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Digitalization of Tanzania Health Care Services: Telemedicine Infrastructures to Link Rural and Urban Areas

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ABSTRACT

The majority of people in Tanzania live in rural areas where decent medical care is still a challenge. Consultation with specialists located in cities where hospitals with modern facilities exist becomes impossible for patients living in the rural areas of Tanzania.he patient travels long distances from the remote areas to cities and makes appointments to see the specialist, for which they incur several costs, including accommodation and subsistence. These can be addressed using information and Communication Technology (ICT) and mobile phones. However, developing an infrastructure for a platform for bringing specialists or a panel of specialists living in cities to offer consultation services to patients living in rural areas has remained a challenge. This research, therefore, is aimed at improving health care services for rural patients by developing telemedicine technology in the context of Tanzania. This will ensure that patients have access to the specialists as quickly as possible instead of travelling long distances to the cities and spending time and money waiting for appointments. With the proposed system, collection and delivery of samples and drugs using drone technology, real-time online consultation with remote specialist doctors, and telesurgery will be possible. This telemedicine platform has been developed and tested. Patients could register, and doctors could prescribe tests and medicine within the system. Both video and audio calls were possible. Payments using the NHIF cards were demonstrated. The drone carried dummy samples from Magufuli Hostels to the UDSM Health Centre in Dar es Salaam. Further improvements could be made by testing the system with a much larger population over longer distances.

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1.0 Introduction

Adequate and affordable medical services are not only a public health issue but are also overall indicators of the ability of the existing health system to deliver quality health care to the community (Akter *et al*., 2013). Communities living in rural areas, particularly in developing countries, are less likely to receive effective health care services than the better-off who live in urban areas (Peabody *et al*., 2006). Less effective health care services are a consequence of an insufficient number of skilled medical specialists, high demand for medical supplies, poor medical infrastructure, and an irregular increase in the prices of medical equipment and its running costs (Marcin *et al*., 2016; Mehrotra *et al*., 2016).

Health services in Tanzania are certainly better in urban areas compared to rural areas. In most cases, specialists are normally located in large cities such as Dar es Salaam, Mwanza, and Arusha, where some of the best-equipped hospitals are found. Even though there are good hospitals in the cities, challenges remain with the limited number of specialists to serve the rural community. For example, one specialist doctor serves around ten people per day in urban areas, while in rural areas, the ratio of patients to doctors becomes very high (Bloor, 2006). In particular, it takes long hours and even months for the patient to travel from rural areas to consult the specialist located in the large cities. To another extent, the costs of travelling and living in cities while waiting for appointments are very high. This is the current situation: despite there being Staffing Level Guidelines since 2014 (Ministry of Health and Social Welfare, 2014), there is still a shortage of about 50% or more health experts.

The use of technologies such as computer application software for health services in Tanzania is highly localised, only covering internal hospital information sharing like processing patient information within the hospital sections, for instance, laboratories and doctor-patient communication. Apparently, this works well, but it leaves out the vast community in the rural area that needs instant consultation with limited specialists. The recent concentration of efforts in the healthy sector has been on the emphasis of Universal Health Coverage (UHC), whose objectives have been insisting on access to health insurance such as the National Health Insurance Fund (NHIF) for public workers, Community Health Insurance (CHI), and others from the private sector (Senkoro, 2018, 2021). This emphasis has been put on the acquisition of health insurance but has not detailed the use of the limited specialists to provide services to the majority of Tanzanians living in rural areas, of which the majority are poor. It is estimated that 66% of people in Tanzania live in rural areas (The World Bank Group, 2019).

The use of modern Information and Communication Technology (ICT) is anticipated to overcome the health challenges in the country due to its low cost, high penetration in urban, rural, and remote areas, and ease of use (Justo *et al*., 2020; Omary *et al*., 2009; Shiferaw & Zolfo, 2012). A recent study in Dar es Salaam indicated the willingness of both carers and service recipients to send and receive medical information via a web-based platform (Mwammenywa & Kaijage, 2018).

In the wake of the COVID-19 pandemic, the World Health Organisation (WHO, 2021) provided guidelines for use in implementing telemedicine services for member countries The pandemic showed a shift in community health to telemedicine, whereby phone visits were beneficial to marginalised groups of people (Payán *et al*., 2022). In the case of Tanzania, there are several challenges that hinder the adoption of ICT applications in health services (Omary *et al*., 2009). Those challenges are a lack of patient unique identifiers, a lack of funds, a lack of standards, a lack of proper and adequate training for health workers, and unreliable ICT services within the country. Some solutions have been proposed since 2009; however, to date, the situation has not improved much. These problems are endemic to Sub-Saharan Africa, where additionally there are regulatory, cultural, and organisational barriers (Dodoo *et al*., 2022). Even going further up to Ethiopia, similar problems abound (Sagaro *et al*., 2020). These failures have been known for several years, and steps to

ameliorate them have been proposed (Mars, 2013) to little or no avail to date. One recommended first step is to put in place a telemedicine policy and operationalize it (Ikwu *et al.,* 2021).

The majority of the people in Tanzania live in rural areas where decent medical care is still suboptimal. Consultation of the specialist located in cities where hospitals with modern facilities exist becomes impossible for the patients living in the rural areas of Tanzania unless the patient travels a long distance from the remote areas to cities and makes an appointment(s) to see the specialist; see, for example, the long-distance walk (Figure 1) and also the long queues at a rural health facility reported by local newspapers (Senkoro, 2018, 2021). Figure 2 shows that when a health facility is located several kilometres from the population in Tanzania, the percentage of live births is negatively impacted.

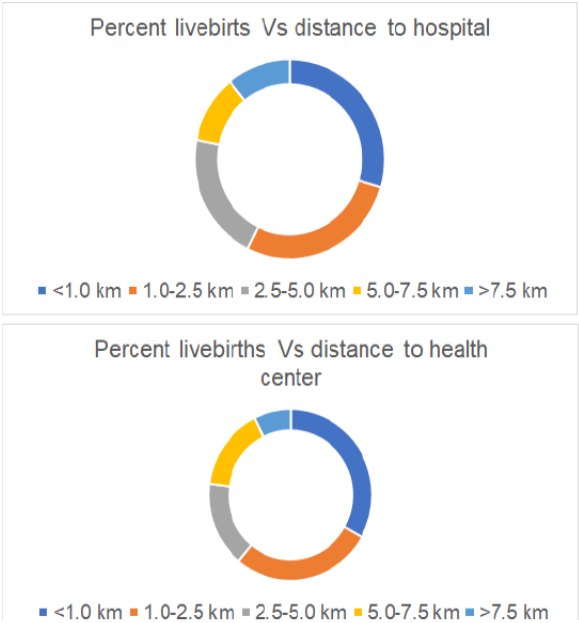
Fig 1
The Situation of a Long Walk to Health Centres in Tanzania to Seek Medical Help or Services

Source: Mamdani & Bangser (2004)

The telemedicine system will enable the following: appointments to the nearest labs and referral hospitals for serious cases: arm or leg breaks, accidents. Telemedicine also improves physicians' practise by facilitating continuing medical education, contacts with peers, and access to a second opinion (Gagnon *et al*., 2006). At the hospital and rural health facility levels, telemedicine has the potential to support the development of rural health facility reference centres, favour the retention of local expertise, and save costs. It can be used to effect emergency diagnosis procedures during ambulance transport (Castellano *et al.,* 2015).

Therefore, this study aims at developing integrated telemedicine infrastructure that can harness existing ICT technology and integrate health care services to produce a platform that can be used by doctors and patients to simplify the means of consultation for most people living in rural areas.

Fig 2
The Long Distance to Health Facilities Negatively Impacts the Percentage of Live Births in Tanzania



Source: Hanson *et al*., (2015)

2. Materials and Methods

2.1 Research Methodology

Hence, the following are the objectives of the proposed research: To develop a telemedicine system using the available technologies for linking the patients living in remote areas with the available specialists in large cities, such as that indicated by Figure 3, To establish a Tanzanian-based model suitable for health services interlinking between the health centres in rural areas and the specialist hospitals or referral hospitals (Figure 3). To develop patient information sharing platforms between various

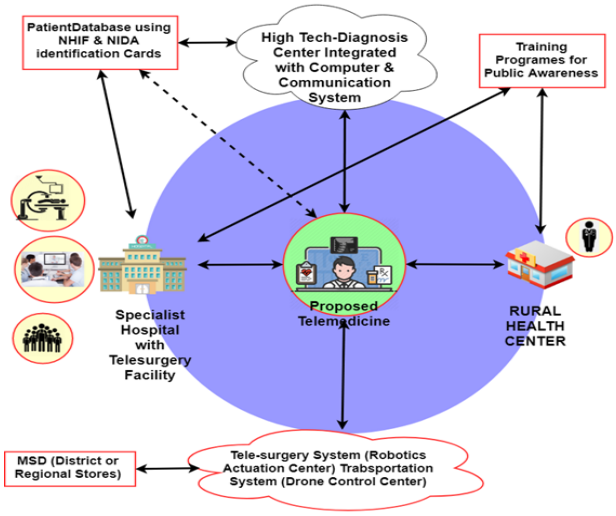
health care providers in Tanzania and patient-doctor mobile application packages (Figure 3). To integrate the available infrastructure that can facilitate the reliability of the doctors to patient consultation (Figure 3). To develop an integrated system that interlinks between health care providers and health insurance companies (Figure 3).

2.2 System Description, Design and Configuration

This subsection presents the system description, design, and configuration of the four subsystems of the telemedicine project. These are the National Identification Number (NIN), electronic medical record (EMR), insurance system, and real-time communication system (RTCS), shown in the contextual diagram of Figure 4. The telemedicine system is developed by interconnecting these four subsystems.

Fig 3

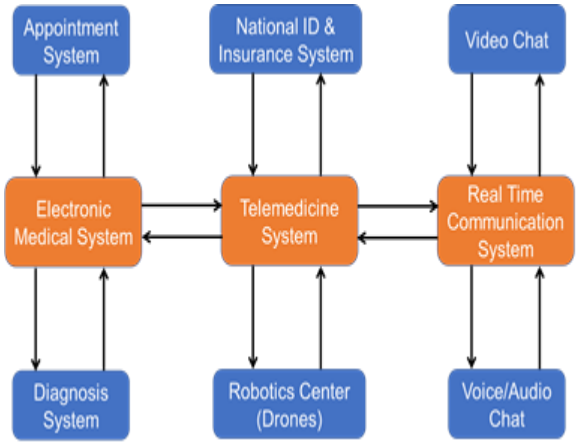
The Conceptual Diagram Showing the Proposed Telemedicine System



The NIN system is responsible for proving the unique identification number for each patient and patient information. The insurance system is available from insurance companies and insurance providers like the National Health Insurance Fund (NHIF). The insurance system provides patients' health insurance information. The EMR is responsible for managing patient medical records such as consultation, diagnosis, and prescription records.

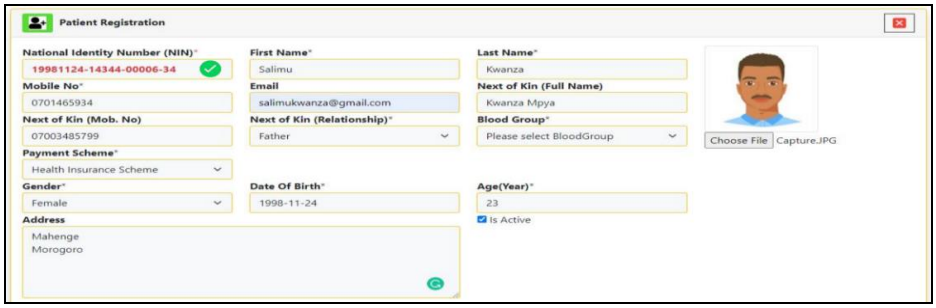
Fig 4

The Contextual Diagram Showing the Interactions Between Different Systems of the Telemedicine Prototype



The development of the telemedicine system was achieved by integrating the EMR system, NIN system, RTCS system, and Robotics centre. First, the EMR system was developed by integrating two custom EMR software modules with a patient registration module, an appointment module, a clinical module, a lab module, and a pharmaceutical module. The patient registration module was used to register patients to the system by providing their NIN, full name, date of birth, gender, blood group, address, mobile number, email, next of kin information, and payment mode. The system contacts the NIN system to verify the patient's NIN and displays a green tick icon if the NIN supplied is valid, as shown in Figure 5. The payment mode can be cash or available health insurance schemes.

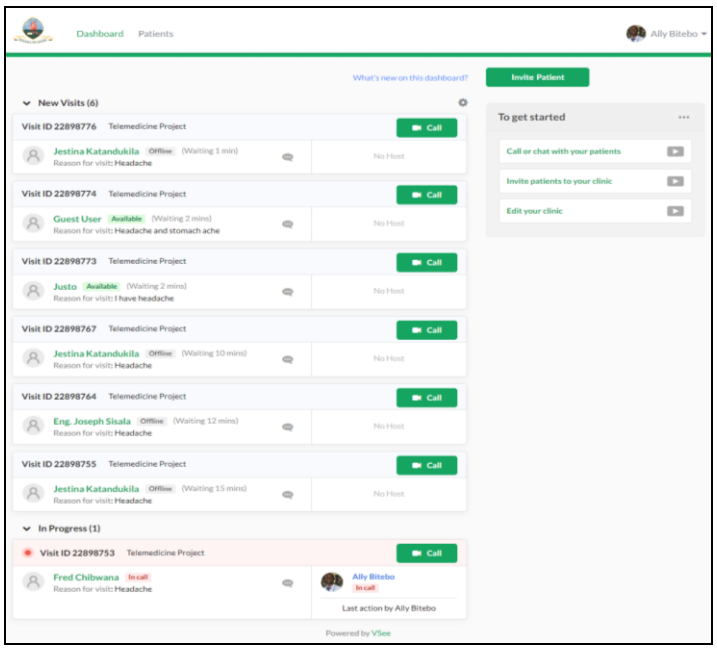
Fig 5
The Process of Using Telemedicine System the Patient Registration Form



The appointment module allows a health officer to book an appointment with remote specialists; see, for example, a list of patients who have made appointments and queued online in Figure 6. Moreover, the diagnosis module allows a health officer to perform clinical activities like consultation, diagnosis, and drug prescriptions. Second, the NIN system is the Tanzanian national identification number system, where each citizen is assigned a unique number. Third, the robotics centre is part of the system dealing with Artificial Intelligence (AI) systems like telesurgery for remote operations and drones for transportation. The drone transports samples or specimens from health facilities to remote laboratories. It transports drugs from a pharmacy to a remote health facility.

Lastly, the real-time communication system allows doctors and patients to communicate in real-time by using texts, audio, and video chats. This module was developed using *VSee Clinic Cloud* software. The doctor can consult a patient through a multimedia chat box where a user can send a text, voice note, or attach a multimedia file like an image or video, as shown in Figure 7(a). Additionally, both users can communicate through video calls online and in real-time, as shown in Figure 7(b).

Fig 6
The Queue of Patients Waiting for the Doctor Online



2.2 The Empirical Data

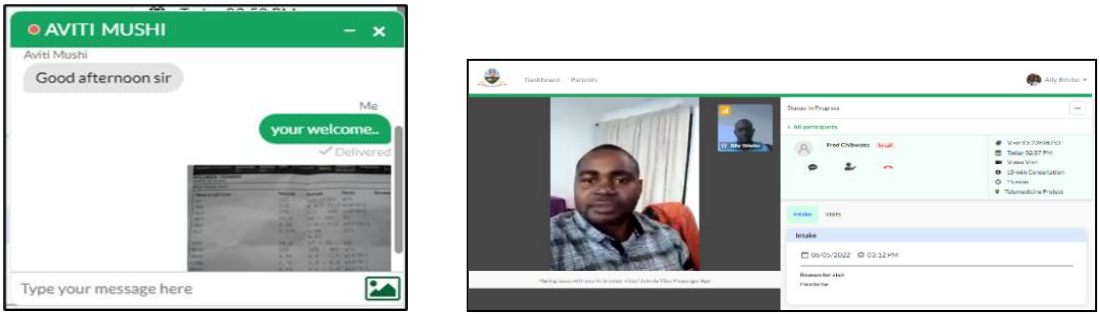
Empirical data was collected through the use of a questionnaire that was constructed on Google Forms, awareness seminars, and interviews. This data informs the needs and requirements of the system.

2.3 System Development Procedures

This research studied several existing EMR software deployments in health facilities in Tanzania. It was identified that several health facilities are using a variety of EMR software, ranging from open-source to proprietary and custom-made. The open-source software used is care2x, OpenMRS, OpenEMR, DHIS, and OpenLMIS. The proprietary software used is Jeeva, AfyaPro, MediPro, E-Health System, and Electronic Health Management System (EHMS). Moreover, the custom software is the Government of Tanzania Hospital Management Information System (GoT-HoMIS), developed by the President's Office, Regional Administration, and Local Government of Tanzania (Chali *et al.*, 2018; Rweikiza, 2019). Additionally, this study analysed five audiovisual communication software programmes adopted or deployed to facilitate the interconnection between patients and remote doctors.

Fig 7

Telemedicine System Deployment, Showing (a) Online Chat With Image File Attached, and (b) Online Video and Audio Call



(a) **(b)**

The software is Intelehealth, Vsee, Doxy.me, Doximity, and Zoom for healthcare. Intelehealth is the health platform used to connect patients in rural areas with remote doctors by using an Android-based application with a cloud-based OpenMRS at the backend (Goel *et al*., 2017). VSee and Doxy.me are web-based software for individuals and group health care service providers to communicate in real-time with remote patients. Doximity is video dialer software with audio and video call capabilities (Perisetti & Goyal, 2021; Singh, 2022). Lastly, Zoom for Healthcare is the web conferencing software used to offer audio-visual communication between patients and doctors in real time (Singh, 2022).

However, all of the platforms presented above need to be compliant with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) in order to ensure secure communication between doctors and remote patients. Moreover, the proposed software has to support SMS messaging and online chat with the option of sending multimedia files like audio, images, and video. It has to support audio and video calls as well as be simple to use with minimal installation requirements. Table 1 summarises the analysis of the presented software.

Tab 1
Comparison of Software Platforms for Deploying Telemedicine

Software Name	HIPPA	SMS	Online Chat	Multimedia	Audio Call	Video Call	Cost Implication
Intelehealth	Yes	No	Yes	Yes	Yes	Yes	Open source
VSee	Yes	Yes	Yes	Yes	Yes	Yes	Subscription with Free Plan
Doxy.me	Yes	Yes	Yes	Yes	Yes	Yes	Subscription with Free Plan
Doximity	Yes	Yes		Only Voice mail	Yes	Yes	Subscription with Free Plan
Zoom for healthcare	Yes	No	Yes	Yes	Yes	Yes	Subscription with Free Plan

2.4 Website User Interface

The website's user interface was developed by Vsee. It was implemented on Doxy.me. This website provided a link between rural doctors, urban specialists, and patients. This website has the hospital information system and electronic health records. These are integrated into the system that connects the patient, hospital, doctors in urban and rural areas, and other medical facilities (such as diagnostic and laboratory centres).

2.5 Selecting the Drone

Tanzania has several drone leasing companies, which are used for various purposes, some of which include carrying cameras for photography and surveying. For the purpose of this study, the drone needs to have the capacity to carry a 3 kg load and ferry it from the urban hospital site (where specialists and doctors are located) to the village hospital site. It is envisaged for the distance to be about 5 km. For this case, the selected drone is the Yangda YD6-1600S Heavy Lift Hexacopter (Yangda, 2020). This is a heavy-lift and versatile drone that can be applied in different applications under all environmental conditions. It is able to fly for 60 minutes with a 2 kg payload and 45 minutes with a 5 kg payload. Its wingspan is 2350 mm, with a wheelbase of 1600 mm. It is capable of a maximum cruise speed of 72 km/h and can best wind gusts of 12 m/s (43.2 km/h). The drone uses easy-to-use ground control software that can be driven by beginners without any flight piloting experience.

3. Results

Several results are presented in this section that highlight the development of the telemedicine system, the views of the public, and the testing of the system.

3.1 Results from the Empirical Data

The data that was collected during a poster presentation at a conference in Arusha in the year 2020 (Justo *et al.,* 2020) showed that visitors were impressed and were eager to know when the telemedicine programme would start to be rolled out for use by the public. The ones who filled out the Google Forms (65 in total) are demographically described as follows: Their education falls into the following categories: holding a certificate or below (1.5%), holding a diploma (4.6%), holding a bachelor's degree (61.5%), holding a master's degree (23.1%), and holding a PhD (9.2%). Their ages were: 20–30 years (30.8%), 30–40 years (32.3%), 40–50 years (35.4%), and 50–60 years (1%).

3.2 Testing the Telemedicine System

This newly developed telemedicine system was tested by first having patients register themselves on the website. When the doctor on the other side opens up one of the patients, that doctor will be able to view the patient's information. The patient and doctor, when both are logged in, can communicate via the website interface and see each other face-to-face. They can use any smart device with a camera, such as any Android phone or iPhone. During the online face-to-face session, the doctor may prescribe the patient to take some laboratory tests to further understand the patient's ailments. To do this, the doctor uses the website interface and can order such tests via the system (see Figure 8), as can the laboratory technician. Before the patient proceeds to the next stage, the doctor asks the patient to complete payments in the system. This process is done through the entry and verification of the NHIF card number (Figure 9), and if it is successful, the telemedicine system displays this success (Figure 10).

Fig 8

Screen Capture of the Doctor Prescribing Laboratory Tests to a Patient via Telemedicine, which the Laboratory Technician can Access the Request

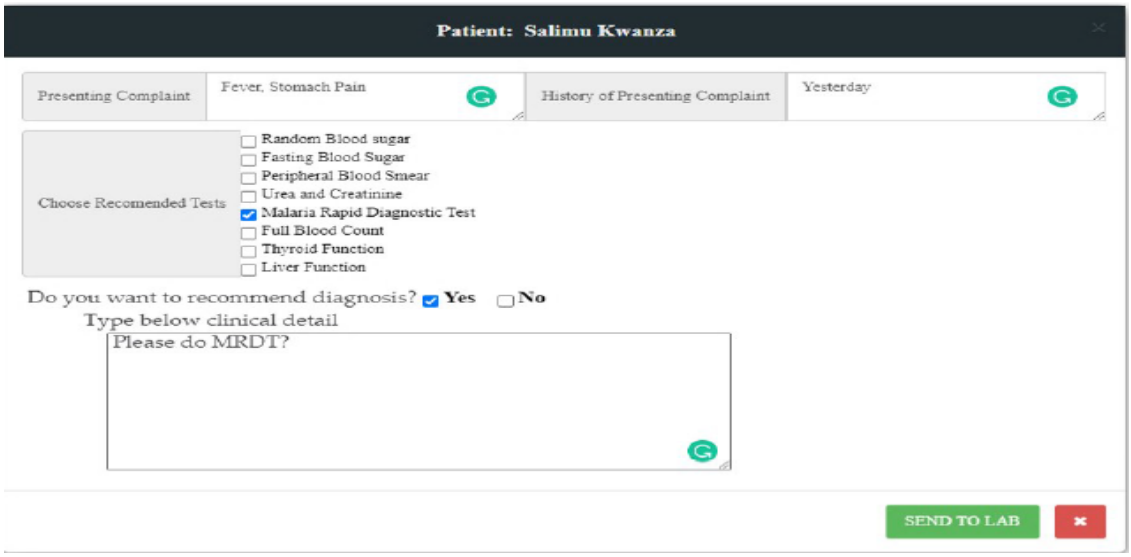


Fig 9

The NHIF Number Entry into the Telemedicine System for Payments

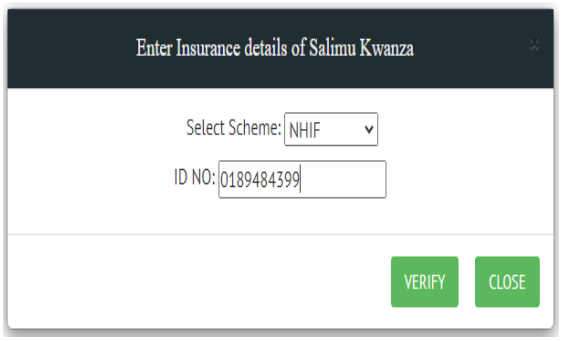
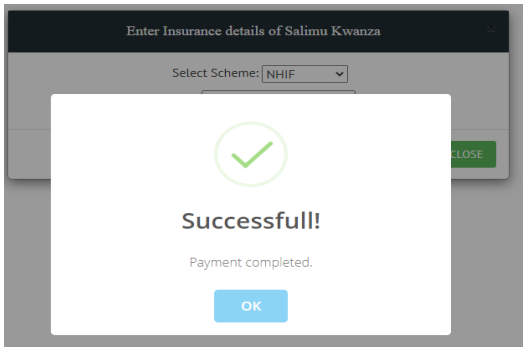


Fig 10

A Screenshot of Successful Payments Recorded in the Telemedicine System



3.3 Drone Delivery

For a patient that is to receive medication, the doctor at an urban health facility can package the medicine and load it on the drone. This drone will deliver this load to its intended destination. For this project, the drone was loaded (by a health technician) with samples at Magufuli Hostels (see Figure 11). It then flew to the University of Dar es Salaam Health Centre, a distance of 300 metres. The samples were offloaded by a health technician (see Figure 12) and sent to the laboratory for processing.

Fig 11

A Health Technician Fits the Drone with the Dummy Samples Collected from a Patient and is Ready to be Flown to an Urban Health Laboratory Centre

Fig 12

A Health Technician at an Urban Health Laboratory Receives the Drone with the Dummy Sample Collected *from a Rural Patient*

3.4 Results of Interviews

The authors collected responses from different stakeholders, as mentioned in the empirical data section. The results showed that 11.1% of respondents lived in rural areas, 11.1% in semi-urban areas, and 77.8% in urban areas. Many of them—about 46%—rated health delivery as good where they live. Their awareness of the applications of ICT packages was 63.1%. The respondents (more than 51%) showed eagerness to adopt telemedicine applications in the health systems sector.

4. **Discussion**

The proposed Telemedicine Health system was implemented, and a simple demonstration was done at the UDSM. The initial results showed that the technology is viable for integration into the health sector in Tanzania. This is shown by Figures 8–12 and the acceptance rate of 51% shown in the Results of Interviews Section.

5. Conclusion

The paper has developed a telemedicine system for connecting rural area hospitals and urban hospitals to enable wider access to medical facilities for the rural population in Tanzania. Through the demonstration, the drone was able to deliver a package from Magufuli Hostels to the University of Dar es Salaam Health Centre, a distance of 300 m. The eagerness of the respondents shows that this system is welcome and is awaiting deployment. This work could be enhanced by deploying the telemedicine system in pilot areas (such as Islands in Lake Victoria, the Indian Ocean, and such remote areas) and linking in real time all the proposed and developed systems.

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