Engineering World Health January Institute
2020 Uganda
Final Report

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Executive Summary

This year was Engineering World Health's second time holding a January program in Uganda, and this program was a general success. We expanded the number of hospitals we worked with in Uganda and completed a record number of equipment repairs. This program hosted 27 total participants from 6 different countries. 17 participants were from the University of New South Wales, 1 participant from the University of Auckland, and 9 Ugandan participants from Makerere, Mbarara, Bugema, and ECUREI Universities.

During the first month of the program, the participants underwent intensive language, cultural, and technical training conducted at Makerere University. The technical training comprised lecture, lab, and hospital visits. The group took a tour of Kampala and watched a cultural dance troupe.

After the training, participants were placed in 10 hospitals throughout Uganda. During their time in the hospitals, the participants **collectively repaired nearly 400 pieces of equipment**. Equipment ranged in complexity from clothing irons to oxygen concentrators. Notable, high impact repairs included the repair of a very old oxygen concentrator which was the only one in the hospital's male ward, installing an oxygen cylinder in a neonatal ward when there was a power outage in the town, repairing the only infant scale in the maternity ward (which allows for the proper doses of medication to be provided to the infants), and the repair of a hospital's only operation theater light.

Our participant feedback was very positive: participants felt they were able to make a significant impact in their placement hospitals, while gaining confidence and skills as engineers.

In summary, the Uganda January Institute was highly productive and an overall success. We are grateful to all who helped make this program possible.

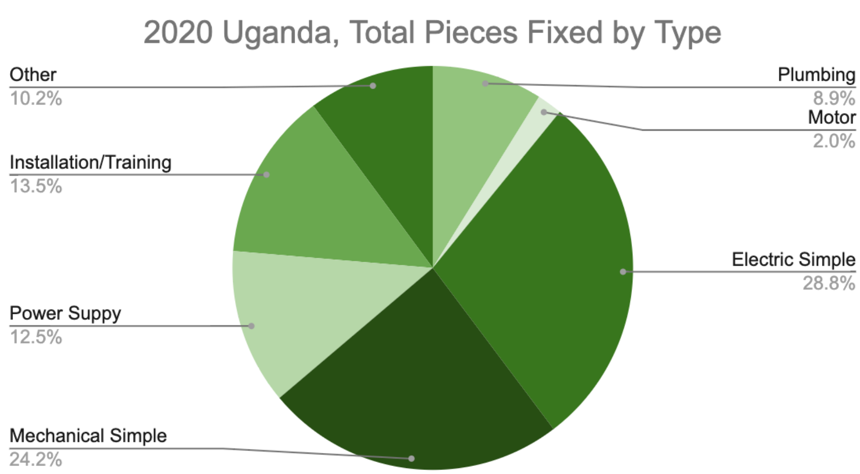
Medical Equipment Repair

Our participants' main objective during the Institute program is to complete hospital equipment repair and maintenance. The training portion of the program prepares them to complete these repairs in a low-resource setting. Once the training is complete, participants are placed in teams of 3 in our partner hospitals with EWH-provided toolkits to complete as many repairs as possible. Each team included both Ugandan and Australian/New Zealand participants. Participants do not repair every piece of broken equipment that they encounter, which is to be expected, as there are many barriers to equipment repair. The most common barriers we see are lack of parts and repairs which require more advanced knowledge.

The 27 participants repaired or completed preventative maintenance on **389 pieces** of medical and hospital equipment, totaling approximately USD $778,000[1] of equipment repair service. We ask participants to complete a "Work Summary Form" during their time in the hospital to document the pieces of equipment they encounter, the reason the piece of equipment is broken (e.g, power supply issue, blown fuse, etc.), and if the repair is successful. Their repair work, as taken from the Work Summary Forms, is summarized below.

<u>Repairs by Type of Fix</u>

Participants indicate the main reason for the item being out of service from the following categories. This year, mechanical and electrical issues were the main issues seen in the broken equipment (which is common across our programs). This chart only summarizes data from successfully repaired equipment.



Repairs/Maintenance by Type of Equipment

The table below summarizes the types of equipment on which participants completed repairs. Scales, blood pressure devices, and oxygen concentrators made up the greatest percentage of successfully completed repairs. “Other” also made up a large percentage, which is typical, as participants often encounter a number of devices not included in our provided list, or are unsure how to classify an item. Some examples of “other” pieces of equipment include syringe pumps, blood collection monitors, or wheelchairs.

Type of Equipment	Repair Total	Type of Equipment	Repair Total
Air Compressor	4	Lamp, examination	2
Air Conditioner	3	Lamp, surgical	9
Anesthesia Machine*	2	Microscope	6
Aspirator/Suction Machine	18	Nebulizer	6
Autoclave (lab, surgery, and other)	20	Operating Table	4
Blood Pressure Device, Automatic	31	Other	97
Blood Pressure Device, Manual	19	Otoscopes	4
Centrifuge	3	Oven (laboratory, not kitchen)	2
Computer	2	Oxygen Concentrator	27
Defibrillator*	1	Patient Monitor	12
Dialysis Equipment	1	Phototherapy device	6
Distiller	1	Pulse Oximeter	8
Drying Machine	2	Scales (laboratory and in wards)	36
ECG Machine	1	Stethoscopes	5
Fetal steth (fetoscope or Doppler)	1	Thermometers	7
Furniture (chairs, tables, and beds)	13	Transformer	2
Hot Plate (laboratory)	1	Ultrasound Machine (imaging)	2
Incubator (infant)	5	UPS (battery backup for computer)	2
Infant Warmer (radiant or other)	7	Ventilator	1
Infusion pumps	1	Water Bath (laboratory)	7
Iron (for clothing)	7	X-Ray Film Dryer	1

*User training and/or low voltage and peripherals repairs only

Secondary Projects

In addition to their primary task of repairing medical equipment, EWH asks participants to identify other ways they can use their skills to benefit the hospital. Through conversations and interviews with hospital staff and directors, the participants identify a need in the hospital and complete a secondary project to address that need, working on a budget of $100USD per person, as provided by EWH. This year, the groups completed a total of 14 projects across 9 hospitals.

<u>Hospital 1</u>

This group had two main secondary projects. The first was to construct privacy screens to be used in the hospital's wards. The screens needed to be easily movable, very robust, and provide patients with the comfort of privacy when required. The second project involved making directional signs across the hospital to increase efficiency for patients and staff. This involved three parts: creating matching signs outside the few departments that didn't already have a sign, creating a main directional sign out the front of the hospital, and finally two street signs for more specific directions deeper into the hospital.

Completed curtains; participants with the newly installed sign

For their first project, the group was able to complete three privacy screens. One frame was given to the group in a good condition with a matching curtain set, but was missing some parts, and one of the curtains had holes. They were able to find the spare parts they needed from the hospital's "equipment graveyard" (a term commonly used to describe a collection of a hospital's discarded equipment). They were able to create two more frames from parts found in the "graveyard." They sanded and painted the frames. They then went to a local tailor to have curtains made. The privacy screens were given to the female, male, and post-natal wards.

For the signs, the group contacted a local carpenter and painter to have the signs made. The group reports that the signs turned out very well.

<u>Hospital 2</u>

This group's secondary project was to replace as many fluorescent tubes as they could with more energy efficient, more reliable LED light bulbs. This involved a fundraising project to obtain funds to purchase 7W light bulbs, light bulb holders, screws and paying an electrician to assist in completing the work.

The group reports that their project went very well. They were able to install 150 light bulbs overall. This involved purchasing 150 light bulbs as well as their holders. Fluorescent tubes were replaced with a single bulb in the Male, Female, Pediatric, and Maternity wards. Bulbs were also installed on the exterior for security lights. Security lights were also installed on the exterior of the kitchen. Functioning fluorescent tubes were then moved to the inside of the kitchen.

Left over funds were then used to fund a battery to store solar energy as well as purchase solar bulbs for the pediatric ward.

Participants and a local electrician with the finished project

Hospital 3

This group's secondary project was installing new mosquito nets for the male ward of the hospital.

When researching for projects, a doctor pointed out that patients getting malaria during their stay at the hospital was a major concern. Thus, the group decided that addressing the lack of mosquito nets in the male ward could have a significant impact. The group decided to make each net with a double layer of netting to improve the longevity of each unit.

Windows with mosquito nets

Hospital 4

This group's secondary project was rewiring the autoclave room in their placement hospital. The primary reason for selecting this project was that it would have the most direct impact on the hospital. Their hospital was, at the time of their placement, severely short on sterilization equipment and the means of operating it, with only 1 small autoclave in use in the whole hospital. Even when several small ones were repaired, it was clear that the hospital needed much more capacity. So once the group repaired the large autoclave in the autoclaving room, they tried running it and soon realized there were many key safety concerns with running that autoclave.

When multiple autoclaves were running, the wiring in the room got so hot that it started to melt plastic. Also, any circuit breakers and isolation switches which were installed had been bypassed since they were broken. This meant that for the large autoclave, which was directly wired into the wall, there was no way of shutting mains power off from it, and was therefore quite dangerous.

Their project involved getting new, higher capacity, properly insulated wiring to run to the autoclave, which wouldn't get warm under normal loads. They also installed a circuit breaker to prevent any issues cutting power to the whole building, and installed a master isolation switch for the whole room, so that it was possible to turn power off to the numerous large autoclaves

The group reports that the project went very well. Everything was installed and wired correctly, it was all tested and working without issue. As a result of their project, equipment in the autoclave room can operate simultaneously, more safely (properly grounded), and can also be worked on much more safely by any future technicians who need to isolate power to equipment in that room.

Participant soldering the new system

<u>Hospital 5</u>

In this hospital, the pediatric ward had 6 cots where the legs had broken off, resulting in the cots being not level and too close to the ground. The staff also requested waterproof covers for the mattresses (a continuation of last year's secondary project). This group decided to obtain waterproof covers for the cots and an additional 5 beds in the ward (their waterproof covers were damaged), and to level the cots and bring them up to a suitable height for the staff.

They organized with local welders to weld longer legs to the beds. They also decided to repaint the beds, as the old paint had flaked off. Three IV stands for the cots were also repainted.

The group went to Kampala to organize the waterproof covers with a tailor, and contacted craftsmen who worked with rubber tires to make rubber feet for the beds to ensure that the legs remain intact for longer.

The group reports that the project went well. The cots have now been leveled and are at a suitable height for staff to comfortably look after children. The IV stand can also now be placed in its holder on the cot.

Refurbished cots

<u>Hospital 6</u>

At this group's hospital there is a large furniture scrap pile behind the workshop that had about a dozen broken wheelchair frames. A nearby member of hospital support staff told the group that the chairs had been in the pile for eight years. Each chair had destroyed tires, perished support fabric, and missing or destroyed front casters. This group's secondary project was to repair as many wheelchairs as possible to good working condition (with the help of a small online fundraiser). This would greatly augment the three working wheelchairs currently in service in this hospital.

Participant repairing a wheelchair; hospital technician with the repaired wheelchairs

The group reports that the project was a success. The group repaired eight chairs to perfect working order, two of which are paediatric chairs. There are three further chairs which require trivial work to simply affix the fabric supports to the frames with screws. The group left the equipment workshop with spares and methodologies to maintain the chairs.

<u>Hospital 7</u>

This group created a navigation system for both patients and staff of their placement hospital. This included: 5 outdoor free standing maps with frames designed specifically to match the dimensions of the maps, 3 outdoor wall mounted maps, and a detailed floor plan (softcopy) for the main building.

After the program, they plan to continue progress by conducting fortnightly communications with the BMET and hospital administrator to learn of further construction. As new hospital renovations are completed, the group will make updates to the soft copy of the map system, so that the administrator or BMET can print new copies and install.

Participants with their newly installed map

The group reports that their project was very successful. The staff from the hospital were very open to and appreciative of the installations and provided the group with very useful feedback throughout the project. They also noted that the entire process which spanned from creating first digital copies of maps, to final installations of the maps was very enjoyable and a memorable experience.

<u>Hospital 8</u>

This group completed three projects.

1.The first was a mobile application for user training.While working in the hospital, the group found that providing user training would be an impactful way to increase and improve healthcare delivery in the hospital after the Summer Institute was complete. They decided that the most effective method of providing the training was via a mobile application. The application, called "Healthcare Technology Trainer," provides PDFs of user training guides and maintenance guides on a variety of equipment found in the hospital. Many of the guides were designed or improved by the participants. Each device also comes with a training module which allows the user to test their knowledge and understanding of the equipment's correct usage and maintenance. Apart from equipment, the app also contains information about general safety in a hospital environment.

The app works in conjunction with QR codes that are attached to most machines. By scanning a QR code, the user is directed to that medical device's page in the app. Upon opening this page, the user can either access the user guide and maintenance guide. Once the user is familiar with the guides, they can take a quiz to test their knowledge.

The app also allows for searching or browsing of medical equipment without the need for QR codes. Finally, the app also has a safety guidelines option which provides hospitals with general safety practices that should be exercised in a hospital setting. Currently there are guides about electrical safety and how to prevent the spread of infections.

By choosing an app, the group feels they were able to provide a solution that is extremely cost effective and economically feasible. Previously, staff were required to print and laminate user guides. The app reduces the need for paper and lamination, thus the cost of maintenance, while also increasing the longevity and accessibility of the guides.

While interviewing hospital staff, the participants noticed that the percentage of individuals with smartphones was high, however, the quality of 3G/4G and wireless communications does not compare to the infrastructure available in wealthier parts of the world. In order to ensure the users always had access to the app, the participants decided to have guides and quizzes pre-loaded with the app. This means that once the user downloaded it from the App Store or Play Store, they are able to access all the guides, regardless of internet access.

They spent a period of time testing the app with staff at their placement hospital, during which they used an application called “Xender.” This allowed the group to send the app to most people. This method also allowed for them to discover bugs early, correcting any errors before it was published.

By using QR codes, using the app was quite intuitive for users. As the participants advised users on how to use it, they quickly picked it up. All users had to do was to open the scanner on the app, scan the QR code, then the item page would pop up. The guides also were designed to make them more intuitive and user friendly. Previously, all guides had instructions with bullets points and lacked pictures. While designing guides, the participants made sure to incorporate visual aids that would make reading the guides more interesting and easy to understand. For example, when designing the bottle gases user guide, the participants included colour codes to make it easier for users to understand which gas was in which bottle. Furthermore, they also included pictures of a flow regulator and pressure regulator to ensure users knew the difference.

2. The group's second project was a neonatal vein finder, specifically building frugal versions of the quite expensive device. The price of a neonatal vein finder at a biomedical store in Kampala was 650,000 UGX (about $180 USD as of January 2020), well above the participant's provided secondary project budget, as well as the hospitals' budget. Instead, the team decided to build a frugal version for 36,000 UGX (about $10 USD as of January 2020).

The components required included 18 red LED's, 18 56 Ohm resistors, a PCB and two double AA batteries. The participants built the device by wiring an LED in parallel with a resistor. This configuration was then wired in parallel 18 times. They used a broken light meter's case to house the PCB and connected the battery holder in the light meter to the PCB. The light emitting was enough to detect veins in neonatal infants.

3. Their third project was a dosimeter. While completing repairs in the x-ray room, the participants found that radiation leakage was not a primary concern amongst hospital staff. But upon a visit from a Canadian Professor who specialised in medical imaging, he highlighted this issue and suggested to the group that they develop a simple solution to this problem.

Thus, they built a frugal dosimeter using whiteboard markers and photo film. They opened up the whiteboard markers, removed the ink and cut them down to a size that would house the film perfectly. The whiteboard markers would then be clipped on to the radiologist who would continue to wear the dosimeter whilst operating the x-ray for the next three months.

After three months the film within the whiteboard marker (positive film) would be developed and compared to a negative film that would also need to be developed. The negative film can be placed anywhere to identify any radiation leakage. Ideally, these should be placed in areas you don't expect the radiation leakage to reach. The group placed these negative films in an envelope and placed them in different areas of the hospital, such as the administration block and corridor outside the x-ray room. Upon comparing the two films, one would notice how much radiation leakage is occurring. The participants noted that three pieces of film have to be placed within the marker and in the control in order to more accurately identify radiation. This film must be developed in different ways in order to ensure accuracy.

<u>Hospital 9</u>

This group completed three secondary projects:

1. Building shelves for the main store room in the acute pediatric ward. The hospital carpenter assisted the team with the project. After completion, the team organized the shelves with the In-charge of the ward and once finished, the overall look of the store room was pleasing.

Participants with the shelving; and power box

2. Building a box for the power unit outside the gynaecology ward. The hospital carpenter once again helped with this project. The power unit is now safe and not dangerous to the environment. The team painted the box blue to give it a nice appearance.
3. Building an iron roof shade outside the maternity ward. There is now extra shade outside the maternity ward where patients and families can sit and wait comfortably. The team worked closely with numerous hospital staff and volunteers.

Participant installing the roofing

Participant Debriefs and Feedback

Engineering World Health seeks not only to assist the hospitals in which our participant volunteers work, but also to influence the volunteers' own development as engineers and as global citizens. Our participant feedback was extremely positive this year. Some of the words used to describe the program were unique, fantastic, transformative, and enriching. Most participants found the most challenging part of the program to be the culture shock, whether because of climate, homesickness, or navigating the work in the hospital. The On-The-Ground-Coordinators received overwhelmingly positive feedback, with many participants noting that they could not have asked for better OTGCs.

Below are some comments taken directly from the participant feedback about the January Institute:

"The most valuable part [of the program] was feeling like my study of engineering was making an impact on the greater community. Within the confines of uni lectures, it really does feel like engineering is detached from the real world, but during this program, getting to witness how my repairs directly led to improving the hospital, it was an experience I doubt I would have had otherwise during my uni years."

“I think I found a confidence I didn't know I had. I was able to prove to myself that I can make a difference in the world of engineering. I found that I can work very well within a team of people that I've never met before. I found I had interpersonal skills that hadn't presented themselves to me previously.”

“My favourite experience would be repairing the theatre light in Mpigi. It was one of the easier problems to fix, but the director sought us out afterwards to thank us. He was so glad that operations could be carried out under lighting, and it helped me to see that everything we could contribute, even repairs that seemed simple, could have a great impact on people’s lives.”

Acknowledgements

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[1] EWH estimates the mean value of each repair at USD$2000