Towards Universal Energy Access:
Tools and Technology in Rural Uganda, Improving Health and Tracking Impacts

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Abstract

This paper demonstrates how electrification technology and data tools can help improve community health services and track healthcare impacts in rural communities. Findings from a May 2017 Health and Technology Impact Study in rural Uganda describe how healthcare access, delivery, quality of care, indicators of staff wellbeing, and on-time medical reporting rates changed after the installation of solar electrification systems at nine rural off-grid Health Center (HC) facilities. Let There Be Light International (LTBLI) and Kyosiga Community Christian Association for Development (KACCAD), partnering with local public agency and community leaders in the Gomba District of Uganda, installed low-cost solar electrification systems at nine unelectrified facilities, and used tablet-based surveys to conduct pre- and post-electrification surveys. Results describe how clinical staff were able to provide more healthcare for more people for more hours with higher rates of satisfaction among providers and patients and better outcomes for patients. Findings furnish evidence that the adoption of low-cost, high-impact solar interventions in concert with tablet-based survey evaluation can improve proximal community health indicators in low-resource, off-grid communities, while building the knowledge base to better target intervention and investment.
Introduction

Energy Poverty is the state of living without adequate safe, modern energy access. Approximately 1.1 billion people live in energy poverty globally, and 620 million people in sub-Saharan Africa have no access to modern electricity. Negative effects of living in energy poverty have been well documented and include significant impacts on health, development, education, safety, and well-being.

In Uganda, approximately 15% of the country’s population is connected to the national grid with electrical distribution mainly centered in the urban areas. In the rural areas, where 84% of the population lives, only 7% of the population has access to electricity. Though low, these rates of access may underrepresent energy poverty, because they measure only the potential of a household to connect to grid-based electricity. Similarly, they do not measure the reliability of energy supply to low priority areas and households. More recently, the historical binary conceptualization of energy access (access or lack of access) has been expanded to a multi-tiered access model. Measures of connectivity and usage now include five distinct tiers of energy access with attendant measurements and benchmarks. Indeed, when tiered access is assessed, full electrification rates often plummet in resource restrained areas.

Lack of electricity disproportionately undermines healthcare and outcomes for the rural poor, a problem compounded by the lack of basic data needed to guide improvements. The majority of rural Health Center II facilities (HCII) in central Uganda continue to be unelectrified despite their key roles in frontline healthcare delivery. According to a health facility energy needs assessment conducted by the United Nations Foundation in 2015, “the only centralized tracking of energy interventions or the status of energy systems in health facilities in Uganda is provided by the ERT [Energy for Rural Transformation] program and its monitoring and evaluation exercises in a subset of the many needy localities across the region. For the vast majority of non-ERT facilities, however, there is a general lack of easily accessible and reliable data on energy access, making planning and monitoring energy interventions within the health sector difficult.”

In the Gomba District, which is the focus of this report, all of the HCII facilities lacked modern energy services prior to the interventions by LTBLI and relied on kerosene, wax candles and/or

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battery flashlights for their lighting need – alternatives that impose their own economic costs and health risks.

Since the late 1980s, the Government of Uganda has instituted several health sector reforms and policies aimed at improving the functioning and performance of the health sector and, ultimately, the health status of the population. Despite a number of improvements in performance and outcomes, several key indicators remain poor relative to global norms. For instance, from 1995 to 2015, the maternal mortality ratio dropped from 684 per 100,000 live births to 343 per 100,000. However, to meet the SDG target of less than 70 per 100,000 live births by 2030, Uganda still has room for improvement. When looking at air pollution, the 2017 World Health Organization (WHO) Statistical Report shows that 70.5 per 100,000 people die in Uganda annually due to illness caused by household and ambient air pollution, and 85% are deaths of women and children. Even as some threats diminish, according to a joint study by the World Bank and Institute for Health Metrics and Evaluation, air pollution has emerged as the fourth-leading risk factor for deaths worldwide. While pollution-related deaths mainly strike young children and the elderly, these deaths also result in lost labor income for working-age men and women. The loss of life is tragic. The cost to the economy is substantial. By using tools and technology to support current programming, indicators of healthcare delivery and quality of care can be improved.

The Health and Technology Impact Study

The aim of LTBLI’s Health and Technology Impact Study was to determine the extent to which the provision of basic tools and technology contributes to an increase in healthcare access, the quality of healthcare provided to the community members, and the satisfaction and retention of healthcare providers in rural off-grid communities in central Uganda.

The Solar Health model was developed and funded by LTBLI, a nonprofit organization located in the US, and implemented in partnership with KACCAD, LTBLI’s Solar Distribution Partner in Uganda. All health centers are located in the Gomba District of Uganda and none were targeted by the national Rural Electricity Strategy Plan for on-grid electrification. Working with community stakeholders including the district health ministry and local elected and community leaders, the prioritized health clinics were chosen due to three primary characteristics: their status as frontline providers of community-based healthcare; a lack of modern, reliable energy services; and the servicing of large catchment areas. The basic solar systems installed at the facilities are capable of powering lights and small appliances (such as radios and televisions) and charging mobile telephones used by healthcare providers to support referrals, on-time reporting and staff contact with outside support systems. The clinics targeted by the Solar Health model are Health Center II and Health Center III facilities. HCII facilities are located at the parish or village level.

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and provide first-line emergency and outpatient care and are overseen by a nurse. HCIII facilities are located at the subcounty level and include a maternity unit and a simple laboratory. HCIII facilities are overseen by a non-MD clinician or a midwife.

The electrification technology involved in the Solar Health model consists of 270 watts of installed solar capacity and was purchased in Kampala from Buddu Electrical Supplies. The data tools involved handheld tablet computers, networkable surveys, and database software.

To support the HC staff and administration, LTBLI developed ongoing educational programming to ensure the safety of the staff and the proper usage and maintenance of the equipment. (See appendix 1). LTBLI also conducts free community sessions at the health clinics to educate providers, patients, and perspective beneficiaries about the health, safety and environmental dangers of using kerosene and candles for lighting. To support programming, LTBLI provides grant funding to a local health educator who demonstrates how to use a solar light, explains where lights approved by www.LightAfrica.org can be purchased and discusses the health and safety benefits relative to kerosene lights, known in Uganda as “tadooba.” (Note: LTBLI is technology agnostic and not aligned with any manufacturer of solar products). Since April 2016, 1,325 community members have attended LTBLI Solar Awareness sessions at their local community health centers. LTBLI also works with healthcare providers and aligned organizations to promote the benefits of incorporating an energy-access perspective into current programming especially in sectors addressing the health and safety of women and girls.

In brief, LTBLI’s Gomba demonstration Solar Health Program involved eleven steps:
1. Identification of off-grid rural clinics by the regional health ministry and local stakeholders
2. Administration of a pre-electrification survey
3. Determination of minimum solar lighting system size (uniform 270 Watt system)
4. Identification of appropriate vendor (purchased, installed and serviced locally by Baddu Electric in Kampala)
5. Fundraising in US for the cost of the system
6. Prioritization of health clinics
7. Implementation of solar-electrification
8. Education of healthcare providers and installation of signage
9. Follow-up Support
10. Evaluation (after 6-9 months of use)
11. Ongoing checks on system every 3-4 months

**Design and Sample**

The assessment used a pre-post design to examine a sample of the Health Centers recently solar electrified by LTBLI partners. 29 healthcare workers were interviewed by trained KACCAD field officers at nine rural health centers in Uganda over the course of two weeks in May 2017. At least three healthcare workers were surveyed at each of the nine facilities, representing more than half the staff at each center. The nine clinics serve a total population of 127,767 patients in the nine catchment areas. The average clinic serves 15,734 people, ranging from a high of 70,000 people to a low of 1,500. All nine health clinics lacked on-grid electricity and were, on average, 15 km from the grid.

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Data collection and Analysis

Data collected at the clinic level examined operations. Staff were also asked about their experience providing healthcare care, as well as their perceptions of working and living with the solar electrification system. (See Appendices 2 and 3 for a list of questions). Pre-electrification surveys were administered in 2015-2016 by KACCAD staff, who collected data about health clinic energy need and information about patient loads and demographics. Clinic level data included, rates of patient care disaggregated for presenting condition, rates of attended births, demographic data disaggregated by gender and age, and healthcare service data including hours of operation and days per week of operation. Follow-up surveys were then administered in May 2017 to assess the range of impacts of the solar electrification on healthcare access, healthcare delivery, rates of satisfaction, and quality of care. The Health and Technology Impact Study sought to establish the following relative to baseline data collected through LTBLI’s Solar Health pre-electrification surveys: change in hours of operation per day; change in days of operation per week; change in number of patients treated per week; change in number of children treated per week; change in the number of births; change in incidences of burns and respiratory cases reported per week; benefits and challenges of utilizing and managing the solar systems by healthcare staff; and limitations experienced while working in an un-electrified health center environment.

Assessment data was collected in person, or when necessary, over the phone using three handheld Asus Zen Tablets with installed and pre-designed questionnaires. The surveys were developed and data collected through the CommCare Application developed by Dimagi. The tablet computers were provided to KACCAD by Let There Be Light International. Field Officers were hired and trained by KACCAD in consultation with LTBLI and using LTBLI’s Field Officer Training Guide. The survey respondents were mobilized by the KACCAD Field Officers assisted by the Bukundugulu Parish Chief Lubega Godfrey. When completed, surveys were uploaded to the internet and sent to Let There Be Light International from KACCAD’s offices in Wakiso. LTBLI staff carried out the data analysis.

Results

According to the Health and Technology Impact Study, after the addition of a solar electrical system, four of nine clinics, (Ngeribalya, Bulwadda, Mamba and Kawerimidde), increased their hours of operation by 140% from < 12 hrs/day prior to electrification to 24 hrs/day after solar electrification. The other five health centers, (Kasambya, Namabeya, Mawuuki, Kanzira and Kyayi), increased their hours of operation 100%, from 12 hrs/day to 24 hrs/day. Hours of operation were also affected by an increase in the days/week that the clinics were open after the installation of a solar electric system. Two of nine clinics, Mamba and Kawerimidde, increased their days of operation 40% from 5 to 7 days per week. Seven clinics increased their days of operation 17%, from 6 to 7 days of operation. In the end, all clinics were operating 24 hours per day, seven days per week creating a more reliable community-based response to urgent and routine medical needs.

The nine health clinics also increased the overall number of patients treated by an average of 37%. Kyayi HCIII recorded the highest increase in patients treated with a 78% increase. Kanzira HCII and Ngeribalaya HCII saw increases of 77% and 75% respectively, and Mamba HCII saw a 73% increase. Bulwadda, Namabeya, and Kasambya saw a 33%, 24%, and 17%, while Kawerimidde and Mawuuki recorded an 11% increase.
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The average number of children treated on a weekly basis across the nine clinics increased 48%. At clinics providing maternity services, attended births increased nearly 200%, from an average of 2.4 births/wk to 7 births/wk. The Health and Technology Impact Study found that the increase in attended births was cited by community members and healthcare staff as an important marker of increased community healthcare access in their rural off-grid communities.

When asked to identify one or more of the challenges faced by residents in their catchment areas when using kerosene or candles in the home, 52% of the healthcare staff cited the risk of fire, and 45% said that kerosene and candles negatively affect the health and safety of residents. 17% noted the risk of ingestion and poisoning by children, and 3% said that the cost of fuel was the greatest challenge. In response to the question of who is at the greatest risk from kerosene and candles used for lighting, 55% of the healthcare staff felt that children were at the greatest risk, and 45% thought that elders were most at risk.

When asked about the challenges of using kerosene or candles at the HC facilities, 41% of the healthcare workers said that the health of patients and staff was negatively affected by the poor lighting. 34% cited fire safety as the primary challenge. 28% said that the quality of services suffered without safe lighting, and 14% said that communication was adversely affected when staff at the HC facilities relied on kerosene or candles for lighting.

The 29 staff members were asked about the perceived benefits they have realized since the installation of a solar health system at their clinic. The survey allowed for the healthcare staff to select up to 11 potential benefits, ranging in topic from healthcare access to healthcare delivery to safety and indicators of wellbeing.
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All 29 health workers surveyed responded that the primary benefits of working in solar electrified clinics were the increased hours of operation, the ability to charge mobile phones, and the increased number of emergencies they could handle during the night. The ability to charge mobile phones was reported to have improved communication between health workers and the district health authorities and the on-time weekly medical reporting. Increased patient and staff safety were reported to be valuable outputs as well as increased staff retention. The decreased cost of maintaining the health facilities was another major benefit realized. 27 of 29 health workers reported that the funds received by clinics to cover monthly expenses was not adequate and that purchasing kerosene and candles affected the quality of services rendered. 16 health workers reported that members of the community and the staff now perceived the health facilities to be modern.

A concern was raised by the researchers about how steep increases in patient services might affect the quality of care by the healthcare staff. According to the Gomba Deputy District Health Officer, (DHO), Christine Kakwenzire, the district maintains staffing norms for health centers depending on the catchment areas, therefore, she maintained that the increase in hours of operation would not affect the ability of the staff to provide healthcare. Ms. Kakwenzire explained that since the health staff no longer needs to travel to trading centers in order to charge their mobile phones, they now have time over the weekend to attend to patients. She reported that they also are motivated to stay on-site, because they now can connect with family members over the phone. Despite the increased workload, the DHO indicated that staff turnover has decreased since the installation of solar electrification systems at the clinics.

**Challenges and Program Modifications**

Key challenges to collecting and using the data included the distances to the remote locations of the 9 health centers and the difficulty encountered by field officers in conducting in-person
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interviews with all of the targeted healthcare staff. Some interviews were conducted by phone after unsuccessful attempts to coordinate interviews in the field.

Due to the unfamiliarity of the staff with the new equipment, overloads and improper connections occasionally required maintenance. To address the lack of awareness about the capacity of the solar electrification systems and battery storage, LTBLI and KACCAD designed, printed and disseminated appropriate use posters for the health clinics and staff.

The DHO reported that the district health authority has planned to increase the stock of drugs available to each clinic to curb shortages in available medications created by the increases in the number of patients treated. The pairing of an increase in available medications with health center electrification should be considered for future projects.

The positive response of participants in local education activities suggested to KACCAD that further outreach was in order. Given the large volume of people accessing clinic services and the limited staffing available to conduct outreach education, LTBLI recognized an opportunity to complement programming through the design and dissemination of a solar health flier. (See Appendix for photos). Working with healthcare staff and other partners, LTBLI and KACCAD designed a flier explaining the dangers of open-flamed kerosene lighting and the safety benefits of pico solar lights. 1,000 fliers are being distributed for display at health clinics, schools and community centers in rural off-grid communities in central Uganda.

Discussion

The Health and Technology Impact Study found that powerful partnerships illuminated by solar energy and informed by data can be prime movers toward achievement of health indicators of the Sustainable Development Goals (SDGs) in low-resource rural communities. Indeed, access to safe, modern energy has the potential to broadly impact a wide range of the 2030 Agenda for Sustainable Development. According to the World Bank, “Analysis of the nexus between energy systems and other key areas of development — water, food, health, and gender — suggests that numerous opportunities can arise from wider cross-sector perspectives and more holistic decision-making in energy.” 10 As demonstrated here, however, access to training and technology is necessary to connect last mile populations with first line resources in order to support local programming and expertise with the tools to enhance the success of their interventions.

While there are methodological limitations to the Health and Technology Impact Study, the high rates of self-reported improvement among healthcare staff and administration is both common-sense and compelling. The adoption of low-cost technological interventions in low-resource areas can impact a constellation of complex healthcare delivery and access challenges, encompassing a variety of logistical, administrative, cultural, social and resource limitations. Furthermore, the adaptation of available and appropriate technology can offer an opportunity to implement needs assessments and low-cost evaluations to inform current and emerging programming as well as to identify opportunities for intervention and program refinement.

Successful partnerships across NGO, public agency, and local community development organizations hold promise, especially in high need, hard-to-reach environments. Whereas material resources may be scarce and opportunities for human resource development limited, formal and informal social service delivery channels frequently exist in marginalized communities, and the most vulnerable often can be readily identified by peers, community members and local leadership. Therefore, although the SDG’s commitment to reaching the furthest first is complicated and can present multiple logistical challenges, the identification and servicing of remote communities can be facilitated by leveraging local support networks and utilizing available tools and technology. In sum, low-resource, off-grid, rural communities in Uganda often struggle with the compounded effects of geographic isolation, pervasive poverty, lack of infrastructure, and the underfunding of social services. To support these efforts there is a growing suite of appropriate tools and technology that can be deployed to improve health and track impacts in rural low-resource communities.

Indeed, realization of the Sustainable Development Goals necessitates a critical shift in the way we view and implement development programming. Overlapping goals need not be silo-ed, because in many cases there are existing delivery and intervention channels that can be leveraged to implement SDG-focused cross-sectoral projects. The implementation of tools and technology in low-resource rural communities presents a key opportunity to support the 2030 Agenda for Sustainable Development.
WARNING

SOLAR ENERGY SYSTEM STRICTLY FOR LIGHTS, PHONE CHARGING, PRINTER, LAPTOP, SMALL RADIO, 14-INCH TV

ALL OTHER USE IS PROHIBITED
SUCH AS REFIRIDGERATOR AND IRONING
Appendix 2
Pre-electrification Survey Questions

- **Health Center Pre-Electrification Survey**

  1. What is today’s date? *
  2. Name of the Health Facility *
  3. Location of the Health Facility *
  4. Name of the Person Responding to the Survey *
  5. What is your position at this Health Facility or in the Community? *
     1. Doctor
     2. Nurse
     3. Assistant
     4. Administrator
     5. Health Ministry Worker
     6. Community Member
     7. Clinical Officer
  6. What methods are currently used to light this health facility? *
     1. Solar
     2. Gas Generator
     3. Kerosene Lamp
     4. Candle
     5. Other
  7. How many hours per day is this Health Facility open? *
  8. How many days per week is this Health Facility open? *
  9. How many people are in the catchment area for this facility? *
 10. How many Kilometers is this Health Facility from the electric grid? *
 11. How many patients are treated at this Health Facility per week? *
 12. How many children are treated per week at this Health Facility? *
 13. How many births are attended at this Health Facility per week? *
 14. How many times per month does this Health Facility treat someone who has been burned by a kerosene light? *
 15. How many cases of asthma or respiratory illness or disease are treated at this Health Facility per week? *
 16. In your opinion, what would change if this Health Facility had a source of reliable electricity? *
     1. Hours of Operation
     2. Staff Retention
     3. Number of Patients treated per week
     4. Number of Emergencies handled at night
     5. Increased Number of Attended Births
     6. Increased Staff Safety
     7. Increased Patient Safety
     8. Ability to Charge Mobile Phones
     9. Increased rates of on-time submission of reports by Health Facility Staff
    10. Decreased Costs to run the Health Facility
 17. In your opinion, what are some of the hazards of using kerosene or candles at home? *
 18. In your opinion, who is at the greatest risk from using kerosene or candles at home? *
 19. In your opinion, what are some of the hazards of using kerosene or candles at a health facility? *
Appendix 3
Health and Technical Impact Study

- **Health Center Solar Electrification Impact Survey**

1. What is today’s date? *
2. Name of Health Center *
3. Location of Health Center *
4. Name of Person Responding to Survey *
5. What is your Position at this Health Facility or in the Community? *
   1. Doctor
   2. Nurse
   3. Assistant
   4. Administrator
   5. Health Ministry
   6. Community Member
   7. Clinical Officer
6. On what date was this facility solar-electrified? *
7. What methods are currently used to light this health facility? *
   1. Solar
   2. Gas Generator
   3. Kerosene Lamp
   4. Candles
   5. Other
8. What methods were used to light this facility prior to the installation of solar? *
   1. Solar
   2. Gas Generator
   3. Kerosene Lamp
   4. Candles
   5. Other
9. How many hours per day is this Health Facility now open? *
10. How many hours per day was the Health Facility open prior to solar-electrification? *
11. How many days per week is the Facility now open? *
12. How many days per week was the Facility open prior to solar-electrification? *
13. How many people are in the Catchment Area for this facility? *
14. How many Kilometers is this Health Facility from the electric grid? *
15. How many patients are treated per week at this facility? *
16. How many patients were treated per week before this facility had electricity? *
17. How many children are treated at this facility per week? *
18. How many children were treated per week before this facility was solar-electrified? *
19. How many births are attended at this Facility each week? *
20. How many births were attended at this Facility prior to the installation of the solar system? *
21. How many times a month does this facility treat someone who has been burned by a kerosene light? *
22. How many cases of asthma or respiratory illness are treated at this facility per week? *
23. How has the solar electrification of your facility improved the services offered? *
   1. Increased hours of Operation
   2. Increased levels of staff retention
   3. Increased number of patients treated
   4. Increased number of emergencies handled at night
   5. Increased access to maternity services
   6. Increased staff safety
   7. Increased patient safety
   8. Increased ability to charge mobile phones
   9. Increased rates of on-time submission of reports
   10. Increased perception of the facility as "modern"
   11. Decreased cost to maintain the facility
24. In your opinion, what are some of the hazards of using kerosene or candles at home? *
25. In your opinion, who is at the greatest risk from using kerosene or candles at home? *
26. In your opinion, what are some of the hazards of using kerosene or candles at a health facility? *
27. What challenges have you face since the solar electrification of your facility? *
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Photos from LTBLI’s Health and Technology Impact Study in Uganda

Signage at a rural health center and installation of solar at Ngeribalya HCII.

Safe solar posters at a health clinic in Uganda and ready for distribution.

Nurses at Mawuuki HCII and at Kanzira HCII.
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References


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