.3 Estimated Healthcare Kiosk Market in India

It is estimated that, if one healthcare kiosk serves 15,000 people, it will need 59,865 kiosks to cater to approximately 90 crore rural people, while for the urban slum population, assuming that one kiosk can serve 30,000 people, we will need 5655 kiosks. This is supposed to generate employment opportunities for 151,351 people. For a small kiosk without integrated lab, we require one comprehensive health officer (CHO) per machine. There are about 6,64,369 villages in India. If we install one such machine per village, then it will provide employment to around 6,64,369 rural people across the country.

5.4 CIBioD Telehealth Kiosk

Telehealth kiosk is an electronic machine that allows patients to connect with healthcare professionals. The ICMR Center for Innovation and Bio-Design (CIBioD), PGIMER, Chandigarh, has upgraded the primary healthcare system with telehealth kiosks (Fig. 5.1). Our telehealth kiosks are equipped with medical devices and communication tools to enable virtual consultations and monitoring. We have devised two kiosk models, i.e., TELEMASTER (TM) 201 (telehealth kiosk with integrated biochemistry lab) and TM 101 (telehealth kiosk without integrated biochemistry lab) which can be integrated into TM 201 in a hub and spoke manner. TM 201 has a built-in, diagnostic lab with a hardware-cloud interface. Our kiosks can provide a point-of-care diagnosis and teleconsultation services to the rural, marginal population at their first point of contact and can measure ten noninvasive body parameters automatically. In addition, more than 85 biochemistry tests/parameters

can be performed in the kiosk itself. From the vital acquisition to the lab tests, the entire process is automated and data is stored in the cloud storage. Our kiosk has a 19” LED display with a touchscreen and user-friendly module. A 12-channel electrocardiogram (ECG) and a digital spirometer are also integrated with the kiosk. All these facilities make it a human error-free virtual platform to provide point-of-care diagnostics and teleconsultation services anywhere. It is an innovative, robust, comprehensive, easy-to-install, and -operate telemedicine clinic which can decongest the tertiary care centers and strengthen the primary healthcare system. This kiosk bridges the gap in service delivery and allows uninterrupted services even during situations like epidemics. Our telehealth kiosk consists of automatic height and weight measurement system, noninvasive automatic pressure measurement (NIBP), contactless thermometer for body temperature measurement, pulse oximeter rate and SpO₂ measurements, digital stethoscope device, 12-lead ECG integrated devices with built-in thermal printer, spirometer device for lung functions testing, urine analyzer, biochemistry analyzer, dermoscope, otoscope, glucometer, hemoglobinometer, diagnostic tests for dengue, typhoid, malaria, HIV, and pregnancy, and finally measurement systems for urine glucose, urine bilirubin, urine ketone, urine blood, urine pH, urine protein, urine urobilinogen, urine nitrite, and leukocyte. The design patent on the telehealth kiosk has been granted by the Indian Patent Office, Government of India, with design number 346372-001. The procedure to operate our kiosk is shown in Fig. 5.2.

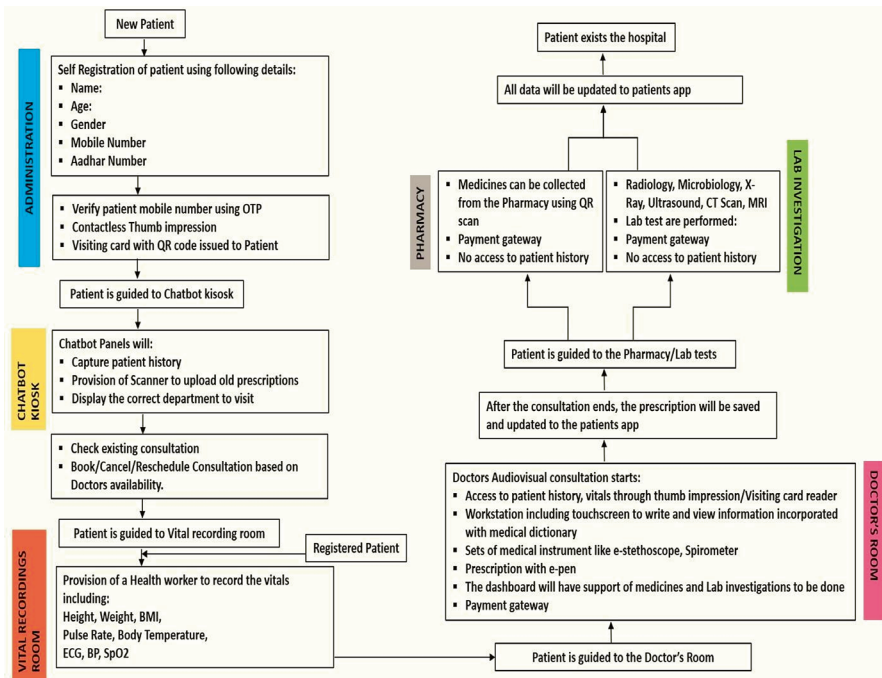


Fig. 5.2 Flow diagram showing the whole procedure of the operation of a telehealth kiosk

5.5 Telehealth Kiosk Incorporates an Advanced AI System

All the gadgets and devices integrated into our telehealth kiosk meet the gold standards, ensuring the highest level of accuracy and reliability. The seamless hardware–software interfacing enables automatic data fetching, eliminating the need for manual entry and reducing the chances of errors. As an example, ECG interpretation is based on an AI-based module which captures 500 samples/s/channel. The signal captured is then interpreted on the basis of an algorithm developed after being trained on Massachusetts Institute of Technology–Beth Israel Hospital (MIT-BIH) databases. The ECG signal is also stored in the kiosk in a secured proprietary format. Spirometry interpretation is based on an AI algorithm which contains prediction equations both for adults and children. The AI-based algorithm evaluates the patient as per their age and sex and selects suitable equations for computation of predicted norms making a basis for interpretation of patient’s results. The algorithms used in all integrated devices are AI-enabled in such a way that any malfunctioning device can be auto-detected. The clinical data (patient identification, history, and vitals) and investigations (like ECG, spirometry, blood, and urine tests) are fed and auto-fetched by various devices and equipment in futuristic healthcare delivery (FHCD) kiosk. The entire system has secured data transmission and encrypted data storage. All the devices comply with IEC 60601 standard. The signals fetched from the devices are collected into numerical, visual, and audio formats. We have developed specific software, the components of which are loaded on the medical devices performing the tests and the computing device of the kiosk. This software organizes and stores all the data fed and fetched by all the devices. The data captured in the kiosk can be accessed only through the authenticated credentials (login ID and password). Different levels of hierarchy authorizations (like lab technician and doctor) are used to access the data. Biomedical signals captured by the devices integrated with kiosks are in analog form which are amplified, processed, and then converted into digital format and transmitted to the FHCD kiosk in a proprietary encrypted format. The audio and image data are stored in wave and jpg format, respectively. In the case of data from a biochemistry analyzer (BCA), the BCA has 48 different algorithms to capture the parameters of a blood sample. The basic software features of our kiosk is given in Fig. 5.3.

5.6 Insights Gained from Our Experience

The results from patients’ feedback form for telehealth kiosk (see Chap. 3 for details) reveals that more than 80% of users gave our kiosk a five-star rating (one star: poor; five star: best) on various parameters (such as appearance of kiosk, convenience of use, accessibility of basic health checkup, ease of giving blood tests and getting report, satisfaction of interaction with medical personnel, speed of service, and affordability), while approximately 20% gave it four-star rating. Only one (0.49%) patient gave a three-star rating to interaction with medical personnel,

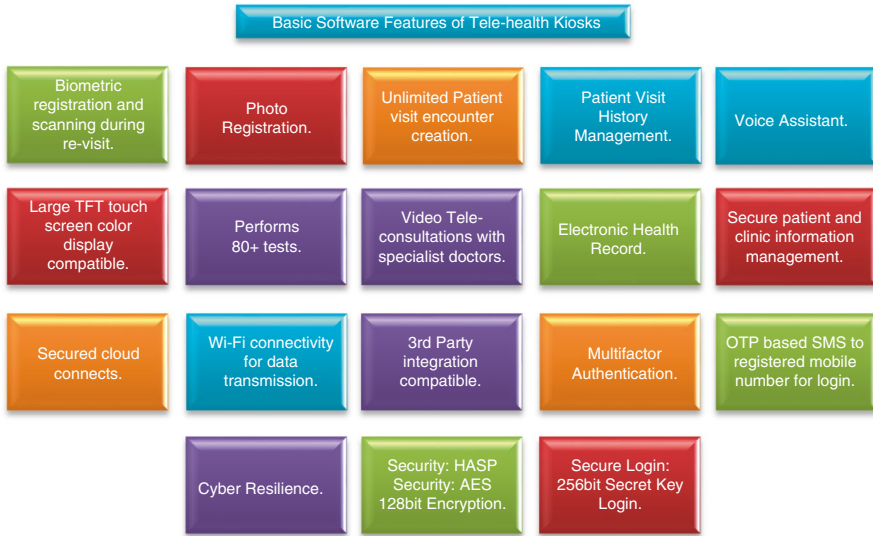


Fig. 5.3 Basic software features of telehealth kiosks

while six (2.93%) gave three-star rating to speed of service. Similarly, most medical practitioners gave either a four- or five-star rating to our kiosk (refer to Chap. 3 for detailed results).

5.7 Conclusion

The use of telemedicine through the deployment of telehealth kiosks at primary health centers appears to have potential for further improvement in healthcare with many advantages such as affordability, accessibility, timely diagnosis, and initiation of treatment for populations which traditionally do not have quick access to healthcare. It allows adherence to treatment and good follow-up, effective implementation of national programs to achieve the SDG3, reduction of human errors, and better synchronization of health data through national health information management system (HIMS) and national digital health mission. It provides opportunities for the promotion of social stability by reducing travel expenditure and saving time and out-of-pocket expenses, along with reduction in the carbon footprint associated with health-related travels.

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