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ARMAUER HANSEN RESEARCH INSTITUTE

Grand Challenges Ethiopia Annual Bulletin

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The abstract report of seed grant and progress reports of transition to scale grant projects in the bulletin were prepared by grandees of each innovation projects and edited by Dr Shallo and Dr Tekeste.

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ABREVIATIONS

ABI	Applied Biosystem Integrated Genetic Analyzer
ADC	Analog-Digital Converter
AFB	Acid fast Bacilli
AHRI	Armauer Hansen Research Institute
AI	Artificial Intelligence
AIDS	Acquired immunodeficiency Disease Syndrome
ALERT	All Africa Leprosy Rehabilitation and Training Center
ANC	Antenatal Care
ART	Anti-Retroviral therapy
bCPAP	Bubble Continuous Positive Airway Pressure
BP	Blood Pressure
CA	Canada
Co.PI	Co Principal Investigator
CPAP	Continuous Positive Airway Pressure
CPLD	Complex Programmable Logic Device
CTG	Cardiotocography
C#,	Object-Oriented Programming Language for Networking & Web Development
DHS	Demographic Health Survey
DNA	Deoxyribonucleic Acid
EFDA	Ethiopian Food and Drug Authority
FASTA	DNA and Protein Sequence Alignment Software Package
FHR	Fetal Heart Rate
FMOH	Federal Ministry of Health
FOV	Field of View
GCEth	Grand Challenges Ethiopia
2G/3G	2 Giga byte/ 3 Giga byte
GPS	Global Positioning System
GTP2	Growth and Transformation plan 2
GUI	Graphical User Interface
Hb	Hemoglobin
HIV	Human Immunodeficiency Virus
HR	Heart Rate
HSTP	Health Sector Transformation Plan
IEC	International Electro Technical Commission
INSTI	Integrase Strand Transfer Inhibitor
INT	Integrase
IoT	Internet of thing
IQR	Inter Quartile Rate
IR	Infra-Red
LCD	Liquid crystal display
LED	Light-emitting Diode
MCU	Microcontroller Unit
MD	Medical Doctor
MMAS	Modified Maximum Average Score
MMC	Millennium Medical College

My-SQL	"My"- *name of co-founder*, and "SQL"- Structured Query Language.
MOH	Ministry of Health
NICU	Neonatal Intensive Care Unit
NRTI	Nucleotide Reverse Transcriptase Inhibitor
NNRTI	Non Nucleotide Reverse Transcriptase Inhibitor
PCR	Polymerase Chain Reaction
PHD	Philosophy of Doctor
PI	Principal Investigator
POC	Point of Care
PPH	Post-Partum Hemorrhage
RIDE	Reducing Individual Driving for the Environment
RNA	Ribonucleic Acid
RT	Reverse Transcriptase
SAM	Severe Acute Malnutrition
SDG	Sustainable Development Goal
SDLC	Software Development Life Cycle
SMS	Short Message Service
SNNP	South Nation Nationalities and People
SpO2	Saturated Pulse Oximeter
TB	Tuberculosis
TTS	Transition to scale
UN	United Nation
UNFPA	United Nations Population Fund
US	United States
USA	United States of America
v3	Version 3
VHD	Valvular Heart Disease
WHO	World Health Organization
WIFI	Wireless Fidelity
YOLO	You Only Look Once
ZN	Ziehl Nielsen

EXECUTIVE SUMMARY

Over the past years, healthcare has experienced an explosion of innovations designed to improve life expectancy and quality of life. Particularly, the health sector among resource-limited countries face unprecedented challenges of quality improvement, prevent preventable causes of death, improve access and efficiency, lower costs of service provisions and globally committed SDGs attainment. Thus, innovation is motivated by health care provision in resource-constrained settings.

In 2012, Ethiopia approved Science, Technology and Innovation Policy with a broader aim of encouraging research and development locally and importing proven foreign technologies that potentially accelerate socio-economic development. Based on this policy foundation, the Ethiopian Federal Ministry of Health has established Grand Challenges Ethiopia Program in 2015 and hosted by Armauer Hansen Research Institute 2017.

The principal aim of GC Ethiopia is to stimulate the creation, appraisal, promotion and scale-up of innovative ideas and concepts that are responsive to the defining health-related challenges, assist effective implementation of the health sector transformation plan (HSTP) and contribute to the achievement of the SDGs. The Ministry of Health has identified Newborn and Childhood health, Maternal health, Adolescent and Youth health, Antimicrobial Resistance and Pastoralist health services as the health sector Grand challenges that need innovation to end all preventable deaths of children and mothers by 2030.

The Grand Challenges Ethiopia is fully funded by the Government of Ethiopian Ministry of Health through SDG pool fund. It supports innovative ideas through the provision of seed grant to explore proof of concept, validation of grant to test innovation and technological solutions surfaced elsewhere to the Ethiopian context and transition to scale funding to end all preventable deaths of mothers and children by 2030.

Since 2017, a total of 31 seed, four transition to scale and one validation test innovation projects have been supported. From these, nine ongoing and eight new seed grant project, four transitions to scale and one validation test innovation projects implemented in 2019/2020.

This annual bulletin of Grand Challenges Ethiopia presents the overall implementation progress of health innovation projects, brief concept of health innovation, abstracts of each seed grant projects completed in the year, lesson learned, challenges encountered during the year and the way forward.

INTRODUCTION

Over the past several decades healthcare has experienced an explosion of innovations designed to improve life expectancy and quality of life. However, the health sector among resource-limited countries is facing unprecedented challenges to improve healthcare access, system, quality, efficiency, effectiveness, sustainability, safety, and affordability to prevent preventable deaths and to attain the global sustainable development goals (SDGs)[1].

The term "health innovation" has been used to describe policies, systems, products and technologies, ideas, services, and delivery methods that provide solutions to existing healthcare problems with the ultimate goal to improve people's health with a special focus on vulnerable population. This kind of innovation often linked to weak healthcare infrastructure, social instability, and poverty. The ultimate goal of health innovation is to improve the health sector ability to meet public and personal healthcare needs and demands by optimizing the performance of the health system[1].

In the past few years, important initiatives have been established to encourage health innovation around the world. One of these is the Grand Challenges program launched by Bill and Malinda Gates Foundation in 2003 with the objective to stimulate innovation in global health especially focusing on an area that was starving for new ideas. Since then, the Grand Challenges model has been spreading across different countries around the world, including Ethiopia. Grand challenge in health is defined as "a specific critical barrier that if removed would help to solve an important public health problem[2].

In 2012, Ethiopia approved Science, Technology and Innovation Policy with a broader aim of encouraging research and development locally and importing proven foreign technologies that potentially accelerate socio-economic development. Based on this sound policy foundation, the Ethiopian Ministry of Health established Grand Challenges Ethiopia programs in 2015. Later it was put under the auspices of the Armauer Hansen Research Institute (AHRI) in 2017.

The principal aim of Grand Challenge Ethiopia (GCEth) is to stimulate the creation, appraisal, promotion and scale-up of innovative ideas and concepts that are responsive to the defining health-

[1] Leighann Kimble, M. Rashad Massoud, (2017); what do we mean by innovation in Healthcare? EMJ Innov. 2017; 1[1]:89-91.

[2] Logie, D et al.(2016); Challenges faced by multi -displinary new investigators on addressing grand challenges in global health, Globalization and Health 2016, 10:27

related challenges and assist in the effective implementation of the health sector transformation plan (HSTP) and contribute to achieving the SDGs. The Ministry of Health has identified, Newborn and Childhood health, Maternal health, Adolescent and Youth health, Antimicrobial Resistance and Pastoralist health services as health sector Grand challenges that need innovation to end all preventable deaths of children and mothers by 2030.

Since 2017, the Grand Challenges Ethiopia is fully funded by the Ethiopia Ministry of Health through SDG pool fund and supports innovative ideas through the provision of seed grant to explore proof of concept, validation grant to test innovation and technological solutions surfaced elsewhere for their applicability to the Ethiopian context to end all preventable deaths of mothers and children by 2030.

Moreover, Grand Challenges Ethiopian also provide the transition to scale grant for prototype developed/ pilot results obtained at seed grant stage with potential to have high impact and low cost at scale for further generation of sufficient scientific evidence before recommended for national wide implementation.

The purpose of this annual bulletin is to describe performance progress of Grand Challenges Ethiopia (GCEth), point out lessons to be learned, explore challenges faced during the implementation and find out possible solutions to improve the initiative in the future. This document has different parts, the first part describes health innovation, the second part briefs the performance progress of Grand Challenges Ethiopia Health innovation awarded projects, the third part presents abstracts of the second year GCEth seed grant recipients and the final part presents challenges encountered and lessons to be learned.

INNOVATION IN HEALTH CARE

Over the past four years, most of the health innovation proposals submitted for the seed and transition to scale grants call were conventional biomedical or public health research proposals that were not qualify for health innovation. This might be due to inadequate understanding about the concept of innovation in health care. Thus the purpose of this section is to clearly describe what we mean by innovation in health care in order to increase participation of researchers in health innovation project to play their role in solving the health sector challenges of Ethiopia.

'*Innovation*' denotes new, better, more effective ways of solving problems. Adopted from the business, technology, and marketing industries, the term has been used to describe policies, systems, technologies, ideas, services, and products that provide solutions to existing healthcare problems.

However, what has been absent from discussions around innovation is a clear, common understanding of what the term means. A clear definition is necessary because lack of consensus acts as a barrier to bringing innovation to clinical practice and all innovators (researchers that might have bold innovative ideas) to solve health sector challenges of the country. Moreover, due to a lack of clarity and consistency, the term 'innovation' has been frequently used inappropriately to describe different developments within healthcare.

Therefore, this is to explore what it means to be innovative, how innovation can be understood in the context of healthcare, and how 'health innovation' affects our understanding in improving healthcare. Defining innovation helps to clarify the concept of innovation in healthcare and potential innovators across different corners of the country to take their part in developing the health innovation project to solve the health sector challenges of the country.

A GENERAL DEFINITION OF INNOVATION IN HEALTHCARE

The term innovation has made its way into healthcare from the fields of business, technology, and marketing. The dictionary definition of innovation includes i) "a new idea, device, or method" and ii) "the act or process of introducing new ideas, devices, or methods. Innovations in healthcare fall under the broader umbrella of social innovations, which aim to solve social issues. Social innovation encourages new approaches to tackle issues of poverty, education, health, and other human development problems by making system-level changes. The World Health Organization (WHO) explains that 'health innovation' improves the efficiency, effectiveness, quality, sustainability, safety, and/or affordability of healthcare.

This definition includes 'new or improved' health policies, practices, systems, products and technologies, services, and delivery methods that result in improved health care. In this case, the ultimate goal of health innovation is to improve our ability to meet public and personal healthcare needs and demands by optimizing the performance of the health system. In theory, innovations in healthcare should yield scalable solutions and improvements in health policies, systems, products, technologies, services, and delivery methods, in order to improve treatment, diagnosis, education, outreach, prevention, research quality and delivery, and access to healthcare.

IN HEALTH CARE: WHAT IS INNOVATION? AND WHAT IS NOT?

When we describe the concept of innovation in healthcare, we must ask in health care what an innovation is, and what is not? And while to answer these questions; we must consider the following points:

I. Healthcare problems and their solutions are related to problems of efficiency, effectiveness, quality, sustainability, safety, and/or affordability of healthcare;

II. Solutions that have resulted from problems in healthcare may be considered as an innovation because they have solved a problem by introducing a new or significantly different approach, concept, idea, service, process, technology, or product; and

III. Not all solutions are innovations, and not all innovations are solutions. Some solutions to problems in healthcare are merely developments within the field.

For a solution to a healthcare problem to be an innovation, it must introduce something new or significantly different from other solutions in the field. Without clarity on what innovation truly is, the term is loosely adopted and applied. On one hand, a general definition allows for praise and recognition of positive developments and new ideas, methods, and products in the field of healthcare. On the other hand, without a concrete understanding of what innovation is, we are unable to develop and properly identify new innovations in healthcare.

PRINCIPAL AIM OF GRAND CHALLENGES ETHIOPIA

The Grand Challenge Ethiopia has three principal objectives. Namely:

1. Stimulate innovations that solve the health sector grand challenges and contribute to achieving SDGs.
2. Test innovations and technological solutions surfaced elsewhere but are applicable in our setting for its cost-effectiveness, social and cultural acceptability, potential peacefulness and scalability.
3. Invest in the implementation of selected innovations at scale after ensuring the implementation at transition to scale to have high impact at low cost towards the provision equitable and quality health service in short team and achievement of SDGs in long term.

METHODS OF FUNDING

The funding source for GCEth initiative is the Government of Ethiopia through FMOH SDG pool fund. It has three annual funding schemes. These are**:**

1. **Seed Grant Support**: for up to 20 ideas or proof of concept innovation in the priority areas with the provision up to 300,000 Ethiopian Birr of every grantee.
2. **Validation Test Grant Support:** for testing innovations surfaced elsewhere those are applicable in Ethiopian context.
3. **Transition to Scale Grant Support:** for selected effective and impactful innovations. It awards up to 1,000,000 Ethiopian Birr for every grantee.

2019/2020 Progress Report

1. GRAND CHALLENGES ETHIOPIA TASK FORCE WORKING PROGRESS

The grand challenges Ethiopia taskforce is an independent, impartial team of experts established by AHRI to provide a rigorous technical assessment of proposals submitted to the GCEth Secretariat based on pre-defined review process and criteria. Annual review meeting of the Grand Challenges Ethiopia (GCEth) taskforce was conducted in June 2019 to evaluate the overall progress of GCEth projects. During the meeting, the GCEth secretariat presented the annual progress report of Grand Challenges Ethiopia health innovation projects which was followed by thorough discussion. After indorsing the annual report, the taskforce discussed the 2019/2020 Grand Challenges Ethiopia annual plan. Following the discussion made on this annual plan, taskforce members have given a direction to make separate calls for Seed and Transition to Scale (TTS) grants to avoid confusion.


Dr. Zelalem Mekonnen


Dawit Hailu


Minyahil Taddesse


Kiya Kedir


H/Michael Getachew

Grand Challenges Ethiopia in house AHRI Screening committee members

Grand Challenges Ethiopia Taskforce Members (Partial)

Grand Challenges Ethiopia Taskforce Members Attending TTS Grant Proposal Defense

Grand Challenges Ethiopia Competent Defending TTS Grant Proposals

Accordingly, AHRI has separately announced calls for both Seed and Transition to Scale grant projects in 2019/2020 for which 52 applications for the Seed grant and 54 for Transition to Scale grant proposals were submitted. After and screening of the proposals by the in house AHRI screening committee and rigorous evaluations , the Grand Challenge Ethiopia taskforce selected and awarded best eight Seed grant and four Transitions to Scale grant projects for the year 2020/2021. Moreover, the Grand Challenges Ethiopia taskforce had three round meeting to evaluate the progress of the awarded grand challenges innovation project in the year.

2. GRAND CHALLENGES ETHIOPIA ANNUAL REVIEW MEETING

Grand Challenges Ethiopia annual review meeting was held at the end of December 2019.In this review meeting, all previous Grand challenges Ethiopia grant recipients and new grant winners participated in the workshop. During this review meeting each 2019/2020 Seed grant project winners presented their project progress and received feedbacks.

Moreover, senior grantees shared their experiences for the new winners. The four Transitions to Scale grant winners also presented experiences of their seed grant implementation, which was followed by displaying and demonstrating the prototype they have developed at the Seed grant stage. It was an excellent lesson for the new health innovation grant winners.

Participants of Annual Review Meeting Held at Jimma, December 1919

In addition, the first Transition to Scale Grant winners identified some challenges they encountered during their Seed Grant implementation. The most critical challenges they long bureaucratic procurement procedures and lack of some materials in local market. The Grand Challenges Ethiopia and the AHRI management appreciated the identification of the problems and took commitments to resolve them.

Frist year transition to scale grant winners of Infant Radiant Warmer and Neonatal Jaundice Treatment (Phototherapy) project prototype presented by Mr. Habitamu Abafogi

At the end of the meeting, all first year Transition to Scale Grant winners were given an award of certificate in the hands of Dr. Abebe Genetu, AHRI Director General and Mr. Kora Tushine, Jimma University Vice President.

Certificate award given to the Transition to Scale Grant winner by Dr. Abebe Genetu, AHRI Director General

Certificate award given to Transition to Scale Grant winner by Mr. Kora Tishune, Jimma University, Vice President

Media brief given by Mr. Kora Tishune, Jimma Uinversity Vice precedent, about the Importance of Grand Challenges Ethiopia Grant

Media Brief Given by Mr. Habtamu Abafogi, Jimma University, Transition to Scale Grant Winner

3. GRAND CHALLENGES PROJECT IMPLEMENTATION PROGRESS

Since 2017, a total of 31 Seed Grant innovation projects have been selected by the Grand Challenges Ethiopia taskforce. Of these 14 were selected for the year 2017/2018. They were completed at the end of 2018. By the end of 2018, another nine Seed Grants were selected and implemented as ongoing projects during the year 2019/2020 and all were completed at the end of March 2020.

Moreover the rest, eight Seed, four Transition to Scale and Validation Test grants were selected and awarded at the beginning of 2020. They are still under active implementation as per their plan. Summary reports of each ongoing and Grant project reports and new Transition to Scale projects are presented below.

3.1. Ongoing Seed Grant Health Innovation Project of 2019/2020

As mentioned above there have been nine ongoing Seed Grant projects. They were selected and awarded at the end 2018planned to be implemented until the end of March 2020. All these ongoing Seed Grant projects were finalized as per their original plan and submitted both final project and financial reports. The overall results obtained from Seed Grant implementation stage were encouraging where some of the developed tools have good potential to be qualified for the transition to scale phase. Titles of the ongoing Seed Grant projects with their physical performance, financial utilization and liquidation status are presented in the tables below.

Table 1: Physical project performance, financial utilization and liquidation rate of the ongoing seed grant projects of 2019/2020.

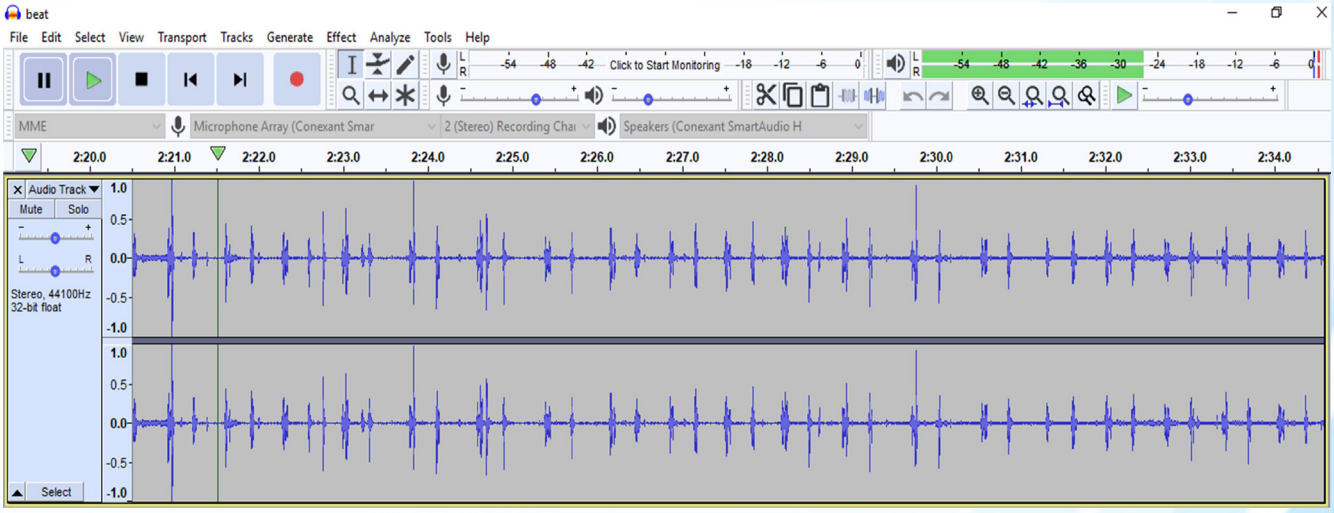
Table 1: Physical project performance, financial utilization and liquidation rate of the ongoing seed grant projects of 2019/2020

No	Innovation Title	Priority area	Hosting Institution	Physical project performance	Financial utilization and liquidation rate
1	Internet of Things (IoT) Enabled Fetal and Maternal Care Follow up, Vital Sign Monitoring & Alerting System	Maternal Health	Jimma University	100%	99.4%
2	Infant Radiant Warmer with Ceramic Heat Source for Developing Nation	Child Health	Jimma University	100%	100%
3	Mobile Application to Improve Early Diagnosis and Treatment of Malaria and Tuberculosis (TB)	Microbial Resistance	Jimma University	100%	100%
4	Telemedicine, Dermatology and Leprosy Patients/HIV / AIDS & TB-HIV Patients Case Consultation	Cross cutting	Alert Hospital	100%	70%
5	Development of an In-house HIV-1 Drug Resistance Assay for Integrase Strand Transfer Inhibitors (INSTIs)	Microbial Resistance	AHRI	100%	100%
6	eAmbulance: Innovative Mobile Based Ambulance Management and Private Rideshare Program to Improve Maternal Child Health in Ethiopia	Maternal/ Child	University of Gondar	100%	100%
7	Improving the Outpatient Medication Adherence Towards the Chronic Diseases by Sending SMS to Remind the Dosing Instructions	Microbial Resistance	Jimma University	100%	99.9%
8	Android–Based Fetal Heartbeat Monitoring System	Child Health	Alert Hospital	100%	95%
9	Manufacturing of Electronic Stethoscope & Pilot Trial	Cross cutting	St. Paul Hospital (MMC)	100%	74.7%
Total					91%

Heart disease is the leading cause of death in most countries in the world. The valvular heart disease (VHD) is one classic type of cardiovascular disease-causing significant indisposition and adverse effect on the functionality and long-term life of the patient. In the reduction of deaths from heart diseases (particularly VHD), diagnosis plays a vital role. Therefore, it is very important to have a cost-effective and accurate method for the early detection of cardiac illnesses.

The acoustic stethoscopes that are in use today are not capable of picking up these findings especially at the early stages. Also, the country imports all of these stethoscopes from abroad. So, if we produce electronic stethoscope domestically, it is possible to make early detection of diseases and avoid foreign hard currency expenditure. In conclusion, we can produce better performing electronic stethoscope using materials that are easily available locally. Here are some of our prototype photos.

Prototype electronic stethoscope prototype developed from local material



Heart sound wave visualized and recorded using the developed electronic stethoscope prototype on mobile phone

Innovation Title: Mobile Application to Improve Early Diagnosis and Treatment of Malaria and TB

By Fetulhak Abdurahman (PI) Dr. Kinde Anlay (Co-PI) from Jimma University

Background

Malaria and TB are major public health problems in many parts of the world. Early diagnosis and prompt effective treatment are required to avoid tuberculosis and malaria-associated deaths. Microscope is the golden standard for point of care diagnosis. However, manual microscopic examination is very laborious and requires skilled health personnel. There is also a critical shortage of this instrument this instrument in the developing world such as in sub-Saharan Africa. Critical shortages of trained health personnel and inability to cope with the workload to examine slides to diagnosis TB and malaria are among the main limitations of manual microscopic examination in low-resource settings where there is and high burden these diseases. Today's major progress in computer vision technology allows making extensive use of medical imaging data to provide better diagnosis, treatment and predication of diseases.

Object detection is a major problem in computer vision where different object detection algorithms try to find an object in a given image. Object detection is more difficult since object detection needs specific indication of the coordinates of the object in the given image. There are different algorithms for object detection, and they can be classified into two major groups. The first groups of algorithms work in two stages. The first stage is to find the region of interest in the given image and the second stage is classifying those regions using convolutional neural networks. Such kind of object detection algorithms is very slow in computation since prediction is done for every region of interest. The second group of object detection algorithms work based on regression. Instead of selecting region of interest in separate stage they predict classes and bounding boxes on a single run of the neural network.

This innovation research was aimed to demonstrate the application of deep learning to microscopy based POC diagnostics, with particular focus on the end-to-end application of those methods in a resource-constrained environment, using images captured by a low cost smartphone microscope adapter developed for this study. We provide experimental results for two diagnostic tests: malaria (in thick blood smear samples) and tuberculosis (in sputum samples).

Objective of the innovation

The objective of this innovation research is to develop and implement malaria and tuberculosis diagnostic point of care using artificial intelligence based mobile application to automatically detect malaria parasite in microscopic images of thick blood smear and acid fast bacilli in sputum samples.

Summary of key findings

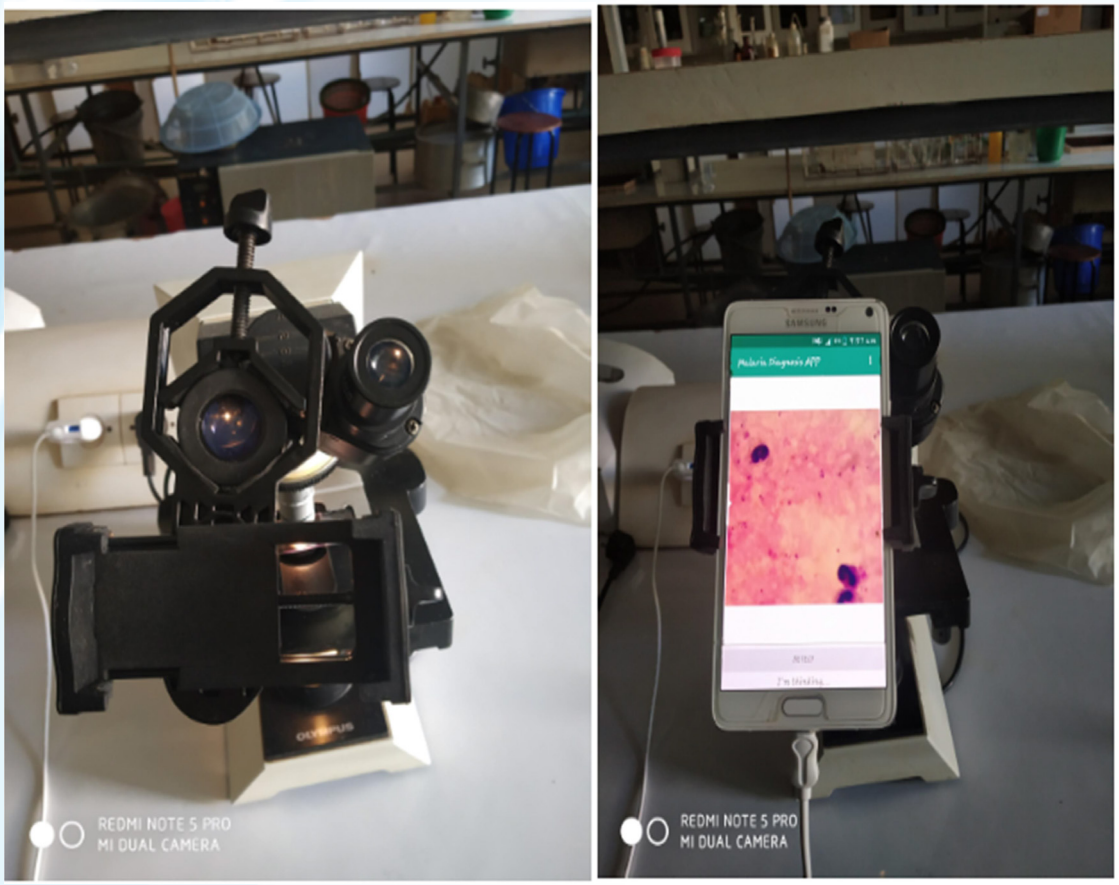
In this study, we adopt and modify the YOLO algorithm for malaria parasite and acid fast bacilli (AFB) identification task. YOLO is currently one of the fastest object detection algorithms among the state of the art due to its unique approach in processing of images. The lightweight version of YOLO can run at 155 frames per second which makes it suitable for what we are trying to achieve in this innovation research.

The data collected for this innovation research was captured by integrating the smartphone camera with the eyepiece of the light microscope using a hardware attachment unit designed for this purpose. Figure below shows the smartphone-microscope setup at clinical setting during data collection. We collected plasmodium falciparum (wright stain and Giemsa stain at different qualities with x1000 magnification) microscopic images from Jimma zone and Hadya zone areas using thick blood smear slides. We captured AFB images from sputum sample at the same health centers using ZN (Ziehl Neelsen) stain. We collected a microscopic images of 3001 malaria parasite and 929 AFB which we used them to train the AI based algorithm to detect malaria and tuberculosis at point of care.

After preparation of the dataset for our study and selection of state-of-the-art deep learning algorithm, which is YOLO v3 in our case, we started training the deep learning model. In the dataset collected using a microscope camera, our model achieved 99.07% accuracy for plasmodium falciparum parasite detection from thick blood smear microscopic image and 97.46% accuracy for acid fast bacilli (AFB) from sputum sample microscopic image.

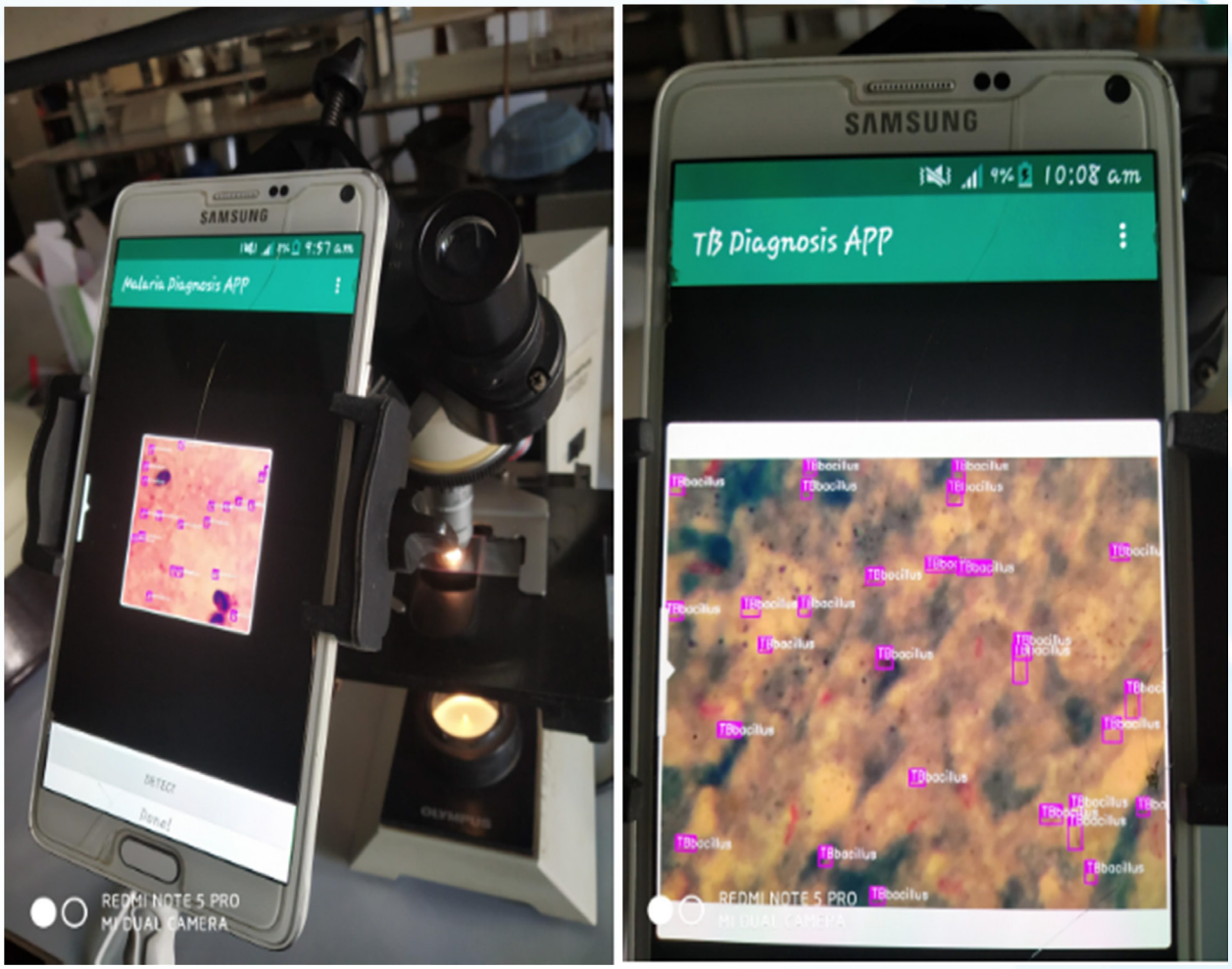
Based on the deep learning algorithm in our case YOLO v3 algorithm for plasmodium falciparum and acid fast bacilli detection, we developed a smartphone supported semi-automated system to diagnose malaria and tuberculosis from microscopic images captured through the

phone camera. Our implemented system is very helpful in rural settings where there is a high shortage of experienced laboratory technicians who need some assisting technology like ours.



a.Attachment Unit b. Microscopic Image Captured Using Smartphone Camera

We implemented the system as android application since most of the users in Ethiopia use the android based smartphones. In the future we have a plan to develop architecture independent application of the system. When using the application, the camera of the smartphone is attached to the eyepiece of the microscope. The lab technician adjusts the microscope to find the target parasite and AFB as the conventional microscopy is done manually. The application then detects the malaria parasite and AFB. When the user presses the detect button on the GUI of the application. Our application takes at least 10 seconds to finish the detection for 1 FOV which is much faster than the manual detection.



a.Detection Result for Malaria b. Detection Result for Tuberculosis

Conclusion and recommendation

In this innovation research, we obtained a promising result that demonstrating low cost mobile devices can be integrated to point of care with cutting edge deep learning algorithms running inside smartphones to diagnosis malaria and tuberculosis. Today deep learning algorithm researchers are coming up with a lot of outstanding ideas which can help our system in the diagnoses of other diseases. We will improve the user interfaces to be easily usable and more functional.

Innovation Title: eAmbulance: Innovative Mobile Based Ambulance Management Program to Improve Maternal and Child Health Service Provision in Ethiopia

By Dr. Binyam Chakilu (PI), Mr. Fedilu Nurhussien, Msc, Dr. Ashenafi Tazebew (Co- PI), University of Gondar, Ethiopia

Background

Women and children bear the health burdens associated with childbirth, which disproportionately affected by healthcare access in resource limited settings, especially in remote areas. Every minute, somewhere in the world, women lose their lives because of complications related to pregnancy and childbirth. It is estimated that globally every day about 830 women die from preventable causes related to pregnancy and delivery. About 99% of all maternal deaths occur in developing countries where home delivery is very common [1]. Majority of these deaths are preventable through focused ANC service, facility delivery and by avoiding delay to arrive to a facility [2, 3]. Sub-Saharan Africa is the region with a high maternal mortality ratio and low ANC utilization [3].

In Ethiopia, the 2011 DHS report found 9.9% of births nationally during the previous five years were delivered at a health facility and 71.1% of women mentioned lack of transport to a facility as a major barrier [5]. Just 0.1% of rural households owned any kind of motorized transport [5]. The challenges of increasing institutional delivery rates and access to emergency obstetric care have now been recognized. The Ethiopian government health service is now unique in sub–Saharan Africa in providing four–wheel drive ambulances in every rural District areas with coverage rate of about 150,000 population per ambulance. There are efforts in making the ambulances available on 24–hours in 7–days basis to serve any woman in labor or with other obstetric problems to transport to appropriate health facilities. There are also parallel innovations to deliver the service using mobile as internet use expansion coverage to rural Ethiopia an opportunity to call ambulances when needed.

This highly innovative approach to improve maternity care has been rolled out nationally in Ethiopia since 2012. A total of more than 3000 ambulances have been deployed, with at least one ambulance per district and nearly larger districts getting two.

There was also an agreement between Federal Ministry of Health and regional governments to make ambulance services available free of charge and ensure safeguard the proper utilization of ambulances.

However different challenges have been reported from the community on the improper use of ambulances for different purposes and also ambulances mostly do not arrive on time as needed during emergency calls for delivery.

New Ambulances received by the regional government from Federal Ministry of Health

The main aim of this innovation project was to develop innovative mobile based ambulance management system to properly manage and track ambulance use. New rideshare programs, such as RIDE, show how transport service can be effectively managed using technology in Ethiopia but are not tailored to health systems. We aim to leverage that approach and deploy a system for the health system and assess its feasibility, acceptability and impact on the use of ambulances.

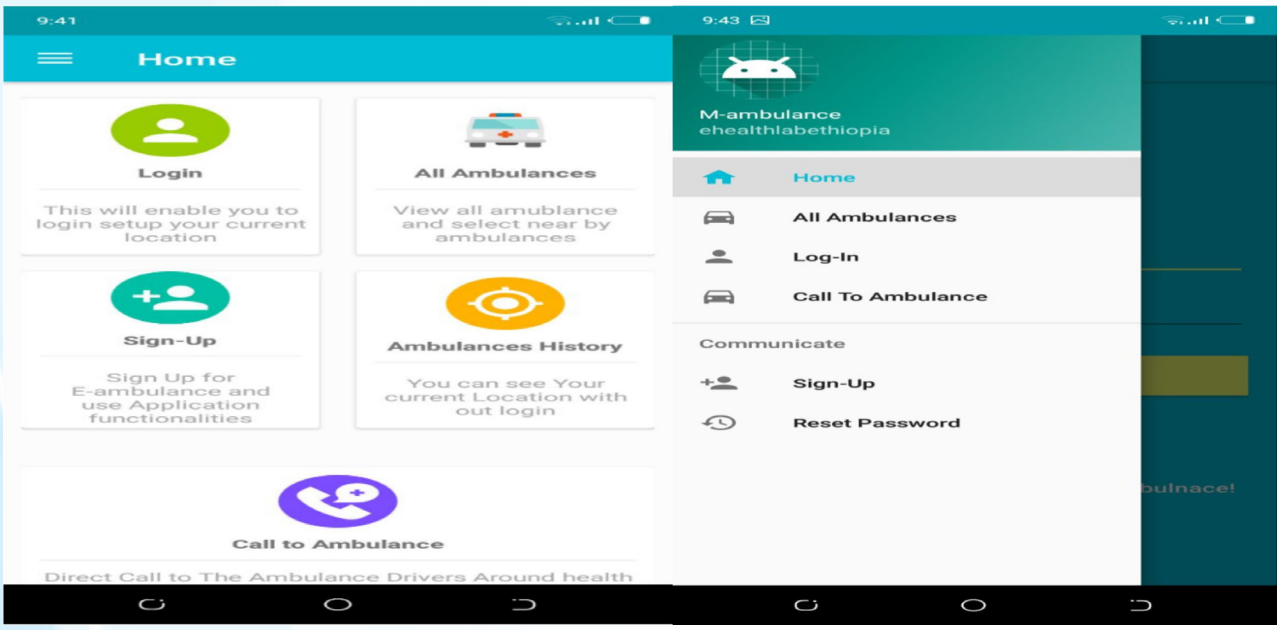
Objective of the Innovation

We propose to develop innovative mobile based ambulance management system called eAmbulance to properly manage and track ambulance use. We have a plan to develop a private public mobile application based ambulance management program which will facilitate the provision of lifesaving transport to laboring mother and high risk pregnant women as the existing public ambulances are not well managed and scarce. This idea is proposed to utilizes an Integrated Innovation Model that combines communication technologies (Applications), GPS, social community rideshare (informally existing), global commercial business innovation of

rideshare fee models (e.g Rise), and public health services. In addition to creating the technological solution (Application service), we also accessed the community demand/acceptability, by the local health authorities to appropriately integrated into the public health system.

Summary of key findings

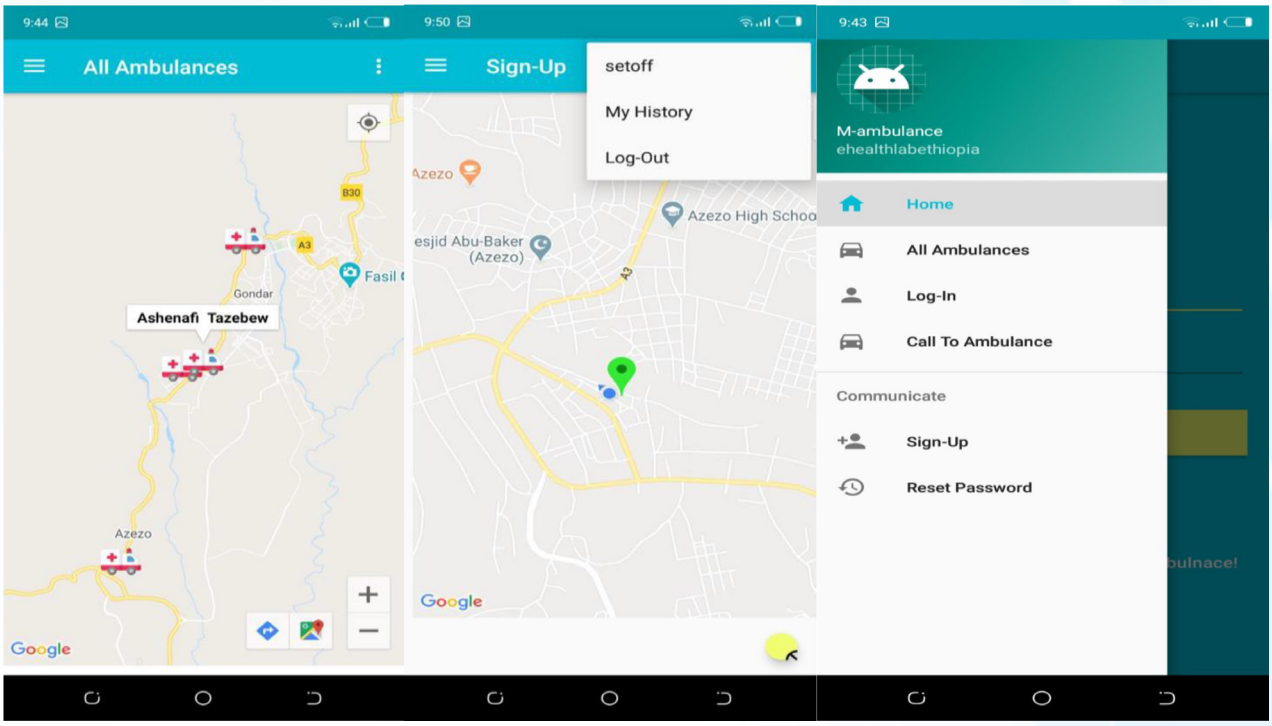
The development of the system was done by our eHealthLab Ethiopia (www.ehealthlab.org) tech team. It follows a standard SDLC application development methodology. A formal phase I need assessment was done at Wogera Woreda. We have conducted key informant interviews involving the head of Woreda Health Office, 2 ambulance drivers and nurses. The application development was done using java and installed on cheap smart phones installed into the ambulances for the testing. Initial registration of the ambulances, drivers, and catchment area of their service has been done before the field testing was done in Wogera Woreda. Screenshot of the main application is shown below.



Screenshot picture of the homepage and the application

Using the GPS data, we integrate real time display of the ambulance locations and functionality that show the travel history of the ambulance for months. When the application is displayed, it can show the exact location of the ambulance which cannot be manipulated by the driver. In addition, the call function was integrated into the application that helps ambulance requester to

search for ambulances around them and make direct call to the ambulance management center at Woreda or directly to the driver. The screenshot of this function is displayed in the below picture.



Picture of Screenshot of Homepage and the Application Service

Key findings

- We developed an application by integrating latest Applications, GPS and mapping technology which has a big potential to deploy a system that can effectively manage the ambulances.
- Mobile Connectivity was found to be 100%, 3G internet connectivity 63% and 2G Connectivity 95% in the Woreda.
- The preliminary testing of the application shows the application can help to arrive to laboring mother in faster way than the traditional approach (we see 2 hour save in the preliminary tests).
- The acceptability of the eAmbulance System by stakeholders including the Woreda health managers, ambulance nurses and drivers was very good. Sometimes, drivers show some fear with the tracking of their movement.

Conclusion and recommendation

The preliminary evidence in this innovation project shows that the development and deployment of system to effectively manage ambulances is feasible in remote settings like Wogera woreda. The level of connectivity was very good to deploy such a system. In our test the system shows feasibility and positive impact to improve the service. The acceptance by stakeholders was good but from the driver's perspective more awareness creation is needed. Our main recommendation from this experience is that with some additional refinement of the system, the technology can be implemented at large scale. During the scale up implementation, in addition to the public ambulances, the system can be also expanded to include private minibus cars as we observe. They are also informally used by the community when the ambulances are not around or when they get delayed. If that is included and implemented, the application can play vital role in saving the lives of many laboring and high risk mothers and change the way ambulance function.

References

1. UNFPA. World Bank Group and the United Nations Population Division: Trends in Maternal Mortality to 2015. World Bank Group and the United Nations Population Division: Trends in Maternal Mortality to 2015 2016:2016.

2. WHO. WHO Guidelines Approved by the Guidelines Review Committee: WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience 2016.

3. Alkema L, Chou D, Hogan D, Zhang S, Moller AB, Gemmill A, United Nations Maternal Mortality Estimation Inter-Agency Group collaborators technical advisory group. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. Lancet 2016 Jan 30; 387(10017):462-474 [FREE Full text] [doi: 10.1016/S0140-6736(15)00838-7] [Medline: 26584737].

4. Abalos E, Chamillard M, Diaz V, Tuncalp Ö, Gülmezoglu AM. Antenatal care for healthy pregnant women: a mapping of interventions from existing guidelines to inform the development of new WHO guidance on antenatal care. BJOG 2016Mar;123(4):519-528 [FREE Full text] [doi: 10.1111/1471-0528.13820] [Medline: 26694196].

5. Tayler-Smith K, Zachariah R, et al. An ambulance referral network improves access to emergency obstetric and neonatal care in a district of rural Burundi with high maternal mortality. Trop Med Int Health. 2013;18:993-1001. Medline:23682859

Innovation Title: Improving the outpatient medication adherence towards the chronic diseases by sending SMS to remind the dosing instructions

By Mr. Fekede Bekele (PI), Dr. Ramanjireddy T (Co-PI) Kokeb Dese(Co-PI), Fanta Gashe (Co-PI) , Dr. Bheemalingaiah T (Co-PI and Yibeltal Andarge (Co-PI) Jimma University, Ethiopia, 2019

Background:

Poor patient adherence towards medication has a major impact on drug resistance, mortality rate and treatment cost. The magnitude of this mpact is higher in developing countries including Ethiopia. Several factors that affect recalling of the dosing instructions on medication schedule leads to loss of control over the treatment of chronic diseases. This could leads to the emergence of the drug resistance. One of the possible ways of recalling the dose instructions can be made ease by SMS notification. Hence, it could be a great platform to alert the patients on dosing instructions. Therefore, we proposed this innovation research to develop independent desktop-based software that can send alerts to remind the dose instructions to patients with chronic diseases receive treatment at outpatient department. The instructions must be in their preferred local languages such as Afan Oromo and Amharic.

Objective of the Innovation

The main objective of this innovation research is to improve the adherences of patients with chronic diseases seek treatment at outpatient department sending SMS. This innovation research has the following four specific objectives:

1. To conduct a national survey of approved drugs with their type, dosage forms, strengths, brand/generic names routes of administration and to translate into local languages (Afan Oromo, Amharic).
2. To develop software that can send SMS to patients with chronic disease received treatment at outpatient department.
3. To formulate a database that can identify Drug-drug interactions in the prescription and to establish the developed software system at drug information center as well as to validate the system.
4. To test the applicability of the developed system and study an outpatient medication adherence among the patients who received dosing alerts though SMS.

Summary of key findings

The first phase of this innovation research was carried out a nationwide survey of pharmacies including the Ethiopian food and drug administration (EFDA) using structured questionnaires. A total of 343 drugs used for chronic diseases were collected with their brand names, strengths, and type of dosage from manufacturers or importers. The dosing instructions used for chronic diseases medications were also collected, categorized in Microsoft Excel sheet and translated into local languages such as Amharic and Afan Oromo.

We developed a desktop based online prescription software system with the help of C#, My-SQL and Java programming software. The software was linked with the database of drugs used for chronic diseases. The patient registration, online prescription and retrieving the prescription history of patient, sending an SMS modules are logged and secured with the admin password to prevent manipulation.

Then, the drug-drug interactions were identified, collected and categorized from the various sources including books, internet and published peer reviewed journals as major, moderate and minor interactions. The database of drug-drug interactions was linked with the developed software. The software can be accessible only to pharmacist, where s/he entered the prescribed drugs on online and the patient medication was scheduled to send the SMS notifications to the patient with chronic disease received treatment at outpatient department to remind the dosing instructions.

Results:

The data collectors interviewed patients with chronic disease received treatment at outpatient department about the adherence of medications as per MMAS-8 point scale derived before and after sending SMS notification. Data was collected from 24 females and 70 males. Of the total 94 patients, 83 were married, nine were windowed and two were bachelors. Among the respondents, majority of them (35) were government employees followed by farmers (25). Most of them attended school from grade 1-8 (35) and those who can read and write were 34. Among the interviewed patients, most of them were diagnosed with hypertension (32), diabetes (31) and comorbidities (31) like heart disease and kidney disease.

The adherence of the patients with chronic disease received treatment at outpatient department were derived based on MMAS-8 point scale if the value is "0" met with the 8 point scale, those patients were highly adhered, if point scale shows 1-2, the adherence is medium and if 3-8 points they are at lower adherence. Before the SMS notification, 72.3 % of the participants were answered that they forgot the medication sometimes and 38.3% were stated that they remember the medications once in a while. About 36% of them were mentioned that it is inconvenience to take medication, 23% were forgot medication on travel and 21% were stopped the medication due to under control of disease.

Among the total of 94 patients, before the SMS notification, nine were at high, 36 were at medium and 49 were at Low adherence level of medication. After the SMS notification receipt, 40 were at high, 41 were at medium and 12 were at low adherence level but one patient was not reachable on mobile communication.

Conclusion and recommendation:

Based on the MMAS-8 point scale derivation upon receiving SMS notifications, there is a significant improvement of adherence level among the study participants. Our study eases the work of health care worker to analyze the drug-drug interactions on prescription. This helps the pharmacist to control and monitor the drug-drug interaction. Thus, the authors of this innovation research recommended farther study at wide scale to generate concrete evidence on the possibility to use the system at scale.

Innovation Title: Wireless Feto-maternal Vital Sign Monitoring and Follow-up for Resource Limited Setting

By Dr. Rediet Adamu[1], Geletaw Sahle[1], Dr. Yeneneh Yirga[1], Zegeye Kelekilew, Dr. Gizat Molla[2], Tigist Wondeye[1]: [1]Jimma University 2019/2020, [2]University of South Australia 2019/2020

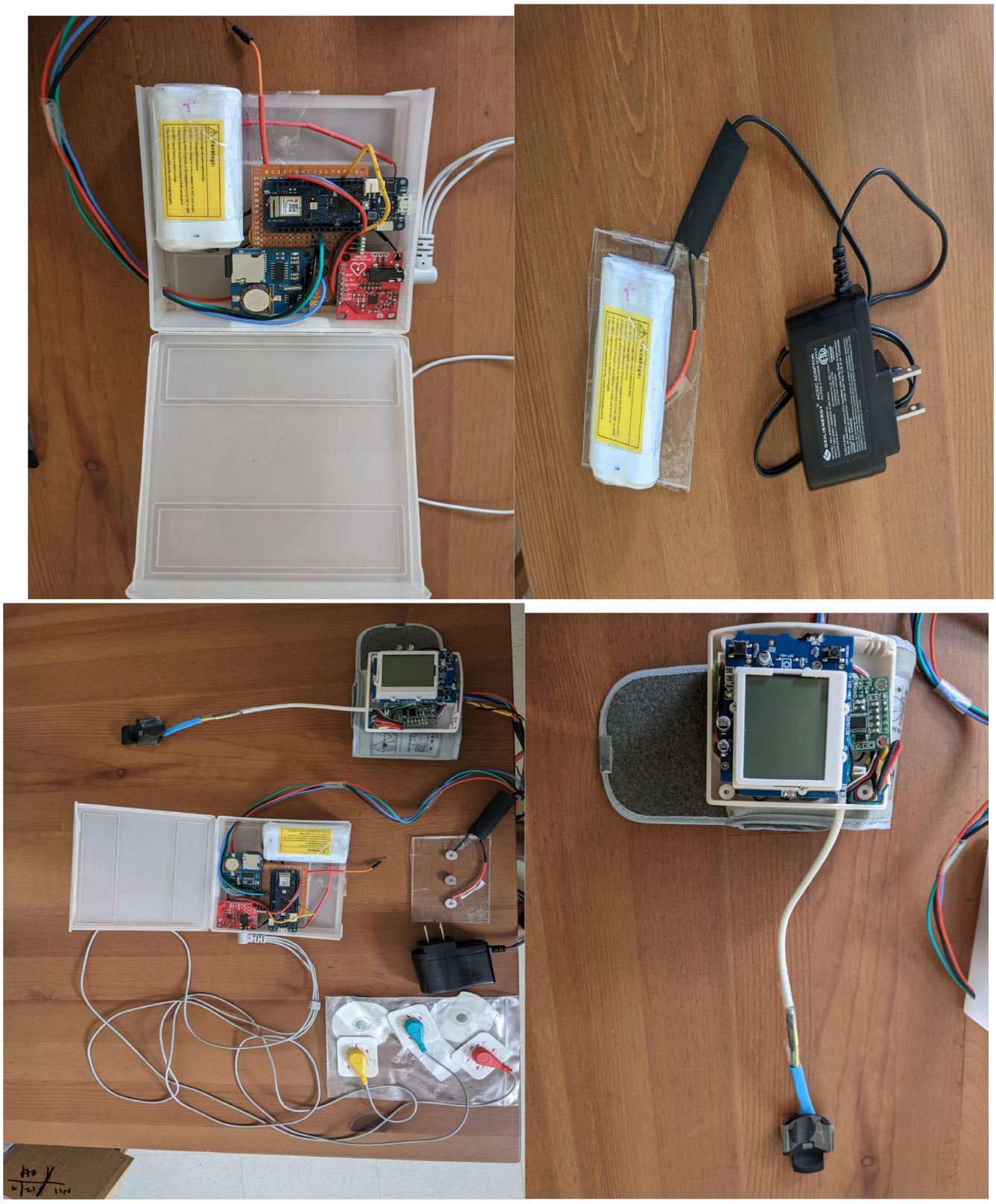
Background

Maternal and neonatal mortality related to childbirth is one of the big challenges of the developing world and its reduction is a key sustainable development goal. One of the reasons for the deaths is poor quality or lack of monitoring on the important vital sign of the mother and fetus during labor and delivery. In one hand the current approach requires trained professionals and their committed effort to capture and analyze the required vital sign in a manual and regular manner. On the other hand, uses of continuous electronic feto-maternal vital sign monitoring tools are expensive, hard to maintain and electric grid dependent. For instance, routine manual collection of the feto-maternal vital sign will take more than half of their time slot and effort according to our survey analysis in Jimma University Specialized Hospital. We also believe that the situation is similar in most of developing countries.

Many of the *de facto* feto-maternal monitoring instruments such as Cardiotocography (CTG) have remained out of reach in developing countries. Hospitals and healthcare institutions in these countries seek a better and innovative solution to reduce cost of ownership, error in manual feto-maternal vital sign collection, and workout burnout and to sustain quality of feto-maternal health care services. To bridge this gap, we tried to: (I). Create assistive intelligence to replace the labor-intensive, monotonous, time-consuming and error-prone way of collecting and monitoring of vital signs of the laboring mother and the fetus with the goal to ensure the adoption of innovations of feto-maternal health care services in low resource setting. (II). Enable continuous monitoring of vital signs during labor and delivery for the wellbeing of the mother and the fetus.

Albite, the type and availability of: (I). Bio sensors used for vital sign data collection in the healthcare setting are becoming enormous while their price becoming cheap, (II). General-purpose microcontrollers which have the capability to take interpret and send collected data from the bio-sensors wirelessly are becoming broadly available and less costly. (III). Intelligent machine learning algorithms for making sense out of the collected healthcare data using classification, clustering and pattern analysis are became effective. (IV). Smart mobile devices to

visualize the interpreted data mobile phones and tablets are becoming ubiquitous, no such vital sign monitoring device comprising and leveraging the above listed facts



Different parts of proto type developed with different sensors

Our innovation idea is to construct a wireless feto-maternal vital sign monitoring and alerting system for low-resource setting, in which sensors are attached to a laboring mother non-invasively collecting vital sign data in real-time. Being processed by the rechargeable battery powered, microprocessor; it can send the data for visualization in a wireless manner to health care professionals or to the labor and delivery ward central nurse station. The widely accepted feto-maternal health status indicators are Maternal Blood Pressure, Uterine Contraction, Maternal Temperature, Maternal Heart Rate, Cervical Dilatation and Fetal Heart Rate. Apart from Cervical Dilation all indicators are considered in this project, and yet the later can be easily integrated to the proposed device in future upgrades.

Objective of the Innovation

- Introduce a low cost, portable feto-maternal vital-sign monitoring device in low resource setting.
- Assist the health care process by:
  - Automating the vital-sign collection and monitoring based on Internet of Things.
  - Reducing health care professional burnout.
  - Active alerting upon the occurrence of abnormal vital signs.
- Deliver optimal care to improve feto-maternal health by:
  - Reducing errors in the vital-sign collection.
  - Producing a real-time vital-sign data of the fetus and the mother to the health care professional at his/her vicinity.

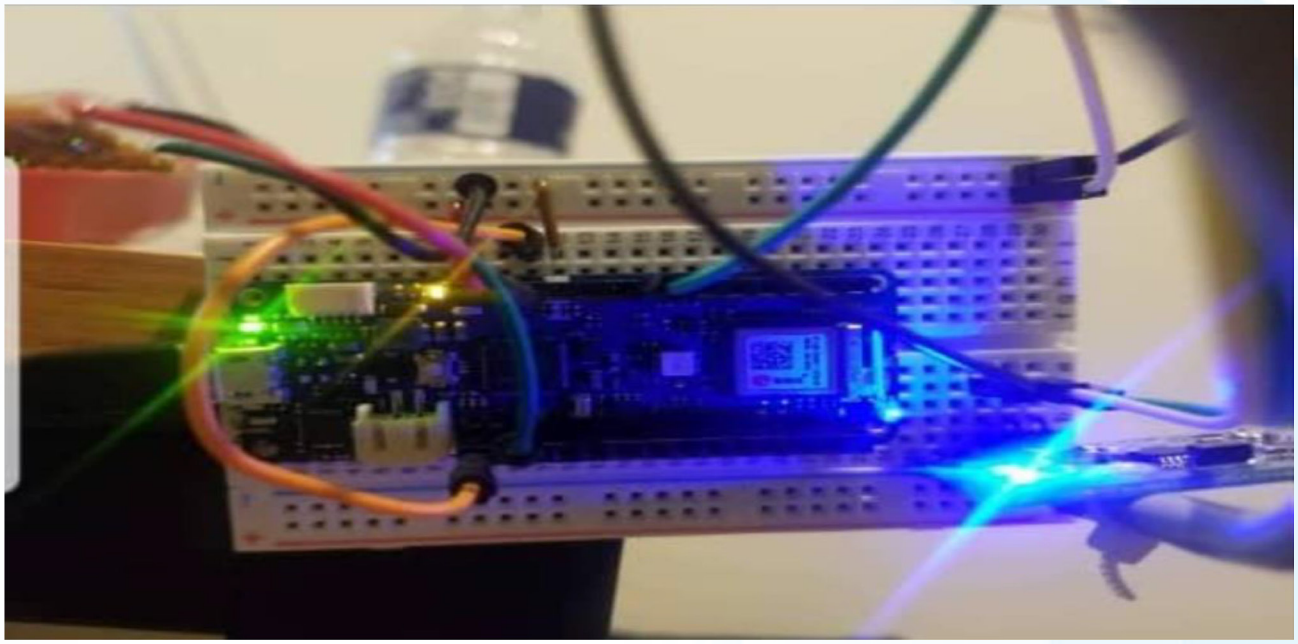
Design of Wireless Feto-maternal Vital Sign Monitoring and Follow-up Device

The device has two modules. The module classification is based on the body where the sensors are attached for vital sign collection. In the first module maternal temperature, heart rate and blood pressure sensors are put together with a microcontroller on the armpit, tipping finger or ear and upper arm or wrist subsequently. In the second module Uterine Contraction and Fetal Heart sensors are placed on the lower abdomen of the mother.

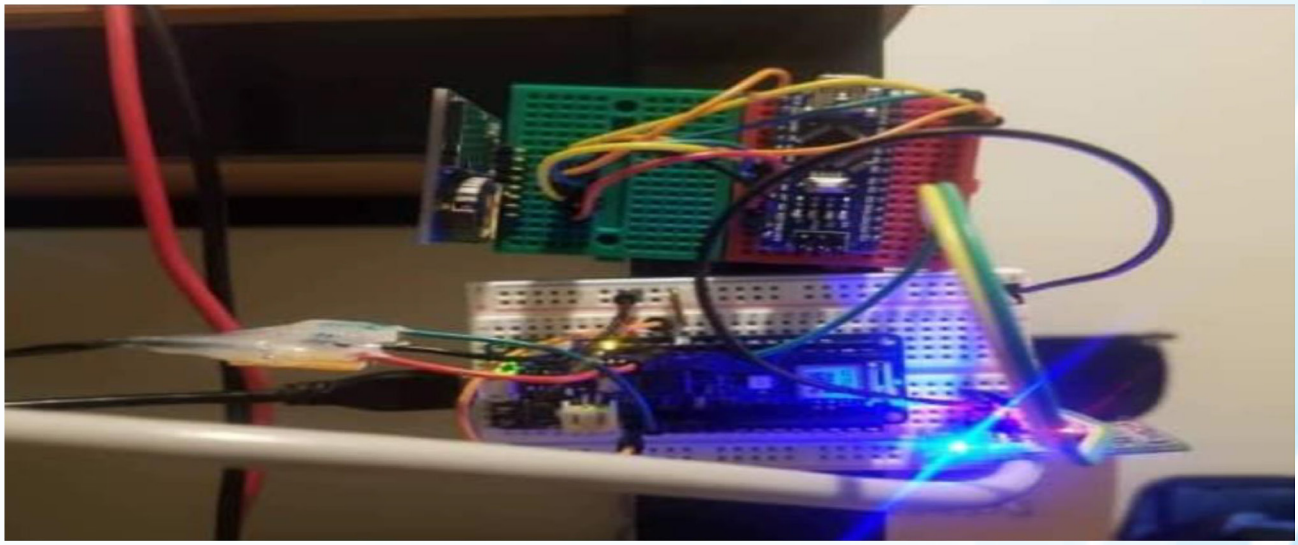
The time series data collected by the sensors are first stored in the data-logging module before it sent to a real-time database for analysis and visualization. This averts data loss in case of wireless communication failure and then visualization software will query the data from the real-

time database, analyze and graphically represent it in a way that the health care professionals can easily understand it. These include charts, graphs and numerical representations of all the collected vital signs.

The visualization software is based on the WHO standard known as the partogram which is a composite graphical depiction of key data during labor. The visualization can be viewed by via smart phones, computers or tablets in real-time in a wireless manner. Furthermore, the software system can alert the healthcare professional if the vital sign measurements of the mother and fetus are out of the normal range for a proper action.



Central processing unit with integrated wireless transmission



Temperature, HR, BP sensor with data logging module

Summary of key findings

1. Introduce and design a low cost wireless feto-maternal vital sign monitoring and follow-up for resource limited setting.
2. Ability to get a real-time vital sign signals/data for continuous monitoring for timely intervention. According to our survey in Jima University Medical College it was noted that more than half of the time and work effort of the healthcare providers spent on collecting the feto-maternal vital signs. However our new innovation device will significantly minimize the time and work efforts of health care workers by providing continuous data.
3. It reduces an erroneous feto-maternal vital sign data collection. In the existing system, re-correcting and tracing the error are a tiresome activities and our device deliver an instance error correction and alert.
4. Ease of electronic vital sign data collection, organization and storage for feature researches.
5. Ease of communication between care providers and consultations at time of need.

Key message of the innovation research

A low cost continuous electronic feto-maternal vital sign collection and monitoring mechanism starting from active first stage of labor to parturition will play a significant role in improving the feto-maternal health outcome specially for developing countries in which the de facto electronic monitoring devices are out of reach and expensive.

Conclusion and recommendation

Maternal and neonatal mortality related to childbirth is one of the big challenges in limited resource settings. This innovation research project tried to develop a wireless feto-maternal vital sign monitoring and alerting system. Low cost sensors are attached to a laboring mother. It non-invasively collects vital sign data in real-time, being processed by the rechargeable battery powered microprocessor and later sent for visualization in a wireless manner for the health care provides or to labor and delivery ward central nurse station. Our innovation expected to slash the manual vital signs collection mechanism significantly in terms of efficiency and error resistance. It also brings ease to the vital sign collection and monitoring for timely intervention, thus for better outcome. However, producing all in one industry standard prototype is very crucial for beta-level usability testing followed by iterative improvement.

Innovation Title: Development of an in-house HIV-1 Drug Rresistance Assay for Integrase Strand Transfer Inhibitors (INSTIs)

By Dr. Andargachew Mulu, Armauer Hansen Research Institute (AHRI)

Background

The development of pre and acquired treatment drug resistance is becoming an obstacle to the success of antiretroviral therapy (ART). Our decade longitudinal study among two groups of patients who had initiated ART at the scale-up (2008) and first roll out (2005) of ART in a well characterized HIV-1C infected Ethiopian cohort showed an increase incidence of virological failure overtime from 11% in 2008 to 30% in 2015. There is also a steep increase in the incidence and accumulation of major acquired NRTI and NNRTI drug resistance mutations (from 40% at 2008 to 64% at 2012 and then to 66% at 2015). Furthermore, recently we found an increased (11%) level of transmitted drug resistance among recently diagnosed patients in Addis Ababa. These indicate that an increasing number of drug resistance mutations in Ethiopia could require alternative regimes as the first and second line regimes failed.

However, every person starting HIV treatment will need to have access to viral load and drug resistance testing. Unfortunately, the current pace of viral load and genotypic drug resistance diagnostic scale-up is unlikely to meet future demand because of high cost and technical difficulties on the existing commercial assays and continue to be an obstacle for early detection of virological failure and drug resistance and their transmission. As a consequence, new approaches to provide diagnostic procedures in developing countries are required and need to be lower cost, technically and logistically simple, albeit in substance equivalent to conventional methods.

Accordingly, we developed an in-house HIV-1 drug resistance assay for protease and reverse transcriptase inhibitors using the conventional plasma HIV-1 RNA as a template and translated to a low cost and straight forward in-house assay for amplification and sequencing of HIV-1 proviral DNA directly from whole blood using in-house antifreezes (under clinical evaluation) for the detection of drug resistance. Following these achievements, we further designed an in-house HIV drug resistance assay for integrase strand transfer inhibitors. Thus, the current study is a continuation of our previous works aimed to translate the evidences generated for HIV-drug resistance for protease and reverse transcriptase inhibitors to integrase inhibitors as Ethiopia has already introduced integrase strand transfer inhibitors. This innovation project aims to

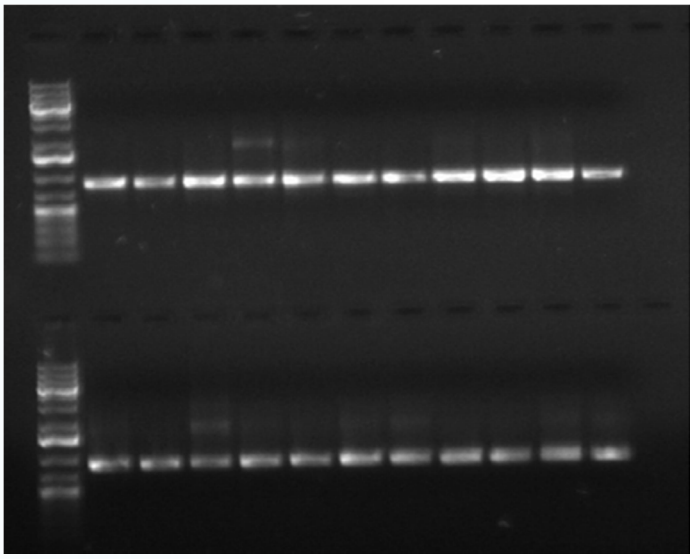
simultaneously transfer know-how and technical preconditions in Ethiopia and also to translate this knowledge in designing monitoring tools for other viral diseases.

Objective of the Innovation

This innovation research aimed to develop a simple low cost direct whole blood assay for detection of drug resistance variant for integrase strand transfer inhibitors.

Summary of findings

HIV proviral DNA was successfully extracted from whole blood using our optimized protocol. The entire integrase gene was amplified using an in-house assay. Amplification of HIV-1 proviral DNA was also made using the same protocol as for viral RNA but omitting the RT step. PCR final products for viral RNA and proviral DNA was purified using manual in-house methods. The purified PCR products were sequenced using the fluorescent dideoxy-terminator method and the ABI Prism 310 genetic analyzer (Applied Biosystem, Foster City, CA, USA) using our in-house amplification and internal sequencing primers.



Gel Photo for HIV INT genome from proviral DNA

The raw data of electropherograms was edited manually. FASTA files was analyzed using Stanford University HIV-1 Sequence Database (http://hivdb.stanford.edu). All sequences obtained from both, viral RNA and proviral DNA was re-confirmed using the Rega HIV-1 subtyping tool, version 2.0 (http://www.bioafrica.net/subtypetool). HIV genotypic drug

resistance assays from whole blood and plasma is analyzed. The drug resistance mutations codon is assessed.

Alignment of the HIV-1 INT genome from proviral DNA

Impact of the innovation

The project presented here aims at developing drug resistance assay using a novel technology for HIV-1 INT genotypic drug resistance monitoring of HIV positive patients in developing countries. The main obstacles in HIV drug resistance monitoring of patients by standard commercial techniques in developing countries include low infrastructure, lack of adequate technical facilities and logistical preconditions and high cost. Direct whole blood proviral DNA drug resistance analysis is a method based on analysis of HIV proviral DNA using DNA as measurement template which is highly robust and stable molecule compared with the conventional HIV RNA molecules. In comparison to RNA, that is required for conventional HIV drug resistance testing, it has only little demands on sample storage and transport.

Furthermore, it will allow the development of a novel community based strategies for prevention and control of HIV-1 drug resistance mutation and to assess the presence of HIV-1 acquired drug resistance mutation/s and transmission of those variants, and to design an evidence based regional and national algorithm for switching of ART whenever there is virological failure without testing for drug resistance in future.

Even though, the current free HIV related activities in Ethiopia has benefit patients economically, our current innovation to test drug resistance will more benefit them at individual micro level in terms of quality of care and in reducing the risk of drug resistance and side effect.

Moreover, at population level, all the community will be directly benefited as the monitoring tools provide evidence to design population and individual level HIV prevention and control strategies. Health care workers at all level can easily manage and monitor their patients. At macro level, the economic benefit of this innovation project in terms of saving hard currency is immense as the aim of the study is ultimately to use the in-house assay for routine clinical practice in the country and to commercialize the assay in line with the GTP2 and the National Biotechnology Road map.

Conclusion and recommendation

High sequence similarity of HIV -1 INT genome between plasma and whole blood is observed. It is suggestive that direct whole blood assay can be used for detection of drug resistance mutation for INT strand transfer inhibitors. However, the clinical utility of the assay should be evaluated at a large scale by including more sensitive sequencing approaches that can detect minor quiespecies.

Innovation Title: Android–Based Fetal Heartbeat Monitoring System

By Dr. Aleazar Abeje, Nathan Melaku, Getaw Dejen, Alert Hospital

Background

The fetal Doppler is a non-invasive diagnostic device used to detect and measure the fetal heart rate which allows evaluating fetal wellbeing**.**

Objective of the innovation

The current trend of fetal heart rate monitoring system is wired, bulky, expensive and constrained to specific clinical locations. The system components are connected via cable to the pregnant mother and to a central non-portable unit equipped with a speaker and a printer. According to Martin (2013) the fetal heartbeat and its corresponding tracing referred to as a fetal cardiotocography, are then audible and visible to providers in the room. However, improper use and frequent movement of the wires leads the cables to be disconnected and cut. This reduces durability of the system & incurs maintenance costs. However if we implement wireless fetal heart beat monitoring system we can eliminate these problems or limitations.

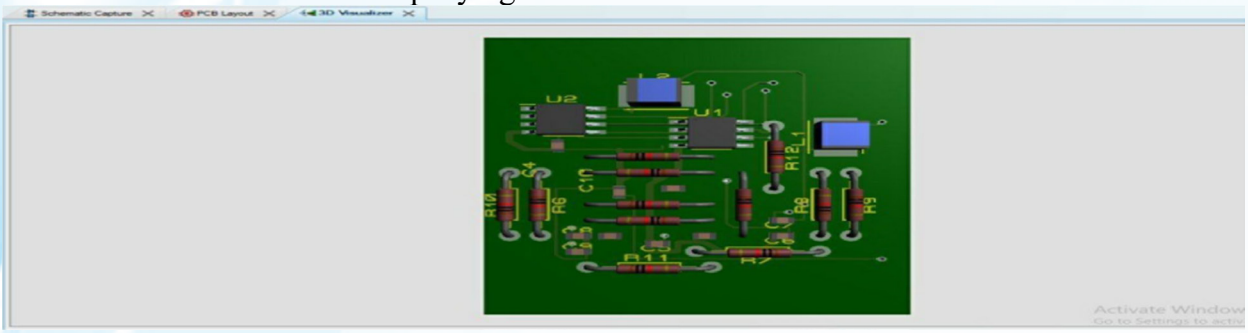
The objective of this innovation research is to design and develop a system which is both wireless and mobile introducing a new paradigm of care. The proposed system is advanced project of new generation fetal Doppler connected with an application and adjusted packaging. It is also ergonomic, intuitive and provides wireless integration with smartphone which aims to increase comfort of use and adds the new features and services like heart rate analysis and personalized recommendation. ***The main factor was to improve functionality and safety.*** Incomprehensible interface, ignorance associated with the use and inability to save results may raise many doubts and inconvenient situations for pregnant women.

Summary of key findings

Our proposed innovation technology comprises of a non-invasive cardiotocography that uses proven Doppler-based technology and sensors to measure fetal heart rate. These components must connect (or "pair") via Bluetooth to a data transmission gateway (i.e., a Smartphone or tablet or a on which the initial fetal cardiotocography is visualized).

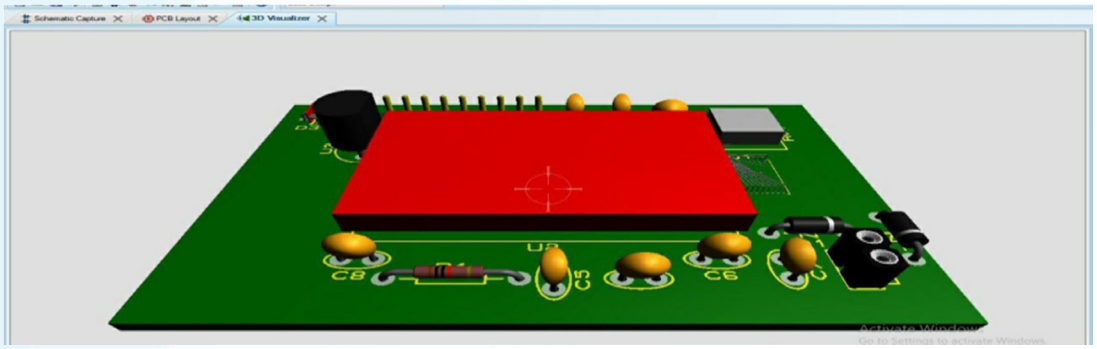
This portable Doppler fetal heart rate detection system consists of three parts, namely:

1. The Complex Programmable Logic Device (CPLD) ultrasonic excitation and acquisition circuit echo reception) which is further consists of three parts:
    I. An excitation generator circuit,
    II. An impedance matching circuit and
    III. A driver amplifying circuit.



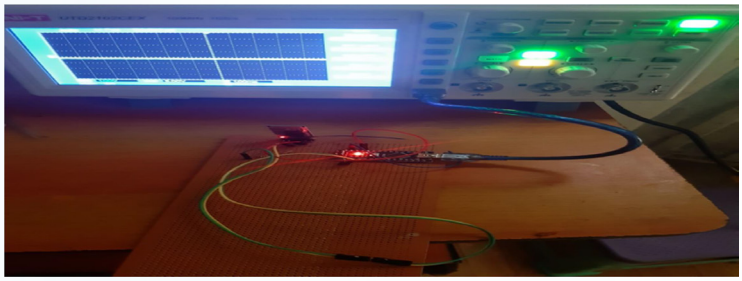
The Ultrasonic excitation and amplifying circuit

The echo reception module includes hardware filtering, echo amplification, and Analog-Digital Converter (ADC) acquisition.



The Ultrasonic echo reception module

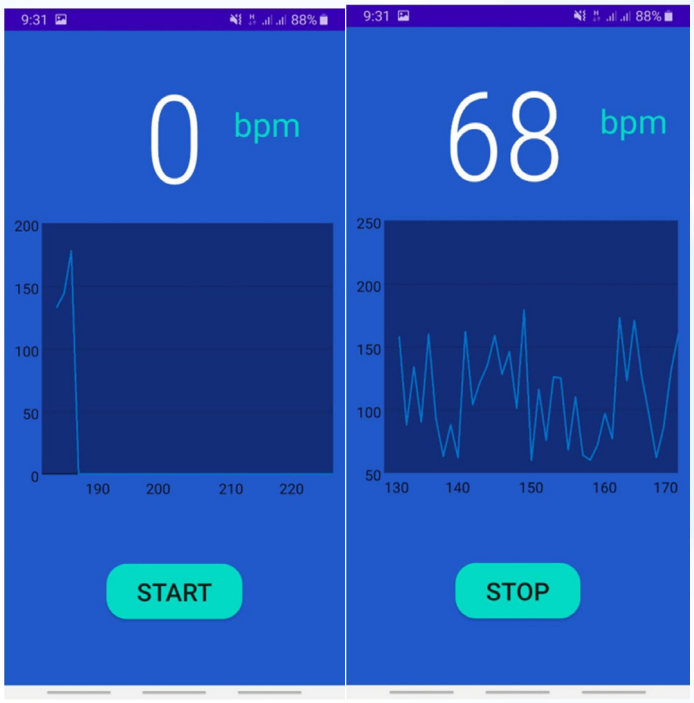
2. The Microcontroller Unit (MCU) and peripheral circuit. As the transducer receives the echo signals, these are sent to the CPLD for digital filtering and demodulation, after steps of hardware filtering, echo amplification, and ADC acquisition



The MCU and Peripheral module

3. The system software (Mobile Application)

Our proposed system is connected to Bluetooth through the serial port, to obtain wireless data transmission using a smartphone. In this way, any Android smartphone or tablet equipped with the corresponding software can dynamically display in real-time the FHR and its trend curve.



Mobil application displaying fetal heart rate

Conclusion

These days, in developing countries like Ethiopia, more emphases are given to decrease perinatal morbidity and mortality rate. However this innovation which uses smart phone to hear, see, read fetal heartbeat in rate and periodic form especially during intrapartem will help early detection of the fetal heart rate abnormality for timely action.

Moreover, if it will implemented at scale it will solve the current health grand challenges related to feto-maternal care during labor through establishing cheapest fetal heart rate monitoring system that can be wireless and easy to use for health care providers with capability to listen, record and report on the mobile application.

3.2. NEW HEALTH INNOVATION PROJECTS FOR THE YEAR 2020/2021

3.2.1. Transition to Scale Projects

A total of 54 applications for transition-to-scale grant were submitted for the call announced for the year 2020/2021. Of these four were selected by the Grand Challenges Ethiopia taskforce and were awarded the grant. The selected transition to scale grant health innovation projects are expected to be implemented over 18 months starting from January 2020, 30% during the first year of six months and 70% during the 12 months second year until June 2021. Accordingly, 30% of the overall projects work has been planned to be executed until June 2020. The average progress performance of the four transitions to scale projects during the first six months of the project life was 25 % of the total project work which is planned target for that period. This means the annual average transition to scale grant health innovation project performance was 83.4% compared to the annual planned. Description and detailed performance of each transition to scale grant projects are presented as below.

3.2.1.1. Affordable Infant Radiant Warmer to Prevent Premature Neonates' Death Due to Hypothermia: by Habtamu Abafoge (PI) and Abel Beneberu (Co.PI)

Background

Neonatal hypothermia contributes to morbidity and mortality risk of newborns as it has been recognized by the World Health Organization (WHO). Absence of warmers makes the condition so difficult. By nature, hypothermia is a preventable condition in providing warm and proper handling of newborns and preterm born neonates. Due to lack of affordable infant radiant warmers thousands of infants would die. Currently, the price infant radiant warmers are over $ 4,200. But our proposed innovation with the design of Simbona baby warmer only costs $1,200 which is almost 76% less expensive than that of the market offering.

Description of Intervention: Infant radiant warmers are overhead heating units. They typically consist of a heat source, a skin-temperature sensor, an automatic (servo) control unit, and visual and audible alarms. Additionally, Simbona baby warmer has integrates LED based neonatal jaundice treatment unit in the same device. A heating element generates a significant amount of radiant energy in the far IR wavelength region. The radiant output of the heating unit is automatically controllable to prevent hyperthermia condition to the infants.

Project Status

Built with similar technical characteristics with products currently available in the market, this technology presents additional features in temperature regulation and component mechanical parts & a microprocessor unit. The baby body temperature display LCD is designed to integrate more than three parameters to operate and use friendly by end users. All selected circuit board, body temperature and computer language algorithm makes the product high quality and affordable price. This design is less complicated, and is easy to use, transport, manipulate, install, and replace main parts and to troubleshoot. Currently, the final recalibrated product for multiple sites use is finalized for implementation. Overall, so far 25% of the project implementation has been achieved this is almost in line with the planned to be achieved in the first six months of the project life.

Picture of developed prototype with unique features

3.2.1.2. Improvement of Compound Light Microscope through Advanced Medical Image Analysis, Automation and Monochromatic Light Sources by Abel Worku (PI), Shimels Nigusu (PI) and Gadissa Wagari (Co-PI)

Background

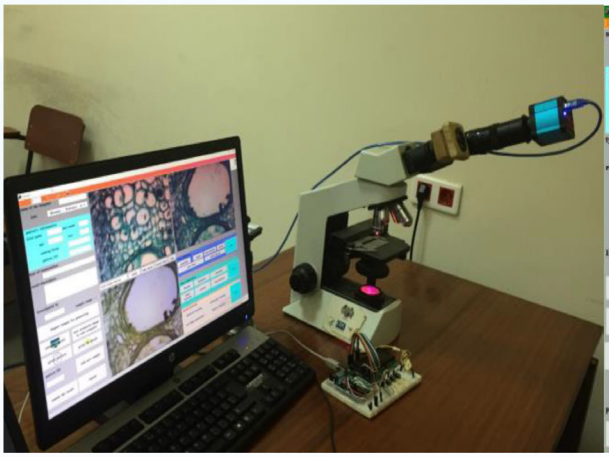
Clinical laboratories are responsible for analyzing patient specimens in order to provide information to aid in the diagnosis of diseases and evaluate the effectiveness of therapy. Compound light microscope is the most commonly used medical equipment in various applications including in Health care, Education, Industries and in the research activities as well as in a clinical laboratory in the diagnosis of Malaria, TB, Diarrheal disease, and different blood-related diseases like leukemia.

However, there are major gaps with the existing diagnosis technology in Ethiopia. These gaps include acquisition method, poor storage/recording system, no image processing to be validating the diagnosis, discomfort for the user (back pain and sight problem) and high cost for advanced type of microscopies.

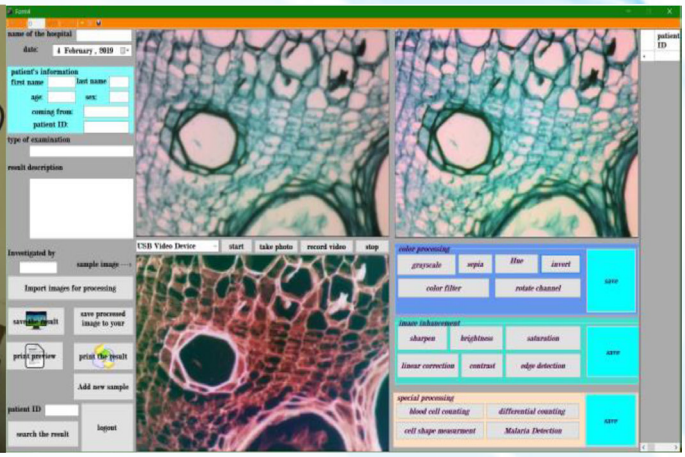
In addition, there is high level of subjectivity of the results as there is no advanced medical image analysis that harmonizes and decrease subjective variation. Therefore, the current innovation that have already developed prototype and planned to implement at transition to scale will solve the above problems.

Project Status

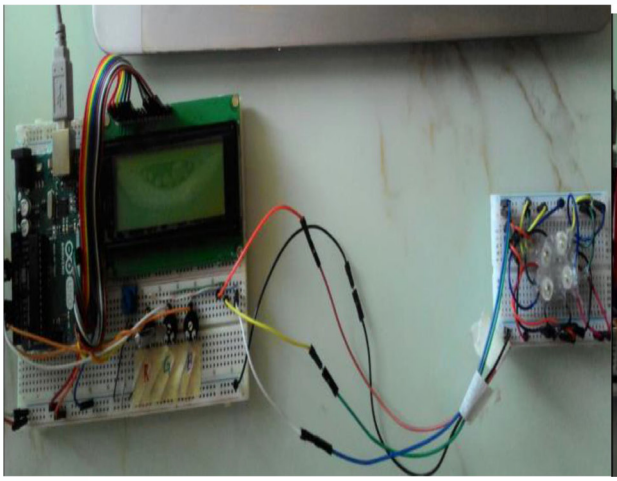
Currently, the final recalibrated product for multiple sites use is finalized for implementation. Different tests were conducted on the first prototype to evaluate the design. Based on the response form the users, final recalibrated product for multiple sites clinical trial has been finalized. Overall, the plan for the first six months of the project to accomplish about 30% of the entire innovation work and the achievement was also 30% which is 100% of the planned target of the time. The financial utilization and submission of the statement of expenditure was also good as described above.



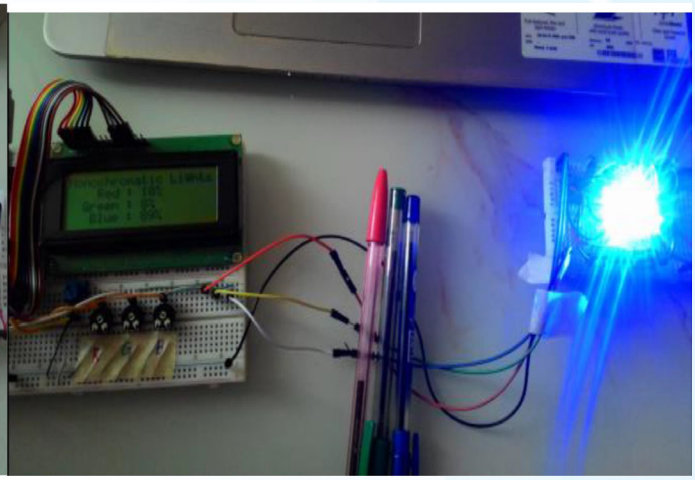
Developed prototype



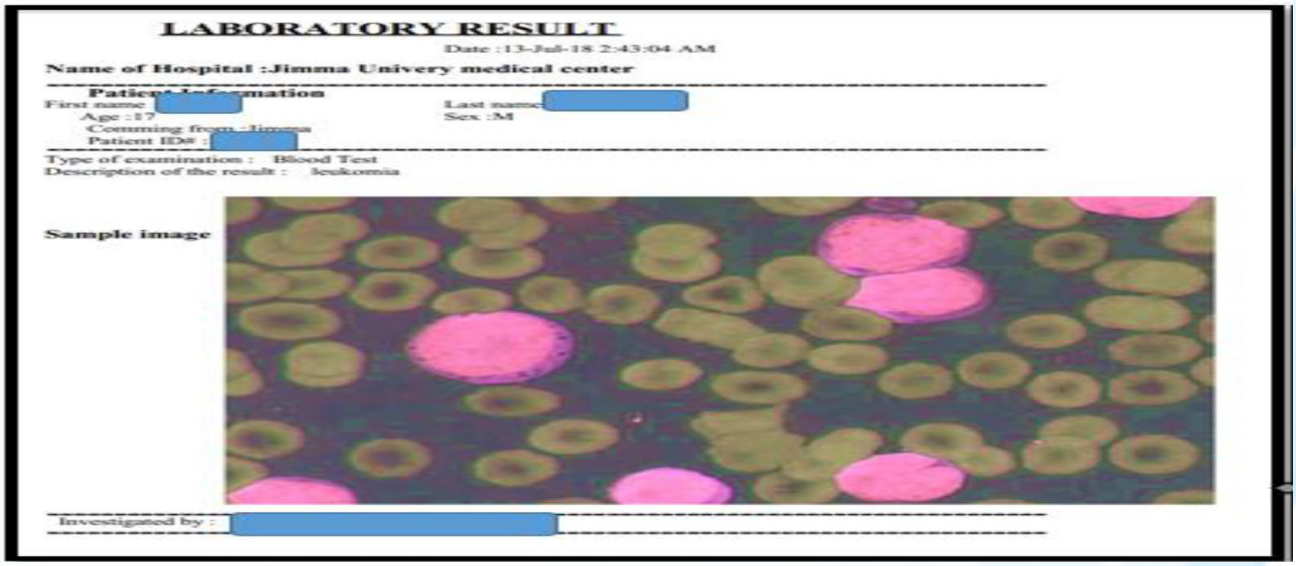
Graphical user interface used for image display, Processing, patient data management, and other features



Constructed lighting system



Lighting system, showing blue 90% blue, 10%red, 10% green light



The format of clinical result in hardcopy form with sample image

3.2.1.3. Non Invasive Hemoglobin Measuring Device for Detecting Anemia in Pregnant Mothers; by Ketema Lemma (PI), Gelan Ayana (PI), Abdurezak Haji (Co.PI) and Kokeb Dese (Co.PI)

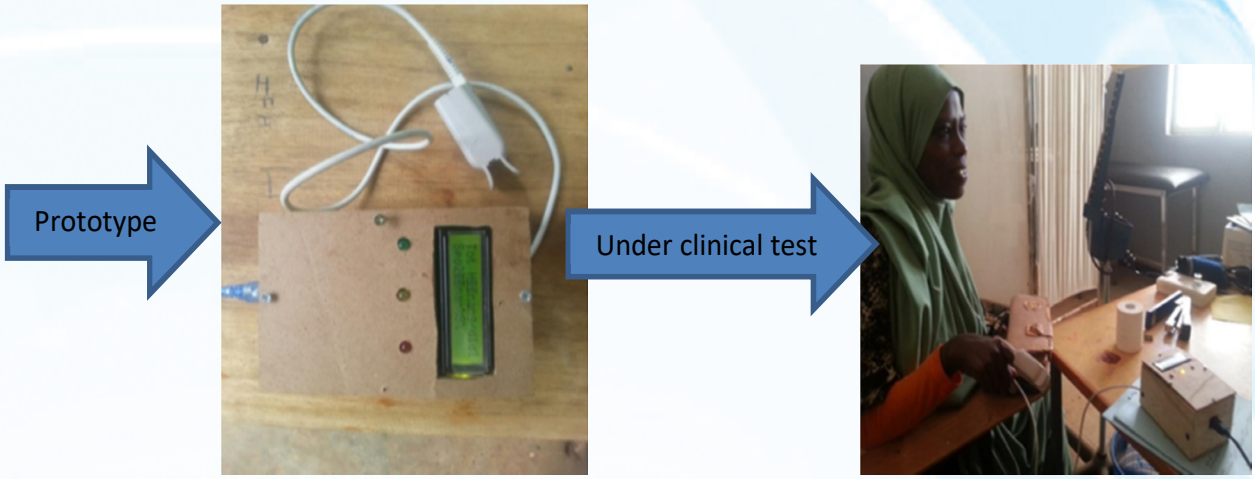
Background

Prenatal programs in most developing countries dictate that women should be given iron supplements and counseled without monitoring for anemia. In reality, many health programs lack iron supplies, women who are already moderately anemic need more than the minimal amount of iron supplement provisions. Moreover, cultural taboos around food during pregnancy across different geographical areas affect the effectiveness of current approaches and calls for accurate anemia screening. Currently, tools to diagnose anemia and assess hemoglobin (Hb) in blood required invasive method to collect blood sample from pregnant mother by finger prick. This method is invasive, painful, discomforting, time consuming, and subjective. Above all, it is not accessible to poor infrastructure settings needs trained professionals and are expensive.

However, the current developed prototype is non-invasive to measure hemoglobin among pregnant women and would solve all the problems listed above. It can also be used at all levels of the health system including at health posts by the health extension works. Our proposed apparatus has an optical photometry to measure hemoglobin levels to diagnosis anemia. The device uses an optical photometry system, light emitting diodes that emit light at 660nm and 940nm.

Project Status

Currently, the final recalibrated prototype product has been finalized and is on clinical trial. Overall, the plan accomplish in the first six months of the project period was 30% of the entire innovation work. However, due to the change of PI, the commencement of the innovation work was lately started. Currently 20 % of the innovation has been accomplished.



Developed Non-Invasive Hemoglobin Measuring Device

3.2.1.4. Affordable Neonatal Jaundice Treatment (Phototherapy) Unit for Low Resource Settings; by Samuel Sisay (PI) and Habtamu Abafoge (Co.PI)

Background

Child survival remains an urgent global concern. A child's risk of dying is highest in the neonatal period, in the first 28 days of life. Neonatal mortality is receiving increasing attention not only because deaths occurring during the neonatal period have been increasing but also because the health interventions needed to address the major causes of neonatal deaths. They are closely linked to those that are necessary to protect maternal health. Globally, the main causes of neonatal deaths are preterm birth complications (35 per cent), intrapartem related complications (24 per cent), and sepsis (15 per cent). Major causes of death during the neonatal period in Africa include infections, asphyxia and preterm birth.

The majority of neonatal illnesses in low-resource settings could be treated with a set of technologies that aim to provide adequate hydration and nutrition, prevent and treat infections, provide temperature stability, provide breathing support when necessary and monitor for and treat neonatal jaundice.

A broad array of devices is available to meet these needs in well-resourced settings. But these neonatal technologies often do not reach the developing world because they are too expensive or have prohibitive infrastructure or personnel requirements. As a result, in many low-resource settings, effective devices and therapeutic possibilities for neonates are not readily available.

Some 60% of normal newborns become clinically jaundiced sometime during the first week of life. Sufficiently elevated levels of bilirubin can lead to bilirubin encephalopathy and

subsequently kernicterus, with devastating, permanent neuro-developmental handicaps. The goal of therapy is to lower the concentration of circulating bilirubin or keep it from increasing. Phototherapy achieves this by using light energy to change the shape and structure of bilirubin, converting it to molecules that can be excreted even when normal conjugation is deficient.

We developed prototype of phototherapy machine using Grand Challenges Ethiopia Seed Fund. The aim was locally to produce the machines to treat neonatal jaundice in Ethiopia and to test its functionalities at transition to scale stage. Then the final products will be available to the market at a competitive price due to a) low cost of production, b) our product design focused on affordability, c) parts are easily replaceable and inexpensive. Furthermore, these products are easy to use, need low maintenances and are durable.

Project Status

Fully functional prototype phototherapy machines were produced with different designs targeting affordability for low resource areas. They are ready for multiple hospital clinical trial tests. Prototype's basic safety and essential performance has been tested by certification body according to IEC 60601-2-50 standard. Currently 25% of the transition to scale implementation has been achieved this is almost in line with the planned to be achieved in the first six months of the project life.

Developed photography machine with solar powered supply

Developed photography machine with Electric powered supply

Unique Features of the Machines: Battery operated (solar), high intensity with controllable system, temperature sensor is integrated, durable, works for 50,000 hrs. Bilichiker is integrated, noise free operation, uniform spread of light.

Table 2: Transition to Scale Grant Health Innovation Physical Project Performance for the year 2019/2020

No	Innovation Title	Hosting Institution	Priority area	Physical performance compared to the annual plan
1	Affordable Infant Radiant Warmer to Prevent Premature Neonates' Death Due to Hypothermia	Jimma University	Child health	83.3%
2	Improvement of Compound Light Microscope through Advanced Medical Image Analysis, Automation, and Monochromatic light sources	Jimma University	Cross cutting	100%
3	Non Invasive hemoglobin measuring device for detecting anemia among pregnant mothers	Jimma University	Maternal health	67%
4	Affordable Neonatal Jaundice Treatment (Phototherapy) Unit for Low Resource Settings	Jimma University	Child health	83.3 %
Total				83.4%

3.2.2. New Seed Grant Health Innovation Projects for the year 2020/2021

A total of 52 applications for seed grant were submitted for call announced for the year 2020/2021. Of these only 8 qualified for the preset selection criteria. They were selected by the Grand Challenges Ethiopia taskforce. Similar to transition to Scale Health Innovation grants, these Seed Grants are expected to be implemented over 18 months starting from January 2020, 30% during the first 6 months and 70% during the next 12 months the project life until June 2021. Accordingly, 30% of the overall projects work planned to be executed in the first 6 months of 2020 and the remaining 70% during the next 12 months until June 2021. The average progress performance of the eight Seed Grant health innovation projects during the first six months was 31.3 % which is above the 30% of the planned for the given period. This means the annual average Seed Grant health innovation project performance was 104.6% compared to the annual planned.

In general, the overall physical project performance of new Seed Grant health innovation projects of the first six months was very good and encouraging which need to continue with the current momentum to finalize the remaining 70% within the intended plan time. The detailed performance of each new Seed Grant health innovation projects is presented in the table below.

Table 3: The 2020/2021 New Seed Grant Health Innovation Projects Physical Performance.

No	Innovation Title	Hosting Institution	Priority area	Physical performance compared to the annual plan
1	Vital Signs and Body Composition Monitoring Device For Pregnant mothers	Jimma University	Maternal health	133.3%
2	Enawura Ethio-Youth Digital Platform	Jimma University	Adolescent health	103.3%
3	Mobile Application development for Adolescent and youth	Mekele University	Adolescent health	83.3%
4	Low cost, reliable and easily accessible device for basic neonatal temperature and humidity regulation in low resource setting	Jimma University	Child health	106.7%
5	Portable Oxygen Concentrator for Low Resource Areas	SNNP health bureau	cross cutting	110.%
6	Mobile Technology and Village Reporters to improve childhood immunization coverage	Amahar public health institute	Child health	83.3%
7	Wearable Electronic Health Monitoring and Reminding Device For Maternal Health Care	Jimma University	Maternal Health	113.3%
9	PPH management	Jimma University	Maternal Health	103.3%
Total				104.6%

3.2.3. New Validation Test Innovation Project for the Year 2020/2021

Background

Pneumonia is the leading cause of death in children under 5 years of age, being responsible for at least 18% of all deaths in this age category. In Ethiopia, acute respiratory infection, particularly pneumonia is the leading cause of morbidity and mortality and accounts for 16% of all under-five deaths. Despite its importance in virtually all types of acute severe illness, hypoxaemia is often not well recognized or managed in settings where resources are limited.

Bubble CPAP is one of the methods by which continuous positive airway pressure (CPAP) is delivered to a spontaneously breathing child to maintain lung volumes during expiration. Several commercial bubble CPAP machines are available. The price varies from several hundred US dollars to US$ 10 000. However, inexpensive form of bubble CPAP which is constructed locally has been shown to be beneficial to manage hypoxemia in studies done in Bangladesh and other developing countries (see figure below)

The Federal Ministry of health higher officials, AHRI Director-General, and family health experts from the ministry went to Bangladesh for experience sharing on child health interventions in 2017. The team found evidence of using bCPAP in the treatment of severe

pneumonia in children under five years of age had a significant reduction of mortality due to severe pneumonia in Bangladesh. After observing the experience, the Ministry of Health recommended bCPAP for validation test through the grand challenges Ethiopia initiative. After obtaining ethical clearance, the first two pilot validation test stages, to determine feasibility and acceptability, were completed in June 2020.

Objectives

- To assess the feasibility and acceptability of bubble CPAP in treating childhood severe pneumonia both by patients' caretakers by physicians and nurses in two tertiary hospitals in Stage I and in two district hospitals in Stage II.
- To determine therapeutic effectiveness of bubble CPAP compared to WHO standard low flow oxygen in reducing death in children admitted to hospitals with severe pneumonia.

Summary of key findings

Quantitative analysis

A total of eighty nine children (49 in 2 tertiary and 40 in 2 district hospitals) were enrolled following parental consent and put on BCPAP. The median SpO2 at enrollment was 80% (IQR 74-84) and increased to ≥90% after an hour of BCPAP in 89% of children. The median duration of bubble CPAP therapy of the patients was 30.5 hours (IQR 16-72) and the median duration from admission to final outcome was 58 hours (IQR 40-116). Eighty three children were well and discharged, 3 left the hospitals against medical advice, 1 was referred to another facility and one child (who had SAM and severe sepsis) died in the hospital.

Qualitative analysis

There were limited nasal prongs, oxygen concentrators, pulse oximeters, flow meters and limited alternative power source which were more pronounced in district hospitals compared to tertiary hospitals. Limited number of trained staff to proper introduction and maintenance of BCPAP was also another challenge identified. However, prior use of bubble CPAP in NICUs was a good opportunity which eased the introduction of BCPAP in older children.

Occasional lack of bubbling in the water-filled plastic bottle, increased nasal secretion and lack of stand for holding the water-filled plastic bottle were the important operational challenges faced during the study. In general there was a good acceptability of BCPAP by clinicians with positive outcomes expressed as rapid recovery of patients, reduced bed occupancy and risk of Hospital Acquired Infection, reduced cost, Simple to handle and no serious adverse events.

Caregivers had concern during initiation of BCPAP but later they expressed their satisfaction with a good outcome of their children.

Conclusion and next plan

We have been able to see that majority of the children with severe pneumonia put on BCPAP had a good outcome (93% discharged, 5% left against medical advice, and 1% each referred and died) and it had a good acceptability by clinicians and caregivers. Our next plan is to do effectiveness study in 12 general hospitals.

CHALLENGES ENCOUNTERED AND POSSIBLE SOLUTIONS

Innovators from some institutions have challenges of bureaucratic procedures like ineffective procurements system especially for the items not found on local market that has been significantly delayed implementation of their projects. Furthermore, lack of basic infrastructure that are essential for developing health innovation including lack of innovation laboratory and incubation center. Thus, establishing an innovation incubation center at AHRI will help to bring health innovators throughout the country to learn from each other and make it easier to link with international partners.

Moreover, there is a lack of understanding regarding the concept about **What Is Innovation? And What Is Not?** Innovation from most of higher institutions in the country is very limited. In the future the Grand Challenges Ethiopia needs to widely advertise its mission and activities to the higher institutions.

Conclusion

Grand Challenges Ethiopia has created a platform and explored the national innovation ecosystem for the health sectors through stimulating the development and testing proof of concepts of new and bold ideas.

The implementation of this initiative has achieved encouraging results where most of the grand challenges Ethiopia grant recipients have been developed new diagnostic and therapeutic tools that will have a potential to solve health sector grand challenges particularly to improve maternal and child health as well quality of health care in Ethiopia.

Innovation Is Key to unlock Health Sector Grand Challenges