Proposal template Part B: technical description

Virtual Hospitals Africa

1. Excellence

1.1 Objectives and ambition #@PRJ-OBJ-PO@#

Virtual Hospitals Africa is creating an easy-to-use cloud platform connecting rural health facilities with a global medical network to better serve patients in sub-Saharan Africa. Nurses and medical staff at remote clinics will be equipped with electronic devices, satellite internet, and diagnostic devices in order to collect patient demographic, vital, and diagnostic information through the Virtual Hospitals Africa platform. The web application makes it easy for health workers to follow the latest medical protocols: recommending specific examinations, tests, and medications depending on the patient's profile, symptoms, and conditions. For high-risk cases, or when patients are not responding to treatment, nurses can request asynchronous reviews and schedule video appointments with remote doctors as well as make referrals to local specialists and laboratories for testing.

In 2024, our key milestone is a pilot of the VHA platform in 8 existing rural clinics in Zimbabwe who have expressed enthusiastic interest. These clinics would receive free access to the platform for all their staff, electronic and medical devices, as well as technical support and training to ensure they have everything they need to be exemplars in the standard of care they may offer to patients. These rural facilities will be backed by a Digital Health Clinic based in Gweru where we have received governmental approval to establish a Medical Center. There, doctors will have a comfortable working environment where they can handle the majority of asynchronous reviews remotely, while also being close enough that they can see patients in nearby villages requiring in-person care.

In early 2025, we plan on directly supporting the Zimbabwe Antenatal Care Protocol which gives specific objectives, medical histories, examinations, laboratory investigations, health promotion, prophylaxis, and treatment to be done over eight encounters with pregnant women. This would give our system, health workers, and patients clear guidance on what to do to maximize the chance of a healthy baby.

In late 2025 we plan on rolling out a school program: monitoring health outcomes for children in four planned annual visits across twelve public schools. Working with this population can help identify and treat infectious diseases at an early stage and has the advantage of efficiency in being able to see many children at once through a trusted network at the school.

As we roll out we would be continuously improving the platform, adding value-adding and time-saving features such as diagnostic hardware integration, image diagnostics, and other quality of life improvements informed by the direct experience of health workers using our software. By early 2026, we would plan on having full offline support, enabling nurses to enter in all necessary medical data on a battery-powered tablet even during a period of zero connectivity and syncing that information with the cloud when the network has healed.

In 2026, we would plan on rapidly scaling our Virtual Hospitals network in Zimbabwe. Improved onboarding and general ease-of-use will enable licensed doctors to create their own remote facilities with minimal direct training, support, and supervision on our end. For patients with mobile devices, we have also begun work on a WhatsApp chatbot where they can schedule appointments, access their medical records, and receive notifications making it easy to follow their treatment plan.

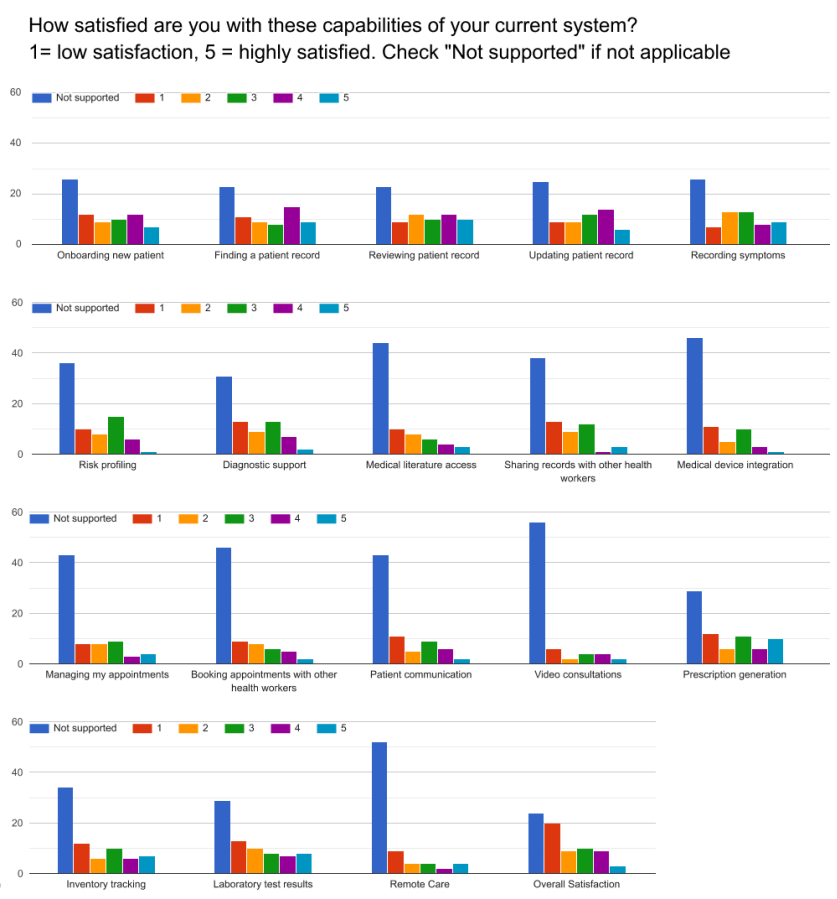
In 2027, we would plan on expanding into other sub-Saharan African countries in which English is a lingua franca. We are in preliminary conversations with prospective partners in South Africa, Nigeria, Kenya, and Uganda who have expressed interest in the platform. Each country would have its own deployment, database, protocols, and available medications while relying on the same underlying software. In future years we would expand our internationalization efforts to support additional languages throughout the application to roll out in other countries.

As a cloud-based platform, the marginal cost of supporting additional patients and health workers is near-zero, making our ability to scale unbounded. We plan to cover all infectious diseases across the general population and enhance the current efforts to eradicate communicable diseases. With full adoption in Zimbabwe we can expand into other countries using the same underlying software, but each with its own deployment, internationalization, and protocols based on available medications and official guidance from federal health ministries. We believe our platform will be key in achieving the Sustainable Development Goals to end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases.

As a true system of record for electronic medical records there is also the massive opportunity to support health analytics and research. A read-only replica of anonymized data could be sent to off-the-shelf solutions such as Tableau where authorized researchers could create custom visualizations to analyze trends at a country-wide scale. This system can be optimized for diseases of public health concern including infectious diseases. We can leverage this technology to give real-time data from health facilities by district, province, country, and region to enable pandemic preparedness: identifying emerging threats to life and helping provide timely responses that can be escalated down to the lowest level of healthcare within the shortest periods of time.

These objectives are directly pertinent to Horizon Europe's interest in supporting the development of innovative digital solutions addressing poverty-related diseases in sub-Saharan Africa. With a focus on our target population of pregnant women with infectious diseases and related co-morbidities, we will be able to clearly record and monitor the health status including changes in outcomes related to mother and child against baseline data. These results are achievable within the time of the Horizon Europe/EDCTP grant given our consortium's expertise, progress to date, and vision.

Virtual Hospitals Africa couples cutting-edge web development technology with empathic design to provide a fast, user-friendly experience that helps health workers serve patients at every step of their journey, offering a better experience than existing solutions. In our survey of 95 doctors and nurses with experience working in sub-Saharan Africa we found that, where electronic record keeping was in place at all, there is little support for remote care and substantial room for improvement in almost all areas of the care management experience. 69.5% of survey respondents primarily used pen and paper to keep track of medical records at their facility. But even when using software tools meant to support certain capabilities, satisfaction was low. For 12 of 18 features we asked about and plan on supporting through VHA, including remote care and medical literature access, 1 = "low satisfaction" was the most common response after "not supported". Overall satisfaction was lowest of all, receiving more "1" votes than any other specific feature.



These poor experiences with health software are not unique to Africa. Leading health professionals have similarly opined Why Doctors Hate Their Computers. But it need not be this way. We believe that with radical focus on the patient journey, as opposed to administration, insurance, and billing we can improve on the overall experience.

Leveraging telemedicine will be particularly impactful in Zimbabwe where there has been substantial "brain drain" with many skilled workers having moved overseas. Among surveyed nurses working in rural facilities, 92.3%

reported a doctor being present a few times a month or less. Luckily, among surveyed African doctors, with most based in the diaspora, 72.5% said they would be willing to offer services at a pro bono or discounted rate, presenting a huge opportunity to tap into skilled medical professionals wanting to serve their home country. This means skilled health professionals can be distributed equitably to support physical facilities in the provision of care.

We self-assess our Technology Readiness Level as TRL 5 — Technology validated in a relevant environment. Our system demonstrates many of the capabilities necessary to roll out and we have been diligently testing our software with medical professionals working in the field, incorporating their feedback along the way.

#§PRJ-OBJ-PO§#

1.2 Methodology #@CON-MET-CM@# #@COM-PLE-CP@#

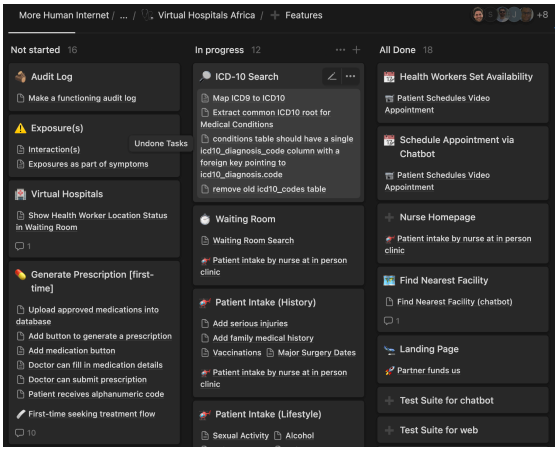
Our overall approach is to build and deploy a best-in-class health care platform enabling in-person and remote health professionals to deeply collaborate in the service of patients in sub-Saharan Africa. Our combined disciplines and expertise all factor into the development of the platform and its collection of critical health data can contribute to researchers and analysts being able to use large anonymized datasets whose insights can be fed right back into improving our offering to health workers and patients. We will start with a pilot study in the first year of deployment focused specifically on pregnant women with comorbidities, which will be followed up by a two-year randomized control study that will address the general population to fully assess the benefits and risks associated with the use of this digital health platform.

How We Work

The Virtual Hospitals Africa Consortium includes leading institutions in technology, health, and research with deep local ties and expertise working in close collaboration to advance our mission. Our leadership team, consisting of Chief Executive Officer Jonathan Tagarisa, Chief Medical Officer Dr. Sikhululiwe Ngwenya, and Chief Technology Officer Will Weiss currently meet 3 times per week to test features looking for opportunities for improvement in real-time, create designs, and prioritize our efforts. Our combined experiences have led to us achieving key milestones within reasonable time and igniting a spark in relevant stakeholders who now see the innovative digital health platform as the next best solution to solve myriad recurring healthcare challenges in delivering communicable diseases care.

Within our values-driven culture, we believe we are all serving a higher mission to bring much needed care and we channel that spirit in the work we do. We begin meetings asking team members something they are grateful for, bringing positivity into the space. During meetings, we encourage radical candor, trusting that everyone is doing their best. Direct feedback and debate is encouraged and frequently through the course of deep discussion we uncover better solutions that may not have been apparent to anyone at the onset. We close meetings asking “does everyone have what they need to be successful?” ensuring that everyone has a clear idea of how their work contributes to the greater whole.

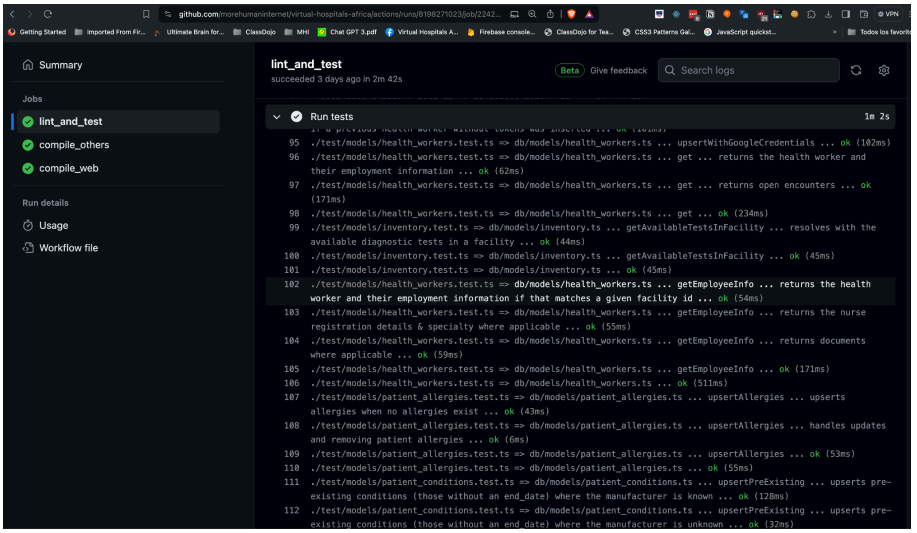
Our product management, design, and development practices incorporate battle-tested technologies and collaborative techniques to enable folks to iterate rapidly and incorporate feedback seamlessly throughout. For product management we use a shared Notion workspace, pictured below. There, we prioritize our efforts using a dashboard view where we can see all planned features and any undone tasks associated with them grouped by status ensuring that everyone has the same view of what’s needed to get things **All Done**. For each feature, we clarify its goal, associated resources, and a clear user journey for how the health worker will complete their objective.



For communication, we use Slack which has enabled a team working in four time zones to function smoothly, often with tasks being completed while some folks are asleep. When designing, we use Figma to be able to edit wireframes

collaboratively in real-time. We also have a team subscription to Tailwind UI which includes off-the-shelf components that give our application a modern look and feel, while we can focus the majority of our development efforts on the data model and overall user journeys.

Our technology stack and approach embraces rapid iteration, collaborating at every stage to respond quickly to stakeholder feedback. We demo and test multiple times throughout the week, often changing small bits of the source code in real time to see if we prefer one approach or another. Contributing to our developers' high confidence while making rapid changes are multiple automated systems that help ensure software correctness. To name a few, we use Typescript, PostgreSQL, and kysely to ensure that the entities throughout our system are well-typed. The underrated kysely-codegen bridges the gap between our database and our codebase, automatically generating code based on the tables in our database to ensure the assumptions of our codebase are never out of alignment with what's actually in the database, all without any extra effort on behalf of the programmer. Our automated test suite runs on Github (pictured right) or can run in the background on a developer's computer in less than five seconds and beeps if an expectation is not met, so the developer can know extremely quickly if they made a change that broke something.

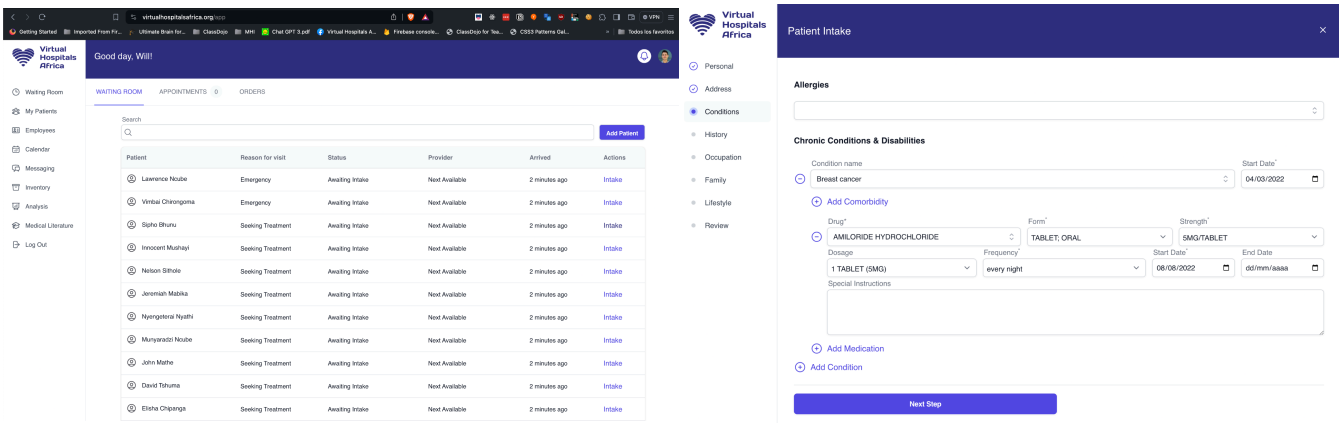


To ensure that VHA is available even amidst unforeseen attacks on undersea internet infrastructure, servers will be deployed on the continent in an Amazon Web Services data center in Cape Town. Additionally, the application will support all data entry functionality in offline mode.

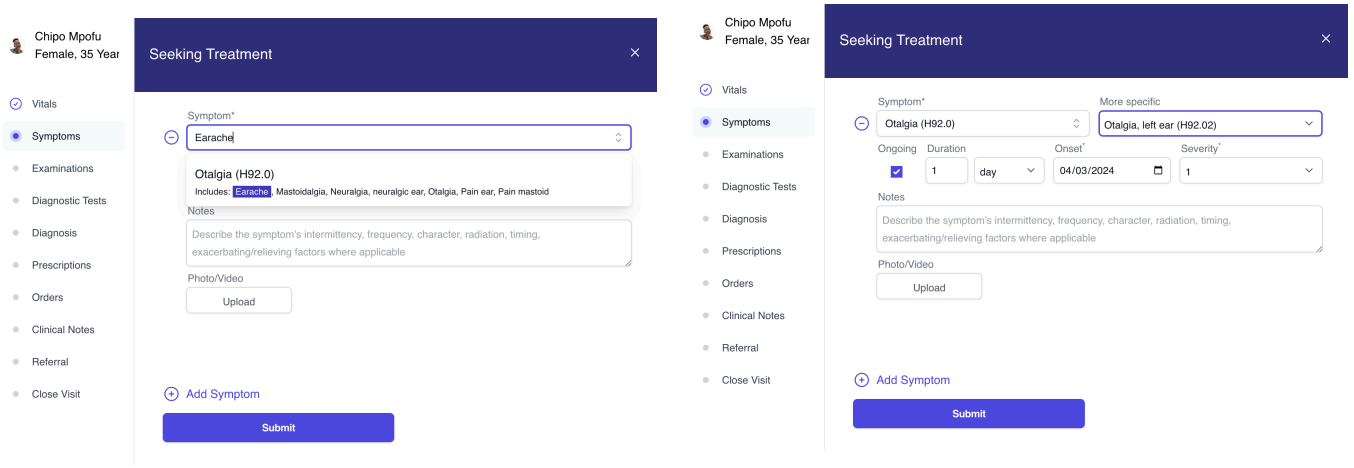
How VHA Works

VHA functions as a cloud-based case-management system with a simple linear flow that takes patients from intake to diagnosis to treatment. All health workers have largely the same functionality with slightly different emphases depending on whether they see patients primarily in person or remotely.

A nurse who works with patients in person at the clinic starts on a homepage that prominently features a "Waiting Room" where they can see at a glance all the patients awaiting care and in consultation at the facility. Emergencies are prominently shown at the top while others are shown in chronological order of arrival. From there they can quickly start the intake process. Medications are sourced from the Medicines Control Authority of Zimbabwe Human Medicines Register. Of course, if we were to expand into other countries, we would use whatever medicines are approved in that country.



VHA uses WHO ICD-10 coding system extensively to encode symptoms, exposures, conditions, and procedures in our system. This coding system follows a tree-structure where diagnoses can be made more specific by adding additional characters. Their extensive index also offers many synonyms for conditions. By leveraging this powerful model we are able provide a simple search experience where professionals can look for familiar terms such as "earache" to find the official code Otalgia (H92.0), then add further specificity as needed: Otalgia, left ear (H92.02) in this example below.



Additionally, health workers at physical health facilities will be able to use affordable and portable digital diagnostic devices to assist with early detection as well as save patients from unnecessary traveling to city laboratories. Devices like the Contec BC401 Urine Analyzer are inexpensive at $129 and perform a battery of tests. We plan on supporting taking a screenshot of the device's readout to quickly capture data without manual entry.

Doctors working at Virtual Hospitals would be brought in by nurses for patients requiring additional care. In a streamlined Review workflow, doctors pick up where the nurse left off beginning with the Clinical Notes, which provide a summary of the patient chart and information about any clinical actions taken by the nurse including vitals, symptoms, examination findings, diagnoses, and orders. From there doctors can proceed to Diagnosis where they can check off whether they agree with the nurse's diagnoses or provide their own. Similarly for prescriptions, doctors can see over the counter medications the nurse dispensed, or specify medications that require a doctor's prescription. When searching for medications to prescribe, doctors can see which are available based on the clinic's inventory. Any unavailable medicines can be accessed at private pharmacies through a whatsapp based e-prescription system incorporated into the VHA platform. If additional care is needed, the doctor can find a time on their calendar to see the patient via a video appointment or refer them to a local specialist. Otherwise, they can revert their orders back to the nurse who can forward them to the patient in their native language.

Throughout this process, health workers will receive clinical decision support based on leading health protocols. In considering the vital importance of women's health, we have chosen to make maternity protocols the first our system understands natively. These protocols are human-programmed and *not* generative, so they will recommend the same specific questions to ask, medications to dispense, and treatment schedules predictably given the patient's profile. In the future, we would have the opportunity to use anonymized data sets to build predictive models to identify suspected diagnoses based on a patient's symptoms. However, even then the final call will always be with health professionals to determine the patient's treatment based on their medical training.

All our policies and practices are and will remain in compliance with the Medical and Dental Practitioners Council of Zimbabwe's Policy on International Telemedicine as well as any regulations from the Ministry of Health and Child Care, with whom we have a Memorandum of Understanding. We don't anticipate that any of these practices have significant environmental impact positively or negatively, although being able to save patients and health workers from having to travel to/from rural settings to urban hospitals could yield a modest carbon savings.

Research Methodology

Our primary research questions concerning patients are:

1. Question: Are patients more likely to see a doctor if their local facility has remote doctor support?
   Metric: Patient encounters with a doctor per capita in villages with a clinic with VHA access vs. those without
2. Question: How much earlier are patients to receive treatment if they can see a doctor remotely?
   Metric: Median number of days between symptom onset and first medicinal treatment in villages for patients receiving a diagnosis by a clinic with VHA access vs. those without
3. Question: What is the impact of early screening & treatment for pregnant mothers?
   Metrics: Maternal & infant mortality in villages with a clinic with VHA access vs. those without
   Grouped by:
   a. Pregnant mothers with malaria
   b. Pregnant mothers with HIV
   c. Pregnant mothers with tuberculosis
   d. Pregnant mothers with other comorbidities
   e. Pregnant mothers without comorbidities
4. Question: What is the impact of early screening & treatment of infectious diseases for school-aged children?
   Metric: Number of missed school days per year for students in schools with access to VHA vs. those without
   Grouped by:
   a. Children and adolescents with malaria
   b. Children and adolescents with HIV
   c. Children and adolescents with tuberculosis
   d. Children and adolescents with other comorbidities
   e. Children and adolescents without comorbidities

while our primary questions concerning nurses are:

1. Question: How satisfied are nurses in rural clinics with their overall system of managing and treating patients?
   Metric: 1-10 satisfaction scores in surveys of nurses in at clinics with VHA access vs. those without
2. Question: What barriers exist in adoption of a digital platform by rural clinics?
   Metric: Qualitative surveys & interviews and monitoring of nurses, doctors, and other stakeholders
3. Question: What countermeasures can overcome these barriers?
   Metric: Qualitative surveys & interviews and monitoring of nurses, doctors, and other stakeholders
4. Question: What improvements can help expedite the treatment process?
   Metric: Qualitative surveys & interviews and monitoring of nurses, doctors, and other stakeholders

Our research methodology plans on leveraging the platform's well-structured data to keep track of patient encounters, conditions, etc. On intake we would ask how long since their symptoms first developed. Using this data we can track how much time passed between the onset of an illness and the patient receiving treatment. This data can be used to have fine-grained information in clinics with access to VHA. These data would be compared against information collected via surveys in villages under test along with villages without rural clinics with access to Virtual Hospitals Africa in order to establish a baseline to compare against.

As more health workers are able to treat patients using the system, we could use information gathered to support other research initiatives. The application's form logic is quite flexible, so we anticipate being able to easily incorporate specific survey questions researchers might have. We would make any research Findable, Accessible, Interoperable, and Reusable by hosting the publications themselves and any anonymized datasets they are based on freely at our domain virtualhospitalsafrica.org.

#§CON-MET-CM§# #§COM-PLE-CP§# #§REL-EVA-RE§#

2. Impact #@IMP-ACT-IA@#

2.1 Project's pathways towards impact

Through the grant, Virtual Hospitals Africa will be able to prove the benefits of equipping rural clinics with a cloud-based solution to manage patient care, connect with remote doctors, and receive clinical decision support. Should these efforts be successful, we would prove that even starting in facilities with *no current adoption of digital health technology* that we can cost-effectively connect patients to doctors remotely and better manage patient outcomes.

During the time period of the grant, we have as a target outcome having VHA be used in 50% of rural health facilities in Zimbabwe and in 10% of rural health facilities in two other sub-Saharan African countries by 2027. From the National Health Strategy for Zimbabwe there are 1122 Local Authority Clinics in Zimbabwe. From our survey of 95 health workers in sub-Saharan Africa, rural clinics encountered 60 patients per day on average, 46% of whom "need[ed] to see a doctor or specialist", while a doctor was only present 14% of working hours. This means that across the country there are approximately 26,632 (= 1122 * 60 * .54 * .86) encounters with patients every day who come to the clinic, need to see a doctor, but none are available. Being able to provide access to a doctor remotely in these cases, and a reliable digital health record solution in general, could thus have a huge impact on health outcomes.

Virtual Hospitals Africa plans on offering its cloud-based solution for *free* to rural facilities forever. To do this at a country and continent-wide scale, Virtual Hospitals Africa plans on maintaining its sharp focus on the patient's overall user journey, avoiding costly development efforts in one-off features for specific hospitals. While the clinics selected for the pilot would receive free training, medical devices, and internet access, we recognize that it is well outside the scope of the grant funding to provide these to all facilities across Zimbabwe. Fortunately, if we prove the model in an exemplary fashion, we would be very attractive at a free price point to facilities and their funding even without those devices.

To be able to fund the platform without having to rely on grants in perpetuity, we plan on exploring earned revenue opportunities when connecting patients to private specialists, which would still be cheaper and better than other options currently available to patients. Today, patients will often delay receiving care until their conditions have worsened, then spend $5 on bus fare and $X to see a specialist at an urban hospital. If instead, they could get an initial consultation with a specialist from their local facility for $Y, they would be saving money and be able to get a second opinion earlier. If VHA charged a nominal $3 for having made such a connection, that could result in $X in earned revenue, more than enough to cover our costs at scale. This is a win-win for specialists who would have a more reliable source of referrals as well as today <1% of patient referrals are done electronically according to a survey by the MoHCC Stocktaking Digital Health Infrastructure in Zimbabwe.

The opportunity to become the de facto standard for how medical records are shared across the country is wide open. From the same study by the MoHCC over 50% of facilities experienced data loss and medical professionals are combining data from different systems manually 66% of the time. Our meetings with medical and governmental stakeholders confirm that integration across systems is a huge pain point today. DHIS2 is in use in some settings and helps with data collection for specific health campaigns, but requires customized deployments and does not support capturing a patient's entire medical record. FHIR provides a standards framework for creating health resources, however the lack of a frontend and unopinionated nature of the standard mean that implementers still have a lot of work to do to build an application using FHIR and even then may not be interoperable with other systems using FHIR.

To achieve these objectives is possible, but there are barriers. Chief among these barriers when speaking with stakeholders is unreliable internet access and low availability of electronic devices. To address these challenges for pilot clinics, we plan on providing these to ensure they can be successful with the platform. Meanwhile, during the course of the grant, we plan on working to fully support an offline mode where all data entry functions can be done without internet access with patient data being uploaded in the background when connectivity is regained. Additionally, internet access is improving year over year and Starlink may provide 100Mbps service for $53 in any setting this year.

The language barrier could affect adoption as our application today only supports English. We plan on supporting other languages in the future, primarily as we start to build patient-facing functions where we'd want patients to receive WhatsApp messages or pdf printouts in Shona and other languages. Until then, English is a lingua franca in many medical and business settings and so for now we are prioritizing our health technology ahead of those

internationalization efforts.

To act as a system of record at a country-wide scale will also require buy-in from governmental officials. Knowing this, we have established good working relationships with magistrates in the Ministry of Health and Child Care with whom we have a Memorandum of Understanding. As the platform develops, we believe that officials will see the tremendous benefit and low cost which would make this an attractive option.

We appreciate your consideration of our proposal for Virtual Hospitals Africa and hope that you see its promise as a new digital technology looking to strengthen health systems in sub-Saharan Africa.

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