Working Paper: Does Energy Access Increase Resilience Against COVID-19?

This working paper is based on research co-financed by EEG in Sierra Leone and led by the Wageningen University in the Netherlands. The research compares 54 communities that received solar PV powered mini grids under a FCDO / UNOPS programme with 54 similar communities without mini-grids. The aim was to assess the economic impact of the provision of electricity in these circumstances. With the onset of the COVID pandemic the research also looked at whether access to electricity improved communities' resilience against the wider impacts of the virus.

This is an interim report. Given the mini grids were only operationalised in 2020 research on the possible economic impacts resulting from access to them is expected to continue through 2022.

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Does Energy Access Increase Resilience Against COVID-19?

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Abstract

This report assesses the impact of the Rural Renewable Energy Project (RREP) on livelihood, food security, health, and education. Using baseline data collected in 108 communities and follow-up data collected during April – October 2020, the report compares outcomes for respondents from 54 communities where solar mini-grids were constructed to 54 communities without mini-grids. In light of the COVID-19 pandemic, the report also lo0oks at COVID-19 knowledge and coping strategies to examine whether this improved power supply system has contributed to improving the beneficiary population's resilience during the country's pandemic response.

We find that the COVID-19 pandemic significantly impacted households' economic situation and food security. Overall, there are no differences between populations that have or do not have access to mini-grids, either in terms of economic impacts or resilience to COVID-19. These results signal more than access to energy alone is needed to transform local economies, although arguably evaluating impacts over a longer time horizon may show increases in economic activities dependent on electricity.

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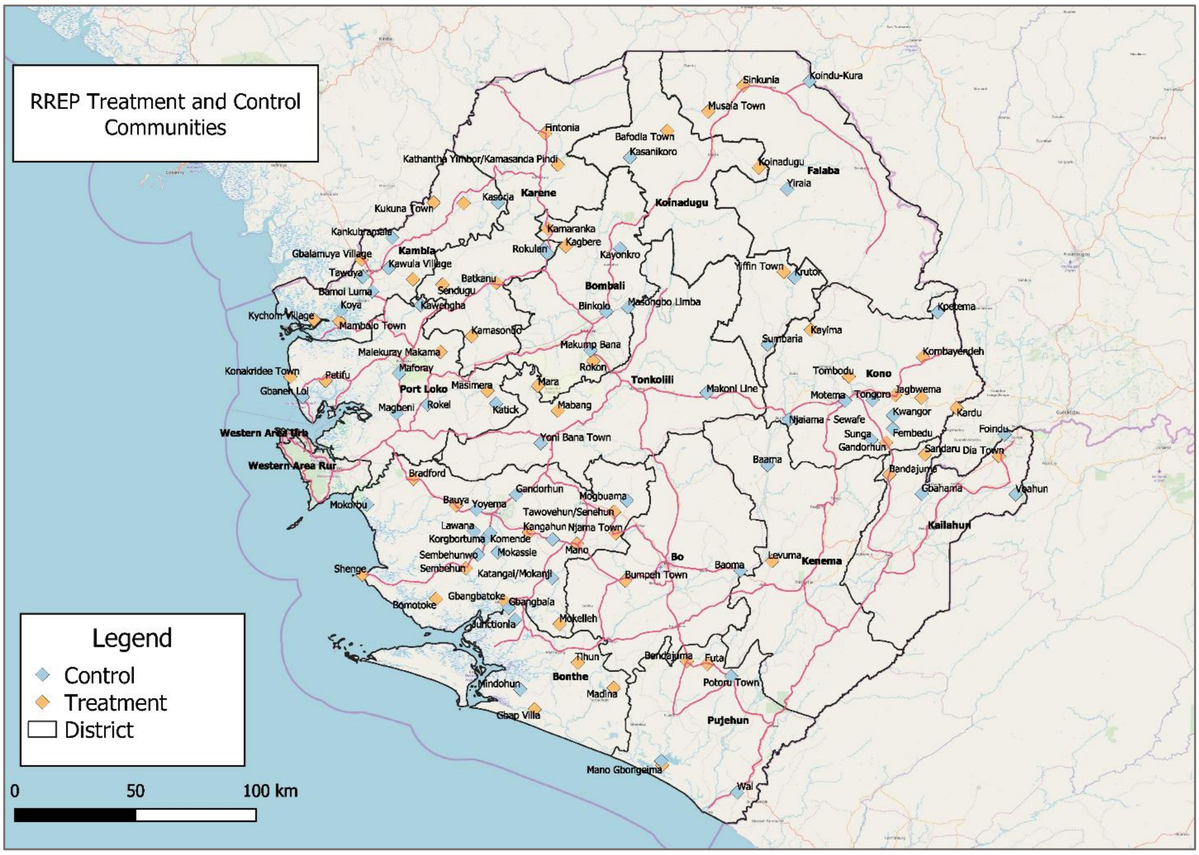
List of Acronyms

ANC	Ante-natal care
BECE	Basic Education Certificate Examination
CHC	Community Health Centre
ENFO	Energy for Opportunity
EWRC	Electricity & Water Regulatory Commission
FQSE	Free Quality School Education
GoSL	Government of Sierra Leone
IGC	International Growth Centre
MoE	Ministry of Energy
MCC	Millennium Challenge Corporation
M&E	Monitoring and Evaluation
MTNDP	Medium Term National Development Plan 2020-2023
NPSE	National Primary School Examination
ODK	Open Data Kit
PNC	Post-natal care
RBF	Results Based Finance
RREP	Rural Renewable Energy Project
SEC	Social Sciences Ethics Committee
SLESRC	Government of Sierra Leone Ethics and Scientific Review Committee (SLESRC)
SLL	Sierra Leonean Leone
SLPP	Sierra Leone People's Party
UNOPS	United Nations Office for Project Service
WASSCE	West African Secondary School Certificate Examination
WHH	Welthungerhilfe
WP	Work Package
WUR	Wageningen University and Research

Map of Treatment and Comparison Sites



1. Executive Summary

This report assesses the impact of the Rural Renewable Energy Project (RREP) on livelihood, food security, health, and education. Using baseline data collected in 108 communities and follow-up data collected during April – October 2020, the report compares outcomes for respondents from 54 communities where solar mini-grids were constructed to 54 communities without mini-grids. We also collected data in health clinics covering the period January 2019 to March 2021 and school attendance for both 2019 and 2020.

In light of the COVID-19 pandemic, the report will also focus on COVID-19 knowledge and coping strategies to examine whether this improved power supply system has contributed to improving the beneficiary population's resilience during the country's pandemic response.

1.1 Economic Outcomes

- Respondents living in communities with a mini-grid were more likely to respond to the phone survey. Likely electrification drives up mobile ownership and offsetting costs for network providers in these communities.
- The COVID-19 pandemic significantly reduced the average wage income for both communities with and without mini-grids. In addition, the average working hours in the post COVID-19 periods significantly increased, suggesting people spend more time keeping their business running. There are no significant differences in outcome trends between mini-grid and comparison communities.

1.2 Food Security Outcomes

- Households living in communities with a mini-grid had higher expenditures on food and bought more staples such as rice and oil and essential food products such as Maggi cubes compared to communities without mini-grids. Respondents in mini-grid communities were more likely to report having eaten less preferred food.
- The COVID-19 pandemic significantly reduced the average weekly food expenditures across both groups. In addition, there is a large increase in the times the household ate less preferred food and whether household members

(adults and children) had reduced portions. There are no significant differences in trends between mini-grid and comparison communities.

1.3 Covid-19 Knowledge and Coping Strategies

- Knowledge of COVID-19 symptoms is equally distributed between mini-grid communities and comparison communities. Overall, 93 percent of all respondents knew any symptom of COVID-19, while 35 percent knew all symptoms.
- Consumption saving is the most common coping strategy, which 56% of all respondents conducted. Furthermore, 27 % of respondents sold assets and 12 % of respondents borrowed money to cope with the effects of the COVID-19 pandemic. A small but significantly larger share of people in the mini-grid communities used up their savings to cope with the crisis compared to the comparison communities. No differences in other coping behaviours can be found between both groups.

1.4 Health

- Community Health Centres (CHCs) connected to a functional mini-grid have more hours of electricity each day: almost all mini-grid sites have more than 15 hours of electricity per day. In communities without a mini-grid installed, more than two-thirds of the clinics have on average zero hours of electricity a day and only 29 percent of clinics have a few hours of electricity per day - mostly through standalone solar panels.
- CHCs connected to a functional mini-grid have a larger number of working electrified appliances and refrigerated drugs stored compared to those CHCs without a connection. This is mostly driven by electrified clinics owning more freezers and refrigerators.
- Overall, utilization rates are significantly higher in CHCs that are connected to mini-grids. More patients below and above 5 visit CHC clinics, a higher number of births is recorded and more households visit for ante- and post-natal care visits. This is likely due to the fact that mini-grid communities are slightly larger in terms of population size and thus have a larger potential patient pool. There is however, no overall difference in the trend in utilisation between clinics with and without access to a mini-grid.

1.5 Education

- On average, schools had 380 pupils across both mini-grid and comparison communities, while a higher number of boys than girls attend school. There are no significance differences between the type of communities and school attendance or student dropout during the COVID-19 lockdown in Sierra Leone.
- Significantly more pupils attend and pass the national primary school examinations in communities which are connected to a mini-grid than in comparison communities. However, looking at the impact of mini-grid access on pupil attendance and pass rate over time, no significant differences in outcome trends can be found.
- Across both, around 48 percent of schools provided alternative learning methods (via home study materials or radio). There are few meaningful differences between mini-grid and comparison communities.

1.6 Leaders' Knowledge of COVID-19

- Town Chiefs and Mammy Queens were interviewed. Nearly all the community leaders own a face mask, and 92 percent state that they are worried about COVID-19, yet only 30 percent feel they are personally at risk of contracting the virus. A similar percentage thinks that their community is at risk of contracting COVID-19. 87 percent of community leaders are avoiding handshakes; 43 percent are avoiding hugs; 66 percent are reporting that they are maintaining a social distance of at least 1 meter; and 20 percent report staying at home.
- There are no large differences across towns with and without mini-grid access.
- Most community leaders were informed about COVID-19 by elected officials. The next most common source of information was the Ministry of Health app for phones. Significantly, more community leaders in mini-grid communities have been informed by their local CHC about COVID-19 than in comparison communities.
- Fever is the most common symptom known about for COVID-19 across leaders. Around half of the respondent can also identify dry cough, headaches, or a runny nose as possible symptoms. Very few leaders are aware of loss of taste and smell as a symptom.
- The majority of community leaders report to avoid handshakes, keep a minimum distance and regularly wash hands in response to COVID-19. Significantly more community leaders contact 117 or stay away from people with fever in comparison communities than in mini-grid communities. On the other hand, a significantly higher proportion of community leader in mini-grid communities wears a mask in to prevent the spread of the virus.

- Most commonly community leaders believed that COVID-19 came from China. A substantial proportion answered that they don't know, that it came from bats or that it was made in a Chinese lab.
- Most community leaders indicate that there is no cure for COIVD-19, which was true at the time they were surveyed.

1.7 Discussion

- Overall, we find that the COVID-19 pandemic significantly decreased households' livelihood and food security. To cope with COVID, respondents report to have consumed savings, sold assets and borrowed more money. These findings resonate with results from other low income countries, see Egger et al. (2021)[1].
- Overall, there are no differences with respect to access to mini-grids. The same holds for schools and clinics. While it appears that local clinics benefitted from increased energy access; they have more hours of electricity each day, and more appliances in stock, there are however no meaningful changes in utilisation rates over time due to electrification.
- Together these results signal more than access to energy alone is needed to help people cope with a health emergency like the COVID-19 pandemic. The COVID pandemic set rural economies back, perhaps muting any positive change resulting from increased energy access. The data suggests that at least any positive gains made before the onset of COVID did not put communities with access to mini-grid on a different path. At the same time, recent empirical work calls in to question whether electrification alone fundamentally can substantially change economic outcomes in the short term. Available studies suggest impacts limited if productive complementary investments in access to (energy dependent) technologies and markets are absent. In a recent project in Kenya for example, Lee, Miguel, and Wolfram (2020) show that large scale rural electrification had few discernible impacts on economic outcomes[2]. This suggests that the government and international donors and practitioners should prioritize complementary investments to allow increased energy access to translate in economic gain, and in case of crisis, in economic resilience.

[1] Egger et al. (2021) Falling living standards during the COVID-19 crisis, Science Advances 2021; 7 : eabe0997, https://www.science.org/doi/pdf/10.1126/sciadv.abe0997

[2] Lee, K., E. Miguel and C. Wolfram, 2020. Experimental Evidence on the Economics of Rural Electrification, Journal of Political Economy, 128(4) https://doi.org/10.1086/705417

2. Introduction

2.1. Background to the Rural Renewable Energy Project

In an effort to support the Government of Sierra Leone (GoSL) to achieve universal access to electricity, the United Nations Office for Project Services (UNOPS) is implementing the US$40+ million Rural Renewable Energy Project (RREP), an ambitious electrification project that will provide access to off-grid solar electricity to up to 94 communities in Sierra Leone. The RREP targets rural towns (often Chiefdom headquarter towns) throughout the country that are regional focal points for economic and social life. The RREP is funded by the Foreign Commonwealth & Development Office (FCDO – previously known as the Department for International Development) and implemented in collaboration with the GoSL Ministry of Energy (MoE) and UNOPS.

The provision of off-grid solar electricity is taking place in different phases. In June 2019 phase 1 of the project (Work Package 1) was conducted, in which 54 communities as well as health centres across the country were provided with electricity.[3] An additional 44 mini-grids are added in a second phase (Work Package 2). There are currently three private sector operators involved in the RREP, brought in through a competitive international tender to operate and maintain the grids. The sites have been split into four geographical lots, with Off-Grid Power awarded two lots, and Winch Energy and Energiciti (a subsidiary of Ghana-based Blackstar) each awarded one lot. Off Grid Power has since been bought by PowerGen, who also head the African Mini-Grid Association.

The project is expected to improve Sierra Leone's economic development through an increase in access to rural energy resources. In doing so, it expects to increase the welfare of rural communities in terms of saved fuel costs, improved income opportunities, improved health and education outcomes, and lower Green House Gas emissions. The project intends to enhance, in an integrated way, energy security, business start-ups, reduction of local pollution, improvement of the livelihoods and living conditions of local communities.

The intended outcome of the project is to improve rural renewable energy access through private sector involvement. It is estimated that approximately 100,000 direct beneficiaries in rural Sierra Leone will be connected to electricity, with a further 480,000 indirectly benefitting via increased economic opportunities and increased in the quality of services offered at schools and health posts.

This report addresses if and how the RREP improved the power supply system in the target areas. It uses data from the 54 communities that are part of Phase/Work Package 1 to look at the effect of increased access to electricity on economic household outcomes, food security, health, and education. In light of the COVID-19 pandemic, the report will also focus on COVID-19 knowledge and coping strategies to examine whether this improved power supply system has contributed to improving the beneficiary population's resilience during the country's pandemic response.

2.2. Country Context

Sierra Leone is one of the poorest countries in the world, ranking 182 out of 189 in the Human Development Index of 2020.[4] Poverty is widespread, more than 53 percent of the population are living below the national poverty line.[5] The country has an increasingly young population, with about 42 percent of the population aged under 15. Youth unemployment is also high, at 60 percent.

The Government has made education a top priority for the country. President Maada Bio's Sierra Leone People's Party (SLPP) manifesto prioritises the Free Quality School Education (FQSE) initiative, launched in August 2018. The FQSE aims to provide free education to 1.5 million children in Government (assisted) schools.[6]

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[3] In total RREP consists of six work packages. The additional Work Packages include: Work Package 3, focusing on providing technical capacity building to government and private sector partners; Work Package 4 was an amendment to the initial contract to support the response to landslide and flooding; Work Package 5 focuses primarily on monitoring and evaluation and closely coordinating with the impact evaluation team; Work Package 6 focuses on private sector engagement and strengthening to promote economies in mini-grid catchment areas

[4] http://hdr.undp.org/sites/default/files/Country-Profiles/SLE.pdf

[5] http://databank.worldbank.org/data/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=SLE

[6] The New Direction

Health outcomes in Sierra Leone are poor. A critical shortage of skilled health personnel is compounded by the majority of health workers working in urban areas (for example, 40 percent of all midwives serve in Freetown). Maternal mortality is the highest in the world, with 1,360 deaths per 100,000 live births, caused primarily by preventable causes. Sierra Leone also has the 4th highest under-five mortality rate globally, again with most of these deaths as a result of easily preventable causes.[7]

Multidimensional child poverty rates are high in Sierra Leone, with 8 out of every 10-children deprived in at least one dimension. Over seventy percent of Sierra Leonean children are poor, suffering a violation of at least one of their basic rights. Rural areas have a higher incidence of child poverty than urban areas.[8]

In Sierra Leone, just 6 per cent of the population in rural areas has access to electricity.[9] Poor access to electricity is recognised as a binding constraint to long-term economic growth in Sierra Leone.[10] As a result, policy makers, donors, and international development organisations have made universal access to electricity a priority in Sierra Leone.

The Government's Medium-Term National Development Plan 2019-2023 (MTNDP) outlines its key policies for the next four years.[11] By 2023, it plans to:

1. Restore electricity in all district headquarters and cities.
2. Increase electricity generation from 25 to 60 percent.
3. Increase installed electric capacity from the current 100 megawatts to 350 megawatts.
4. Increase the country's capacity for renewable energy (solar and hydro) contribution to 65 percent.
5. 20 villages and eight towns in each district connected to the national grid or off-grid standalone schemes.

The GoSL approved in 2019 the Electricity & Water Regulatory Commission's (EWRC) mini-grid regulations. This has provided clarity on licensing, grid arrival, and the tariff formula for mini-grid operators and indicates a long-term commitment to the sector. GoSL agrees on tariffs and contracting processes with the three operators based on the mini-grid code in the regulations. There is also an extension of tax incentives as part of a wider commitment to the off-grid sector in the Finance Act, which includes provisions for a duty waiver and Government Sales Tax (GST) extension.

Three other mini-grids have been constructed in Sierra Leone by Welthungerhilfe (WHH), with funds from the European Union, plus one constructed by Energy for Opportunity (ENFO), funded by the Economic Community for West African States' (ECOWAS) Centre for Renewable Energy and Energy Efficiency.

A number of other organisations are looking at market entry in Sierra Leone, including Cross Boundary Energy and Power Corner. Several are leveraging scale-up opportunities in the region. For example, the Millennium Challenge Corporation's (MCC) Results Based Finance (RBF) programme is funding 40 mini-grids with 8 new companies in Benin. Some of these organisations are looking closely at growth opportunities in Sierra Leone.

2.3. COVID-19 In Sierra Leone

The first Corona virus case in Sierra Leone was confirmed on 31 March, 2020. President Bio closed Sierra Leone's borders on 22 March in an effort to prevent or slow the spread of Covid-19 in Sierra Leone in light of increased global infections. President Bio declared a health state of emergency on 25 March and closed schools and colleges on 30 March. There was a first three-day lockdown on 5 April 2020. This was shortly followed by a ban on inter-district travel on 9 April 2020, and the imposition of a curfew. A second lockdown followed during 3-5 May. On June 23, the inter-District travel restrictions were lifted. In April, 124 cases had been identified; in May, a further 737; and as of 1 July 2020, there were 1,462 registered cases and 60 deaths.

2.4. Electricity access and resilience to COVID-19 pandemic

While the devastating direct effects of the COVID-19 crisis on global health are evident, the more indirect effects of the COVID-19 crisis on the health system are harder to observe and quantify. A report by the London School of Hygiene and Tropical Medicine estimates that COVID-19 related restrictions (and possibly the fear of contracting the disease

[7] See UNICEF Situation Analysis 2019
[8] See UNICEF Situation Analysis 2019
[9] See https://www.seforall.org/news/sierra-leone-closing-the-energy-access-gap-with-mini-grids
[10] Rural Renewable Energy Project Brief, UNOPS, 2018
[11] Medium Term National Development Plan 2020-2023, GoSL, 2019

at health facilities) sharply reduced visits to health facilities. The report predicts that in Africa 140 people will die for every COVID-19 death prevented.[12]

Reliable power supplies are critical to ensure both the provision of, and access to, essential health systems. As such, reliable power can improve both the quality of the health services provided, and citizens' *perception* about the quality of these services to make them demand and utilize more of those services. As such, health systems with electricity are more resilient. For health outcomes, early results reveal that electrified clinics have a slightly higher (3-4%) utilization rate for people suffering from COVID-19 like symptoms (fever, cough, runny nose). Also, electrified clinics have more vaccinations and drugs in cold storage and more appliances -- indicating electrification improves clinics.

In addition to the impacts of COVID-19 on global health, the health crisis is likely to lead to a more pervasive economic crisis. The UN estimates that at least 49 million people will be pushed into extreme poverty[13], undoing much of the progress made to reduce poverty over the past decades.

Access to power improves the ability of citizens and businesses to cope with economic shocks, both by mitigating the negative consequences and speeding up the recovery process to make the population more resilient. In Sierra Leone, like other countries, the government has imposed restrictions on movements. In particular, between 11 April – 23 June inter-district movements were only allowed to those with a special pass. Sierra Leone witnessed a drop in economic activity – as evidenced from the data dashboard developed by the International Growth Centre (IGC).[14]

Households and businesses with access to reliable power may (more easily) benefit from cold storage or processing facilities of otherwise perishable products, reducing losses in income, livelihoods, and food security.

One of the key features of the COVID-19 crisis is that it appeared to move very fast. Conditions changed rapidly, markets in Sierra Leone have shown a high price volatility for key staples, impacting household food consumption. Therefore, it is important to monitor key outcomes indicators over a longer period and observe the underlying dynamics. This will provide a clear indication on whether there are signs of recovery or further deterioration.

While thus far, many studies focus on how improved access to (reliable) electricity impacts people's livelihoods, few have examined how access to (reliable) electricity can increase resilience and help cope with large health and economic shocks such as COVID-19.

The primary evaluation question related to COVID-19 is: What are the impacts of the COVID-19 crisis and response measures on residents, clinics, and schools, and do experiences vary across communities that have access to electricity via mini-grids and communities that do not have access to electricity? Specifically, we assess:

What are the changes in economic outcomes?
What are the changes in food security outcomes?
What are the changes in health outcomes?
What are the changes in education outcomes?
What is respondent knowledge of the virus and of preventative measures to reduce infection rates?

For each domain, we investigate whether changes differ across communities with and without access to electricity via mini-grids. Lessons learnt from this evaluation can inform studies on populations' resilience to other shocks, such as outbreaks of diseases in other areas (e.g. Ebola in DRC) and natural disasters (severe flooding and droughts).

3. Data and Methods

This section provides an overview of the data sources and methods. Section 3.1 explains the collection of the different dataset and the origin of the pre-COVID data. Section 3.2 briefly covers the analytical approach used to report on findings and

[12] 'Modelling projections for Covid-19 epidemic in Sierra Leone', LSHTM. CMMID Covid-19 Working Group 30 Apr 2020
[13] UNU-WIDER, 2020
[14] See https://sl-dashboard.github.io/corona/ For the dashboard IGC are collecting data in 195 rural towns, since 30 April 2020. Data are collected daily and main indicators are included in the dashboard providing both a visual display of time trends as well as variation across the country. The data collection effort has thus far benefitted from pilot funding from the IGC and recently the OPM Energy Insights program.

discusses general research issues such as attrition, data quality, ethics, consent etc. The Appendix provides a detailed overview of the key outcome indicators, the reporting approach of the baseline data, the governance of the survey and the data quality and cleaning approach.

3.1. Data

This report evaluates how a) the COVID-19 pandemic and response measures impacted residents, clinics, and schools in Sierra Leone and b) assesses whether experiences vary across communities that have access to electricity through a mini-grid and communities that do not have access to electricity. To do so data was collected using several survey instruments and combined with previously collected pre-COVID baseline data among the same respondents.

3.1.1. Household Data

Household data on pre-COVID outcomes was collected through the Rural Renewable Energy Project (RREP) survey. For the baseline, we collected data in 108 villages with 3228 respondents during June - August 2019.

When COVID-19 restrictions were put in place in Sierra Leone the evaluation team was limited to contacting respondents by phone. As a result, respondents for the post-COVID survey were sampled from the initial Rural Renewable Energy Project survey, based on the condition that they had a mobile phone. Eventually, 2,745 households in 191 communities were surveyed throughout several "waves" from the 30th of April to the 1st of October (see table 1). Thereby, the research team collected a dataset to primarily track their economic status, knowledge, and COVID-19 preventative behaviours, among other household indicators. These waves vary between two weeks to a full month, depending on when the enumerators can reach the respondents for surveying.

Table 1: Timeline of Key Evaluation Activities

Research Wave Number	2020	Number of Households
Wave 1	30 April - 15 May	2,070
Wave 2	17 May - 3 June	1,612
Wave 3	4 June-16 June	959
Wave 4	17 June-30 June	921
Wave 5	1 July-8 August	1,972
Wave 6	19 August – 1 October	1,789

The evaluation strategy tracks the beneficiaries in RREP electrified communities and non-electrified communities and compares how the two sets are coping with the COVID-19 crisis.

3.1.2 CHC Data

To evaluate the impact of the pandemic on health outcomes over time, the research team collected five of the main registers from the CHCs for the months January 2019 to March 2021. The collected registers included a) Above-Five Treatment Register; b) Under-Five Treatment Register; c) Under-2 EPI Register; d) Family Planning Register; and e) Mother and Neonate Register. In each of these registers we compiled the total number of patients for the specific month and disaggregate them by new/follow-up cases and gender.

3.1.3 School Data

To examine the impact of the pandemic on educational outcomes, the research team collected data from primary, junior secondary and senior secondary schools inside the communities. The post-Covid data is combined with pre-COVID data from the same schools collected during previous surveys. The information gathered from the schools includes general attendance of students and teachers disaggregated by gender; the characteristics of the school such as the number of classrooms NPSE records; and information about how schools managed out-of-school learning when they closed from March to July 2020. Records of the proportion of students who did not return when schools reopened is collected as well.

3.1.3 Leaders Data
Post-COVID data from community leaders such as Town Chiefs and Mammy Queens is collected on COVID-19 knowledge indicators and preventative behaviours. Due to the Town Chiefs and Mammy Queens travelling and limited availability by phone, we were unable to collect data from all communities.

A detailed description of key indicators collected for the study can be found in Table 31 in the appendix.

3.2 Methods
3.2.1 Research Permission
The research team gained ethical and scientific approval for the entire impact evaluation research from the Office of the Sierra Leone Ethics and Scientific Review Committee (SLESRC).

3.2.2 Pilot Testing
Before beginning the phone data collection process, the research team conducted a pilot round of survey calls to the enumerators' families and friends, testing the efficacy of the survey instrument. High-frequency checks were run by the research associates during this exercise to ensure a smooth transition into the full data collection.

3.2.3 Analytical Approach
In this report we include (i) descriptive data (describing the mean, variance and range of each included variable), (ii) show changes between communities with and without mini-grids and (iii) to evaluate the changes for communities with and without a mini-grid during the COVID-19 crisis, we employ a Difference-in-Difference design. This implies we are comparing changes in key indicators before and after the COVID-19 crisis for both types of communities.

To see the logic of such identification strategy, consider that the ideal means to identify for example the welfare effects of the COVID-19 pandemic would be to compare two types of villages that on average have the same characteristics before the pandemic, except that one was randomly hit by the pandemic and one was not. We would then measure key indicators in both types of villages during follow-up surveys. If welfare indicators were different in the two villages, we would be able to credibly claim that this difference was due to the effect of the COVID-19 pandemic.

Similarly, to evaluate the impacts of the mini-grids installed under RREP, consider that the ideal means to identify the welfare effects of the RREP would be to compare two types of villages that on average have the same characteristics before the intervention, i.e. during the baseline survey, except that one was randomly allocated to receive the RREP intervention and one was not. We would then measure key indicators in both types of villages during follow-up surveys. If welfare indicators were different in the two villages, we would be able to credibly claim that this difference was due to the effect of the RREP intervention. However, villages that received the RREP programme are, by definition, not the same as those that did not receive the intervention.

The locations of the mini-grid sites have been selected by UNOPS in consultation with other key stakeholders – e.g. the GoSL Ministry of Energy (MoE) – and may not be representative of the typical community in Sierra Leone. Specifically, each of the community has a Community Health Centre (CHC) and a school. Therefore, during the selection process, the team paid careful attention to how “comparison villages” were selected. These villages are those that we compare to the set of villages that received the RREP intervention. By carefully selecting comparison villages and assessing changes over time, we can create a counterfactual and minimize bias in our comparisons.

To make causal claims about the impact of the RREP, we rely on a Difference-in-Difference comparison, which accounts for all time-invariant differences between mini-grid and comparison villages. Causal identification in Difference-in-Difference relies on a counterfactual assumption— assuming that in the absence of a treatment (mini-grid), the difference between the mini-grid and comparison villages in outcomes of interest is constant over time.

The counterfactual assumption is credible to the extent that mini-grid and comparison units are similar along factors that drive changes in the outcomes of interest. In our case, this means that we should sample households from villages with similar characteristics. As a result, we use a matching algorithm to select villages that are similar to RREP villages.

3.2.4 Inverse Probability Weighting (IPW) for household level outcomes

In the case of the household phone survey, we find that respondents from communities with mini-grids installed were more likely to respond. This is likely because having access to mini-grids potentially increases the likelihood of mobile phone ownership. It is also likely that communities with mini-grids offer mobile network providers cheap electricity, making them more likely to set up there. While this result is an outcome indicator in itself, showing that mini-grids increase people's connectivity, it is also a possible source of bias. The bias is addressed by using inverse probability weight for all household indicators collected through a phone survey.

Inverse probability weight involves predicting the likelihood of being treated in the COVID-19 data as a function of baseline covariates and then weighting the regressions using the inverse of the predicted probability score. This method assumes that attrition is a function of observable characteristics, which are then used to correct estimates.

3.2.5Respondent Attrition

As in every survey, risk of attrition is present, especially for phone-based data collection where having a phone is a requirement to be a part of the sample. Our team worked hard to limit attrition in the sample to the minimum. Enumerators continued to express gratitude to the respondents over the phone, explaining the importance of their compliance, and letting them know that we will be calling back in the future. Other sources of expected attrition in is due to deaths or respondents moving out of the community where they were living at the beginning of the project.

3.2.6 Data Quality and Cleaning

The team developed rigorous processes to ensure that the data was of high quality and cleaned effectively. This included data storage, version control, peer review, and communication processes to ensure that the data cleaning process was accurate and streamlined. For an elaborate description of the data governance process, please see section 6.3 in the appendix.

3.2.7 Inclusion and Ethics

A detailed inclusion and ethics approach was applied to the baseline assessment, taking into account FCDO's commitment to human rights-based approaches of participation and inclusion, non-discrimination and equality, and accountability. WUR has been working in Sierra Leone for 15 years and has conducted a large number of research projects. In this time, it has adhered to international standards of ethical conduct and developed an in-depth understanding of power dynamics, inclusion, and equity issues during research processes.

Respondents were selected randomly from village listings to ensure the sample was representative and inclusive of marginalised households. Female-headed households were interviewed for relevant questions, and the team did not interview children directly.

The Impact Evaluation team received ethics approval from the WUR Social Sciences Ethics Committee (SEC). The SEC stated that the proposal dealt with ethics issues in a satisfactory way, and that it complied with the Netherlands Code of Conduct for Research Integrity. The team also received ethics approval from the Government of Sierra Leone Ethics and Scientific Review Committee (SLESRC).

3.2.8 Data Protection

A number of precautions were taken to ensure the confidentiality of all information collected from subjects in the studies it conducts. Administrative data were collected using Open Data Kit (ODK) software on smartphones/tablet and sent to the server through 3G. Other than usage analytics and crash reports, ODK software does not send or communicate any survey data information back to ODK servers. When we do gather data, we default to anonymous or aggregate methods. An encrypted version of the database is stored on Dropbox and made accessible only to those in possession of a password shared exclusively among members of the research team. All data is backed up on an external hard drive that will be kept in the research team's office, where only authorized persons are permitted.

No identifiable data is ever published or passed to any third party since the digitized data collected are automatically encrypted. This means that not even the person collecting the information had access to it. No identifiable data is ever printed. WUR field staff have access to some identifiable data (names, dates of birth, and village names). This data is exclusively used to identify respondents for follow-up surveys and verify the accuracy of administrative data. This data will be stored securely on mobile devices under password protection. Other researchers assisted the Principal Investigator's (PI) team for data analysis and report writing. These researchers were granted access to de-identified data only (withholding names of respondents).

3.2.9 Informed Consent

All individuals were informed of the identity of the survey enumerator, the nature of the survey, informed of their right not to participate in the survey, and of their right to refuse to answer any question during the survey. Moreover, individuals were informed of the confidentiality of the data and given information about whom to contact in case they have any questions about the status or use of the survey. Only after all of the above was described to the individual was the individual invited to participate in the survey. Enumerators orally translated the informed consent into local languages (English, Krio, Mende, and Temne, depending on the site) when they administered surveys.

3.2.10 Withdrawal from Study

All study participants have the right to withdraw from the study at any point. The study focuses on the impact of electrification, complementary inputs, and market access on development. Withdrawing from the study means that potential beneficiaries do not disclose information to the research team. If any community member decided not to disclose information, she/he was free to do so. Withdrawal from the study in no way affects the subject's relationship with the study team or any partner associated with the study team.

3.2.11 Risks and Benefits to Participation

The evaluation team designed the impact evaluation to ensure minimal risks to respondents from participating in both the intervention and the questionnaire. WUR informed participants that this study will benefit subjects by helping to identify how benefits of electrification can be maximized for the beneficiaries. One risk that the team considered was the possibility of animosity as a result of being a comparison village and not gaining access to electricity through the mini-grid. Enumerators explained to participants that better quality data will enable the government to make informed decisions about how to electrify communities best; identify which sub-populations to target first, and how best to choose which complementary technologies to improve access to.

The questionnaire content is of a non-sensitive nature, and WUR designed the survey process to take as little time as possible from the respondent during interviews. The team also recruited field staff who as far as possible spoke the appropriate local language to ensure that the respondents feel comfortable.

3.12.12 Example Output

The following section summarizes and describes the key results from the surveys. There are two main kinds of tables in this document: summary statistics tables and difference tables.

Summary statistics tables display the sample size (count), variable average, the standard deviation, minimum and maximum values. Table 2 provides an explanation of how to read the typical summary statistics table.

Table 2: Example Summary Statistics Table

Variable	N	Mean	Std. Dev.	Min.	Max.
Cups of rice bough per capita	3.191	1.08	1.21	0.00	11.7
Cassava tubers bought per capita	2.251	0.62	0.70	0.00	5

Note: This table shows summary statistics for food purchase behaviour. Column (1) is the sample size. Column (2) shows the mean of the variable. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variable, respectively. Data source: COVID-19 Response Survey.

Column 1 in Table 2 represents the number of observations in our sample for the underlying variable. This can be higher than the actual number of households in the sample, because households are survey several times. Column 2 shows the mean value of the underlying variable. Column 3 reports the standard deviation of the variable, giving a measure for the amount of variation between observations. A low standard deviation indicates that values tend to be close to the mean, while a high standard deviation indicates values spread over a wider range. Column 4 reports the minimum value observed in the sample and column 5 reports the maximum value observed. A minimum of 0 and a maximum of 1 often indicate binary variables, variables that can only take the value of 0 or 1, e.g. "Employed as of last month". In such a case 0 indicates a negative answer (no) and 1 indicates a positive answer (yes), while the mean value reports the share of the population that answered positively.

Difference tables present the estimated differences of an outcome across two subgroups, e.g., for mini-grid and comparison communities. Statistics presented in the Table include the average of the outcome by subgroup and the difference in averages between the two groups. Between parentheses, we report the standard errors, a measure of uncertainty. Between brackets we report the number of clusters (underlying groups such as communities) in which the observations are grouped for the analysis. Column 3 of Table 3 shows us the mean difference between both groups, in combination with a t-test on the differences in means. The outcome of the t-test is indicated behind the number by stars: no stars means no statistical significant difference between both groups, * indicates a statistical significant difference at ten percent critical level, ** a statistical significant difference at five percent critical level and * a statistical significant difference at one percent critical level. We can see in Table 3 that mini-grid communities reported to buy significantly more cups of rice per capita, on a one percent critical level. However, no statistically significant difference can be found for Cassava tubers bought per capita.

Table 3: Example Table Differences Across Mini-Grid and Comparison Communities

	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/Clusters	Mean/SE	N/Clusters	Mean/SE	(2)-(1)
Cups of rice bough per capita per week	1181 [51]	0.977 (0.087)	2010 [55]	1.140 (0.085)	0.162***
Cassava tubers bought per capita per week	858 [51]	0.607 (0.044)	1293 [55]	0.621 (0.028)	0.014

*Notes: This Table uses data for all communities from all survey waves and uses inverse probability weighting predicting the likelihood of being treated. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at the community level. Fixed effects using variable district are included in all estimation regressions. The covariate variables wave and interactions between treatment and wave are included in all estimation regressions. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: COVID-19 Response Survey.*

Table 4 below provides an example of a Difference-in-Difference Table reporting the changes between baseline and follow-up surveys for communities with and without access to electricity via mini-grid on economic outcomes. For each outcome reported (one outcome per column) we report in row 1 the mean difference between towns with mini-grids to towns without a mini-grid for post-COVID outcomes. This can be interpreted as the effect of a mini-grid on the change in outcomes from pre- to post-COIVID periods. Row 2 shows the mean difference between mini-grid and comparison communities for the pre-COVID periods. Row 3 reports the total mean difference from the pre- to post-COVID periods for the comparison group. The last row reports the total number of observations per variable. Standard errors are reported in parentheses. Here we can see that no statistically significant impact of the mini-grind on economic outcomes could be found. However, as shown in row 2 column 5, mini-grid household do have significantly more leisure hours throughout all periods. Moreover, row 3 shows that there are statistically significant differences in nearly all variables between pre- and post-COVID outcomes.

Table 4: Example Table Impact of Mini-Grid on Change in Economic Outcomes

	(1) Wage income	(2) Average hours spend on business	(3) Average hours spend on wage employment	(4) Total working hours	(5) Leisure hours
Change in towns with mini-grids	-5.161 (50.339)	0.303 (0.456)	0.187 (0.899)	0.078 (0.508)	-0.259 (0.253)
Mean difference mini-grid to comparison at baseline	-7.719 (43.708)	-0.143 (0.294)	-0.405 (0.445)	-0.174 (0.268)	0.329* (0.177)
Mean difference baseline to endline for comparison group	-70.116* (36.961)	2.602*** (0.316)	-0.703 (0.686)	1.247*** (0.398)	1.258*** (0.189)
N	985	1741	693	2383	6741

*Notes: This Table shows the Difference-in-Difference in economic outcomes between mini-grid and comparison communities pre- and post-COVID-19. The pre-COVID-19 measures are from the baseline survey, and the post-COVID-19 measures use the mean across all the survey waves. Row 1 shows DID estimates from a regression estimated where the change in an outcome (post-pre-COVID-19) is regressed on a treatment indicator with district fixed effects and standard errors clustered at the community level. Row 2 reports the mean difference between mini-grid and comparison communities at baseline. Row 3 shows the mean difference in outcomes from pre- to post-COVID-19 periods for comparison the group. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Data source: COVID-19 Response Survey.*

4. Descriptive Analysis and Results

4.1 Economic Household Outcomes

The COVID-19 Phone Survey asks various questions to understand how income and hourly work has changed over the weeks since the first case of COVID-19 was reported in Sierra Leone on 31 March 2020. It also records difficulties faced by business owners due to the lockdown.

Table 5 shows a summary of the most important economic outcomes. We can see that, 89 percent responded that they were employed as of last month; 52 percent reported being farmers; and 23 percent declared themselves self-employed. In the self-employed section, we see that 94 percent of the sample reported that their business has remained open. Of those, the average working hours are 6.8 hours, and the average weekly profits are 123,335 SLL (~9,79 €). Of the entire sample, 14 percent reported being wage-employed. Of those who were wage-employed, the average working hours are 5.5 hours, and the average weekly income is 150,205 SLL (~11,93 €).

Table 5: Summary Statistics of Economic Outcomes

Variable	N	Mean	Std. Dev.	Min.	Max.
Employed as of last month	2948	0.887	0.317	0	1
Farmer as of last month	2948	0.521	0.500	0	1
Self-Employed as of last month	2948	0.231	0.421	0	1
Leisure hours per day	6,741	3.529	3.517	0	12
If Self-Employed					
Business is Open	680	0.944	0.230	0	1
Hours worked on business	1741	6.851	4.184	0	16
Weekly Business Profits ('000 SLL)	982	123.335	275.288	0	2100
Difficulty accessing customers	680	0.747	0.435	0	1
Difficulty accessing suppliers	680	0.576	0.494	0	1
Loss in Demand	680	0.671	0.470	0	1
If Wage-Employed					
Wage-employed as of last month	2948	0.135	0.342	0	1
Hours worked on wage employment	693	5.545	4.300	0	24
Weekly Wage Income ('000 SLL)	985	150.205	261.704	0	2550

Notes: This Table shows summary statistics for Wage and Self Employment Outcomes. Column (1) is the sample size. Column (2) shows the mean of the variable. A mean between 0 and 1 is the share of the sample that replied 'yes'. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variables respectively. Data source: COVID-19 Response Survey.

Table 6 reports the difference in means between the comparison and mini-grid sites on economic outcomes. Column 1 shows the number of observations and averages for the comparison communities, while column 2 reports on mini-grid communities.

Column 3 shows the absolute difference in mean and denotes the outcome of a t-test on the differences in means through stars. We see in Table 6 that on average mini-grid and comparison communities are experiencing similar major economic outcomes. Mini-Grid communities are more likely to be self-employed, but also more likely to face difficulties accessing customers and suppliers. People living in mini-grid communities work less hours on wage employment on average.

Table 6: Mini-Grids and Economic Outcomes

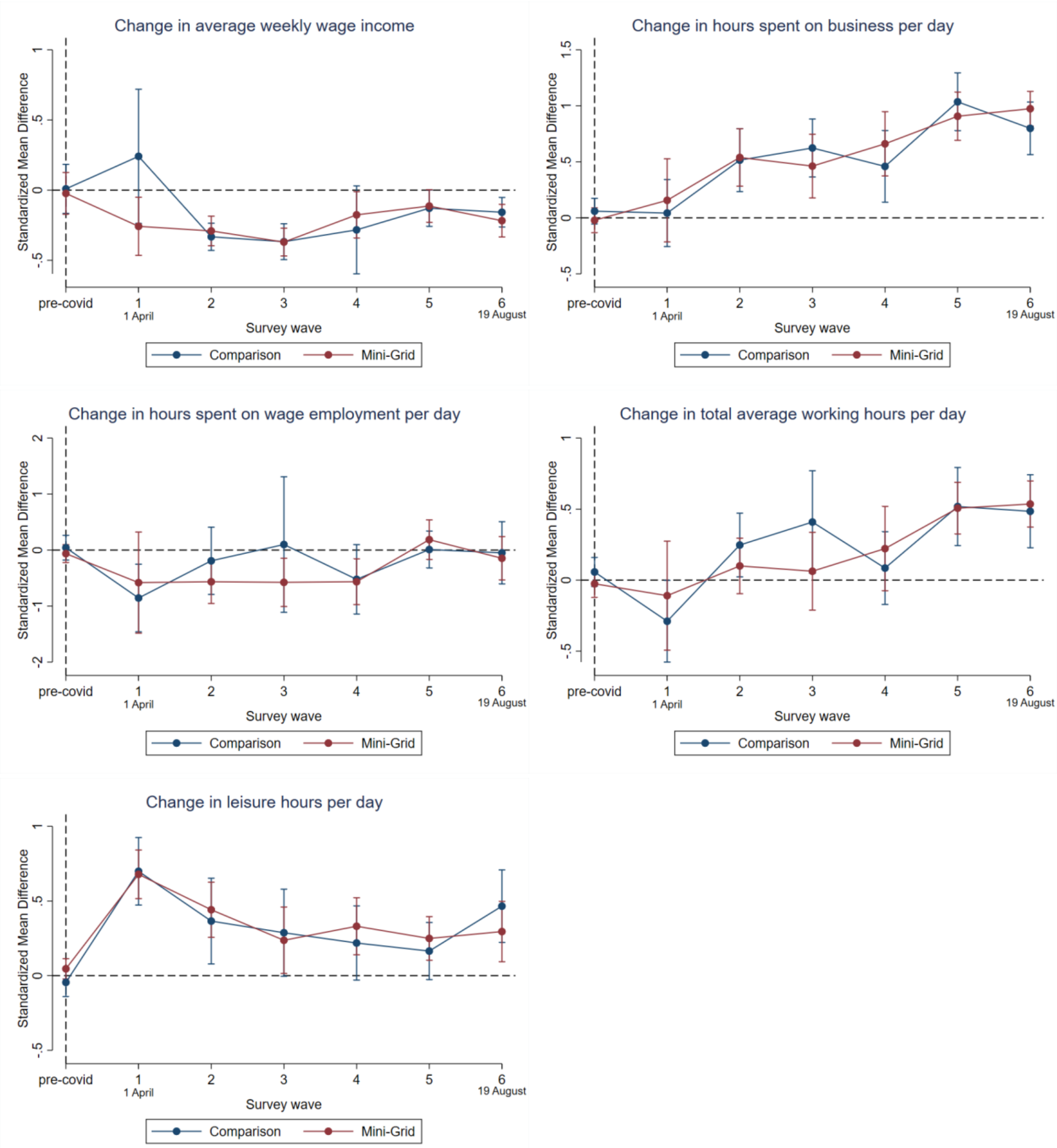
	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/[Clusters]	Mean/SE	N/[Clusters]	Mean/SE	(2)-(1)
Employed as of last month	1102	0.890	1846	0.882	-0.008
	[50]	(0.020)	[55]	(0.015)	
Farmer as of last month	1102	0.539	1846	0.513	-0.026
	[50]	(0.043)	[55]	(0.032)	
Self Employed as of last month	1102	0.225	1846	0.231	0.007**
	[50]	(0.032)	[55]	(0.028)	
Business is open	251	0.932	429	0.948	0.016
	[33]	(0.013)	[49]	(0.013)	
Hours worked on a business	251	8.262	429	8.717	0.455
	[33]	(0.289)	[49]	(0.277)	
Weekly Business Profits ('000 SLL)	359	110.579	623	126.031	15.452
	[39]	(17.930)	[52]	(15.503)	
Difficulty accessing customers	251	0.739	429	0.749	0.010***
	[33]	(0.043)	[49]	(0.024)	
Difficulty accessing suppliers	251	0.487	429	0.629	0.143***
	[33]	(0.046)	[49]	(0.030)	
Loss in demand	251	0.663	429	0.665	0.002
	[33]	(0.036)	[49]	(0.039)	
Wage employed as of last month	1102	0.126	1846	0.138	0.012
	[50]	(0.016)	[55]	(0.017)	
Hours worked on wage employment	144	5.502	254	4.991	-0.511**
	[35]	(0.705)	[49]	(0.395)	
Weekly Wage Income ('000 SLL)	260	143.349	457	118.162	-25.187
	[38]	(19.084)	[53]	(14.923)	
Leisure hours	1290	4.165	2223	4.090	0.074
	[53]	(0.194)	[55]	(0.140)	

*Notes: This Table uses data for all communities from all survey waves and uses inverse probability weighting predicting the likelihood of being treated. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at the community level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: COVID-19 Response Survey.*

The plots in Figure 1 plot the evolution of several key economic outcomes over time, comparing levels before COVID-19 started (set to have a mean of zero) and reporting changes for each period of the phone survey starting 1 April 2020.

The graphs suggest that there are no significant differences in outcome trends between mini-grid and comparison communities. Overall, outcomes follow a common trend and 95%-confidence intervals, denoted by vertical bars, largely overlap. However, during the COVID-19 period average wage incomes dropped and the hours spend on business activities and working hours increased.

Figure 1: Changes in Economic Outcomes pre-and post-COVID



Note: This figure uses pre-COVID data from the initial RREP survey as well as data from survey waves 1-6. Outcome variables are indexed on the average pre-COVID outcomes across both groups. The Y-axis reports the Standardized Mean Difference (SMD) as a summary statistic for the average change in both groups during the post-COVID periods.

One reason we see no differences in economic outcomes between mini-grid and comparison communities is that the short-term effects of electrification are muted. It takes time for the benefits of energy access to generate economic return. At the same time, potential benefits may have been diminished because of COVID-19, and the government instituted lockdowns. Table 7 formalises the comparisons of Figure 1 and report results from Difference-in-Difference estimates. We do not find significant differences between mini-grid and comparison groups for post-COVID outcomes. However, one can see that the pandemic period did significantly reduce the average wage income, increase the average business working hours and the total working hours across both groups. As the total working hours are computed as the sum of the average hours spend on business and on wage employment, this increase is most likely driven by the increase in business hours. Surprisingly, reported average leisure hours increased slightly also. It might be that the general increase in total working hours is mostly driven by an increase in working hours for self-employed respondents, while wage employed respondents experience a decrease in working hours due to COVID restrictions and therefore an increase in leisure hours.

Table 7: Impact of Mini-Grid on Change in Economic Outcomes

	(1) Wage income	(2) Average hours spend on business	(3) Average hours spend on wage employment	(4) Total working hours	(5) Leisure hours
Change in towns with mini-grids	-5.161	0.303	0.187	0.078	-0.259
	(50.339)	(0.456)	(0.899)	(0.508)	(0.253)
Mean difference mini-grid to comparison at baseline	-7.719	-0.143	-0.405	-0.174	0.329*
	(43.708)	(0.294)	(0.445)	(0.268)	(0.177)
Mean difference endline to baseline for comparison	-70.116*	2.602***	-0.703	1.247***	1.258***
	(36.961)	(0.316)	(0.686)	(0.398)	(0.189)
N	985	1741	693	2383	6741

Notes: This Table shows the Difference-in-Difference in economic outcomes between treatment and comparison communities pre- and post-COVID-19. The pre-COVID-19 measures are from the baseline survey, and the post-COVID-19 measures use the mean across all the survey waves. Row 1 shows DID estimates from a regression estimated where the change in an outcome (post-pre-COVID-19) is regressed on a treatment indicator with district fixed effects and standard errors clustered at the community level. Row 2 reports the mean difference between comparison and treatment communities at baseline. Row 3 shows the mean difference in outcomes from pre- to post-COVID-19 periods for comparison group. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Data source: COVID-19 Response Survey.*

4.2 Food Security Outcomes

Table 8 below reports how the respondents in our sample are coping with food security issues. The Average food expenditure during the prior week is just under 106 thousand SLL (~8,38 €). On average, respondents and other household adults have 6.8 days with all of their meals, whereas children in the household only have 5.1 days with all of their regular meals. The rest of the Table reports the staple goods that respondents reported purchasing in the last week on behalf of their household. The average amount of rice cups bought are 8.3; the average number of cassava tubers bought are 4.4; the average pints of palm oil bought are 2.2; the average number of fish bought are 7.0 and the average number of Maggi cubes bought are 3.8.

Table 8: Summary Statistics for Food Security Outcomes

Variable	N	Mean	Std. Dev.	Min.	Max.
Food expenditure '000 SLL	6458	105.722	103.26	0	1001
Days past week had all meals	3498	6.822	0.80	0	7
Days past week children had all meals	3444	5.061	2.76	0	7
Reduced portion served per meal in last 7 days	6720	0.491	0.50	0	1
Less preferred food eaten in last 7 days	6725	0.586	0.49	0	1
Rice cups bought	3191	8.279	8.43	0	35
Cassava Tubers bought	2151	4.389	4.39	0	15
Pints of oil bought	3227	2.198	2.31	0	10
Fish bought	2538	6.986	6.83	0	28
Maggi cubes bought	3207	3.843	3.65	0	14

Notes: This Table shows summary statistics for Food Security Outcomes Column (1) is the sample size. Column (2) shows the mean of the variable. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variables respectively. Data source: COVID-19 Response Survey.

Table 9 reports the difference in means between the comparison and mini-grid sites on food security outcomes. Mini-grid communities have on average higher food expenditures and buy more staples such as rice, oil or essential food products such as

Maggi cubes. Surprisingly however, mini-grid communities also eat more often less preferred food even though they have higher food expenditures and buy more staples.

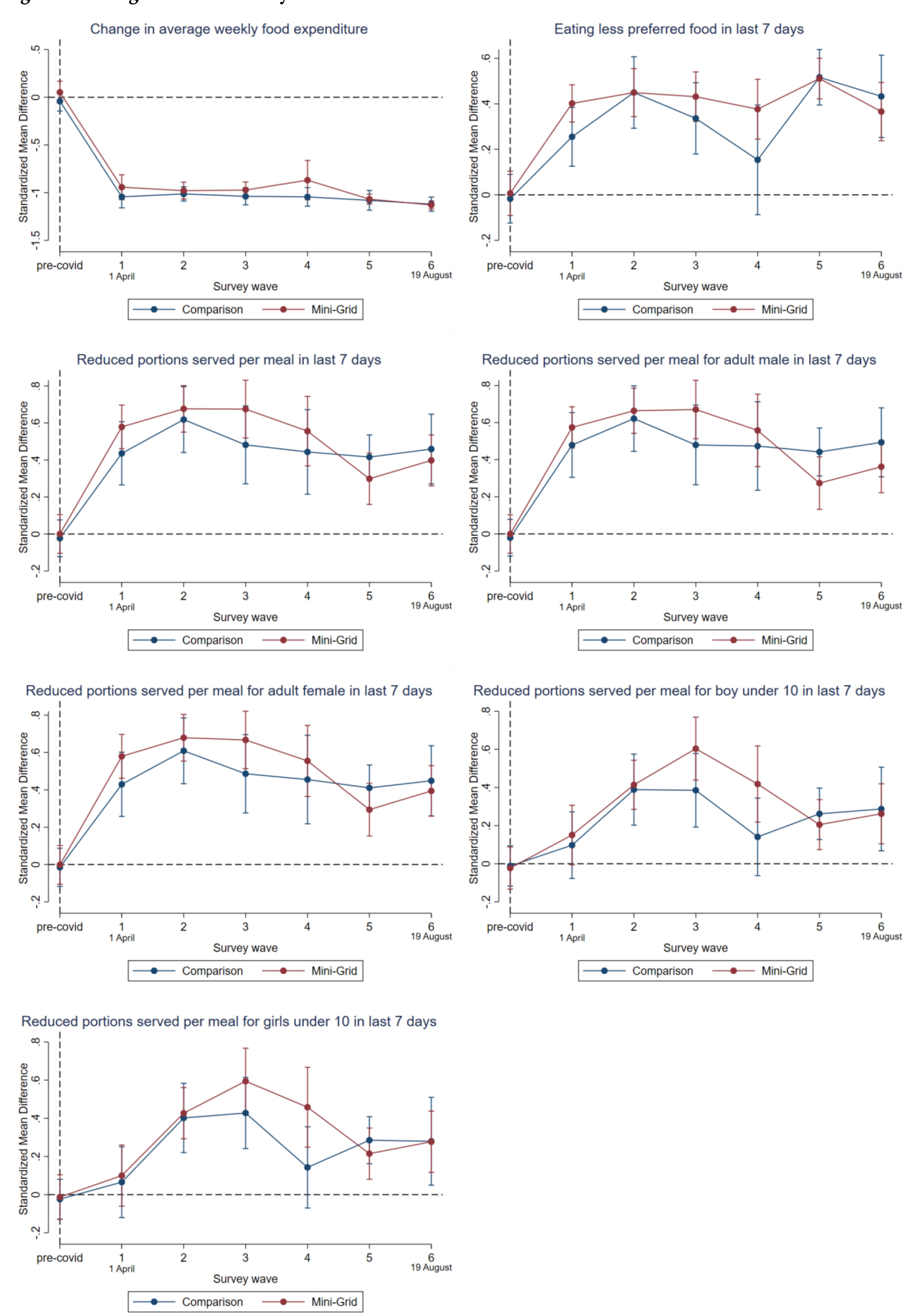
Table 9: Mini-Grid and Food Security Outcomes

	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/Clusters	Mean/SE	N/Cluster	Mean/SE	(2)-(1)
Food expenditure '000 SLL	2782	105.502	3676	106.472	0.971***
	[53]	(3.841)	[56]	(3.592)	
Days past week had all meals	1283	6.816	2215	6.826	0.010
	[52]	(0.040)	[55]	(0.024)	
Days past week children had all meals	1262	5.190	2182	4.991	-0.200
	[52]	(0.192)	[55]	(0.145)	
Reduced portion served per meal in last 7 days	2861	0.483	3859	0.499	0.016
	[53]	(0.016)	[56]	(0.020)	
Less preferred food eaten in last 7 days	2861	0.568	3864	0.597	0.029***
	[53]	(0.018)	[56]	(0.015)	
Rice cups bought	1181	7.594	2010	8.683	1.090**
	[51]	(0.569)	[55]	(0.560)	
Cassava Tubers bought	858	4.278	1293	4.434	0.156
	[51]	(0.351)	[55]	(0.208)	
Pints of oil bought	1190	1.990	2037	2.313	0.323**
	[51]	(0.169)	[55]	(0.163)	
Fish bought	989	6.247	1549	7.433	1.186
	[49]	(0.591)	[55]	(0.523)	
Maggi cubes bought	1184	3.380	2023	4.105	0.725***
	[51]	(0.276)	[55]	(0.273)	

*Notes: This Table uses data for all communities from all survey waves and uses inverse probability weighting predicting the likelihood of being treated. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at the community level. Fixed effects using variable district are included in all estimation regressions. The covariate variables wave and interactions between treatment and wave are included in all estimation regressions. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: COVID-19 Response Survey.*

Figure 2 shows that over time food security outcomes have been similar between mini-grid and comparison communities. Overall, outcomes follow a common trend and 95%-confidence intervals, denoted by vertical bars, largely overlap. However, the COVID-19 pandemic and the related response measures had significant impact on the average weekly food expenditure, the number of times less preferred food was eaten and reduced portions were served.

Figure 2: Change in Food Security Outcomes



Note: This figure uses pre-COVID data from the initial RREP survey as well as data from survey waves 1-6. Outcome variables are indexed on the average pre-COVID outcomes across both groups. The Y-axis reports the Standardized Mean Difference (SMD) as a summary statistic for the average change in both groups during the post-COVID periods.

Table 10 reports results from Difference-in-Difference estimates on food security outcomes for mini-grid and comparison communities before and after COVID-19. We find that mini-grid communities have overall significantly higher food expenditures, but also experience a relatively stronger decrease of their food expenditures from pre- to post-COVID periods compared to comparison communities. At the same time, we cannot find any significant differences between both groups for the other food security characteristics. This could suggest that any benefits from electrification have not translated into food security measures. The relatively larger decrease in food expenditures for mini-grid communities might be explained by the initially higher food expenditures, enabling mini-grid communities to use the reduction of food expenditures to a larger extent as a coping mechanism for with external shocks. Overall, on can see the Covid-19 pandemic significantly impacted the food expenditures and consumption of communities in Sierra Leone. All food security outcomes deteriorated during the pandemic.

Table 10: Impact of Mini-Grid on Change in Food Security Outcomes

	(1) Food expenditures in last 7 days	(2) Less preferred food consumed	(3) Reduced portions served per meal for any household member	(4) Reduced portions served per meal for adult males	(5) Reduced portions served per meal for adult females	(6) Reduced portions served per meal for young boys	(7) Reduced portions served per meal for young girls
Change in towns with mini-grids	-15.721* (9.070)	0.022 (0.044)	0.018 (0.044)	0.000 (0.044)	0.027 (0.044)	0.033 (0.043)	0.020 (0.044)
Mean difference mini-grid to comparison at baseline	20.139** (7.751)	-0.006 (0.035)	-0.003 (0.034)	-0.004 (0.034)	-0.010 (0.035)	-0.014 (0.035)	-0.004 (0.035)
Mean difference endline to baseline for comparison	-101.520*** (5.712)	0.190*** (0.033)	0.229*** (0.031)	0.240*** (0.032)	0.222*** (0.033)	0.117*** (0.032)	0.124*** (0.032)
N	6458	6725	6720	6644	6696	6660	6651

Notes: This Table shows the Difference-in-Differences in food security outcomes between treatment and comparison communities pre-and post-COVID-19. The pre-COVID-19 measures are from the baseline survey, and the post-COVID-19 measures use the mean across all the survey waves. Row 1 shows DID estimates from a regression estimated where the change in an outcome (post-pre-COVID-19) is regressed on a treatment indicator with district fixed effects and standard errors clustered at the community level. Row 2 reports the mean difference between comparison and treatment communities at baseline. Row 3 shows the mean difference in outcomes from pre- to post-COVID-19 periods for comparison group. Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. *Data source: COVID-19 Response Survey.*

4.3 COVID-19 Knowledge & Coping Strategies

4.3.1 COVID-19 Knowledge

This section describes the household's knowledge of COVID-19 symptoms for survey wave one to five, which corresponds to the time period from the 30th of April 2020 to the 8th of August 2020. Table 11 shows that about 93 percent of respondents know any symptom of COVID-19. Only 35 percent can identify all symptoms.

Table 11: COVID-19 Knowledge Summary Table

Variable	N	Mean	Std. Dev.	Min.	Max.
Knows any symptoms of COVID-19 ('1' means 'yes)	2834	0.934	0.25	0	1
Knows all the symptoms of COVID-19 ('1' means 'yes')	2834	0.351	0.48	0	1

This Table shows summary statistics for COVID knowledge Column (1) is the sample size. Column (2) shows the mean of the variable. A mean between 0 and 1 is the share of the sample that replied 'yes'. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variables respectively. Only data from survey wave 1 to 5 was utilized. Data source: COVID-19 Response Survey.

Table 12 reports small differences in COVID-19 knowledge across communities with and without mini-grid access. On average, no significant differences between both comparison and mini-grid communities can be found. These results are perhaps surprising, as they do not support the typical assumption that increased access to electricity increases access to information through information-communication technology.

Table 12: Mini-Grid and COVID-19 Knowledge

	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/Clusters	Mean/SE	N/Clusters	Mean/SE	(2)-(1)
Knows any symptoms of COVID-19	1021 [53]	0.936 (0.007)	1813 [55]	0.930 (0.006)	-0.006
Knows all symptoms of COVID-19	1021 [53]	0.360 (0.025)	1813 [55]	0.285 (0.023)	-0.020

*Notes: This Table uses data from survey waves 1 – 5 waves and uses inverse probability weighting predicting the likelihood of being treated. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at the community level. Fixed effects using variable district are included in all estimation regressions. The covariate variables wave and interactions between treatment and wave are included in all estimation regressions. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: COVID-19 Response Survey.*

4.3.2 COVID-19 Coping Strategies

This section summarizes household's COVID-19 coping strategies, which relates to dissaving, or increasing debt. Table 13 shows that consuming saving is the most dominant coping strategy, about 56% of respondents say they consumed savings to cover living expenses. In addition, 27% of respondents sold assets and 12% borrowed money to cope with the effects of the COVID-19 pandemic.

Table 13: Summary Statistics for COVID-19 Coping Strategies

Variable	N	Mean	Std. Dev.	Min.	Max.
Consumed savings to cover living expense	3159	0.559	0.497	0	1
Sold assets to cover living expense	3159	0.274	0.446	0	1
Borrowed money to cover living expense	3159	0.119	0.324	0	1

Notes: This Table shows summary statistics for Wage and Self Employment Outcomes Column (1) is the sample size. Column (2) shows the mean of the variable. A mean between 0 and 1 is the share of the sample that replied 'yes'. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variables respectively. Data source: COVID-19 Response Survey.

Table 14 and Figure 3 compares respondents across communities with and without mini-grid access. The percentages are about the same throughout.

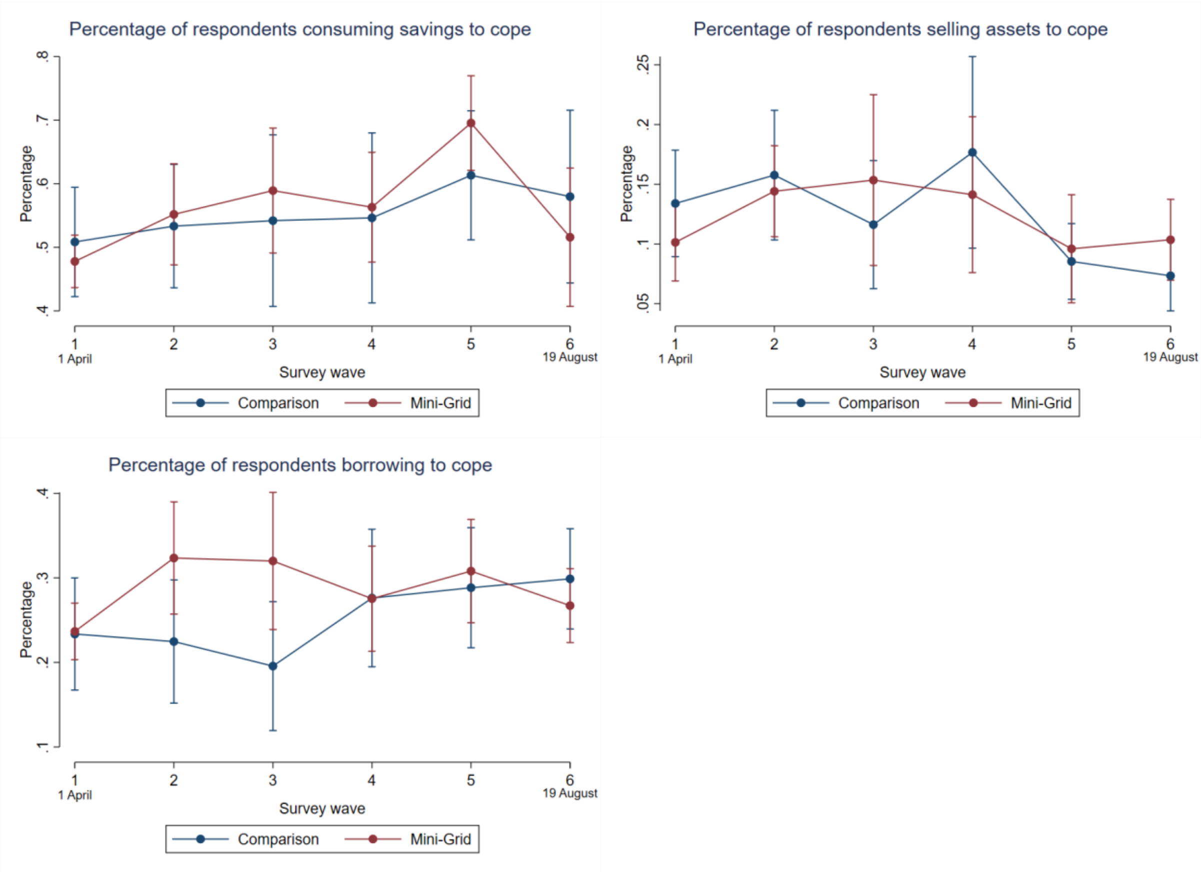
Table 14: Mini-Grid and COVID-19 Coping Strategies

	(1)		(2)		Differences;
	Comparison		Mini-Grid		t-test
Variable	N/Clusters	Mean/SE	N/Clusters	Mean/SE	(2)-(1)
Consumed savings to cover living expense	1162	0.556	1997	0.563	0.007***
	[52]	(0.027)	[55]	(0.023)	
Sold assets to cover living expense	1162	0.254	1997	0.287	0.032
	[52]	(0.036)	[55]	(0.023)	
Borrowed money to cover living expense	1162	0.102	1997	0.129	0.027
	[52]	(0.022)	[55]	(0.016)	

*Notes: This Table uses data for all communities from all survey waves and uses inverse probability weighting predicting the likelihood of being treated. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at the community level. Fixed effects using variable district are included in all estimation regressions. The covariate variables wave and interactions between treatment and wave are included in all estimation regressions. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: COVID-19 Response Survey.*

Figure 3 shows the average change in COVID-19 coping outcomes for mini-gird and comparison villages over all six waves of the survey. As shown in Table 14, no major differences in coping behaviour can be found over time, outcomes follow a common trend and 95%-confidence intervals largely overlap.

Figure 3: Change in COVID-19 Coping Strategies



Note: This figure uses data from survey waves 1-6. The Y-axis reports the percentage of total respondents in both groups during the post-COVID periods.

4.4 Community Health Centres

4.4.1 Community Health Centres (CHCs) Service Quality

This section describes the services offered at CHCs, using baseline data collected from 31st May to 15th July 2019 at interviews with CHC staff. Electrification can increase the number of services offered at CHCs as it enables the use of electricity-powered appliances. For example, the duration of time that fridges or freezers can operate may be extended, which can increase the capacity of the CHC to store drugs or vaccines that require cold storage. Electrification also allows services to be offered for longer hours: the availability of light may extend opening hours and enable staff to work longer hours.

Table 17 summarizes quality characteristics of CHCs for the entire sample of CHCs. It shows that on average CHCs have between 2 and 3 working appliances which include refrigerators, freezers, blood banks, blood pressure machines, and ultrasound equipment. CHCs store 19 different types of vaccines and drugs in refrigeration. Thirty-five percent of clinics are open at night. The head nurse works around 11 hours a day. When patients visit clinics, they, on average, need to wait for approximately 10 minutes.

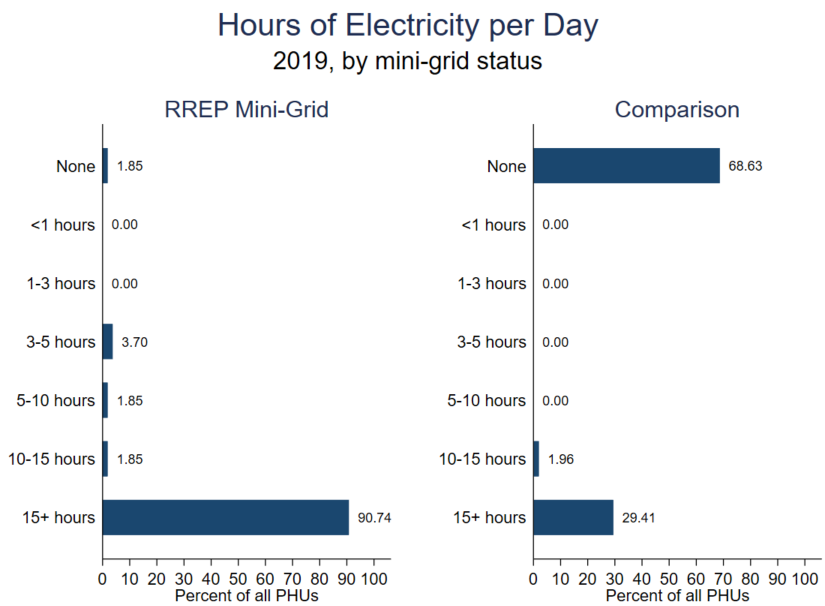
Table 17: Clinic Quality Summary Table

Variable	N	Mean	Std. Dev.	Min.	Max.
Number of electrified appliances	108	2.44	1.41	0	6
Number of working electrified appliances- excluding fridge/freezer	108	1.32	1.03	0	4
Number of vaccines/drugs stored in refrigeration	108	19.08	9.87	0	38
CHC is open at night ('1' means 'yes')	108	0.35	0.48	0	1
Hours opened per week	104	102.33	44.82	33	216
Average waiting time for patients	103	10.47	9.33	0	45
Average hours a day head nurse	108	11.32	6.72	0	24

Notes: This Table shows summary statistics for clinic quality. There are 108 CHCs, for some data on included variables is missing. Column (1) shows the number of CHCs for which we do have data on that variable. Column (2) shows the mean of the variable. A mean between 0 and 1 is the share of clinics in the sample that replied 'yes'. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variables respectively. Data source: CHC Survey.

Figure 4 shows hours of electricity per day for mini-grid and comparison CHCs. Almost all mini-grid clinics have more than 15 hours of electricity per day. 15 out of 54 comparison villages also have more than 15 hours. Their source of electricity is either a generator (1 CHC) or a stand- alone solar panel (14 CHCs). Two of the CHCs without a mini-grid have another source of electricity, and 36 have no electricity access at all.

Figure 4: Hours of Electricity per Day for CHCs



Notes: Data are from the baseline CHC survey for 108 rural towns. Hours of electricity are self-reported.

Table 18 shows the difference in clinic quality outcome between communities connected to a mini-grid and similar unconnected ones. While the average opening hours and working times do not differ significantly between both groups, a large difference can be found for 'stock' variables such as the number of electrified appliances. This effect appears to be driven mainly by an increase in the proportion who owns a refrigerator or a freezer: the effect disappears when refrigerators and freezers are excluded from electrified appliances (row 6). Row 7 confirms that a larger proportion of CHCs with a mini-grid own a refrigerator or freezer. This also translates into a higher number of drugs/vaccines stored in refrigeration.

Table 18: Mini-Grid and Clinic Quality

		(1) Comparison		(2) Mini-Grid	Differences; t-test
Variable	N	Mean/SE	N	Mean/SE	(2)-(1)
Hours opened per week	52	101.400	52	103.260	1.860
		(6.033)		(6.450)	
Facility is open at night	54	0.352	54	0.352	0.000
		(0.066)		(0.066)	
Average hours a day head nurse	51	11.373	52	11.276	-0.097
		(0.938)		(0.945)	
Average waiting times	52	11.327	51	9.588	-1.739
		(1.432)		(1.147)	
Number of working electrified appliances	54	2.037	54	2.852	0.815***
		(0.210)		(0.155)	
Number of working electrified appliances- excluding fridge/freezer	54	1.204	54	1.444	0.241
		(0.141)		(0.139)	
CHC owns fridge/freezer	54	0.667	54	0.926	0.259***
		(0.065)		(0.036)	
Number of vaccines/drugs stored in refrigeration	50	16.300	53	21.717	5.417***
		(1.409)		(1.251)	

*Notes: This Table uses data from interviews with CHC staff from 31st May to 15th July 2019. The value displayed for t-tests are the differences in the means across the groups. Standard errors are reported in brackets. A mean between 0 and 1 is the share of clinics in the sample that replied 'yes'. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: CHC Survey.*

4.4.2 Health care utilization

This section analysis changes in health care utilization over time, using CHC records data from January 2019 to March 2021. We define five sets of health care utilization variables: general health care utilization for above-5's, general utilization for under-5's, vaccinations of infants, family planning visits, and ante- and post-natal care visits. Moreover, mortality rates as recorded by the Community Health Centres are reported. For each of these sets of outcomes, we show trends over time; and the difference villages with a mini-grid, compared to comparison villages without a mini-grid.

Table 19 shows summary statistics for monthly health seeking outcomes between January 2019 and March 2021. On average, CHCs record 466 visits per month, 119 visits by patients above five and 110 visits by patients under five. The discrepancy between the total number of visits and the above/below five visits stems from the fact that not all clinics reported the total numbers of visits in each month, as indicated by the lower number of observations in column 1. Approximately 83 infants get immunized per month, 36 patients visit for family planning and 14 babies are born at each CHC. CHCs have on average 56 visitors for ante-natal care visits (ANC) and 23 for post-natal care visits (PNC) per month. On average 0.6 death are recoded at the CHC per month, 10 new-borns died during delivery and 5 mothers died during childbirth across all CHC between January 2019 and March 2021.

Table 19: CHC Visits Summary Table

	N	Mean	Std. Dev.	Min.	Max.
Total number of visits per month	1,679	466.17	209.30	128	1436
Total patients above 5	2,753	118.53	96.58	0	657
Total patients under 5	2,717	110.47	88.07	0	546
Total infants brought for vaccinations	2,212	82.74	70.82	10	329
Patients for family planning	2,654	35.50	36.71	0	617
Number of births at facility	2,718	13.97	8.99	0	101
Ante-natal care visits	2,718	42.83	38.79	0	307
Post-natal care visits	2,718	20.14	21.65	0	442
Deaths per month	2,750	0.580	1.33	0	14
New-borns dying during childbirth	2,718	0.004	0.07	0	2
Mothers dying during childbirth	2,718	0.002	0.05	0	2

Notes: This Table shows summary statistics for total patients from January 2019 to March 2021. Column (1) shows the number of observations we have (each clinic, for each month). Column (2) shows the mean of the variable over all months. Column (3) shows the standard deviation, and columns (4) and (5) show the minimum and maximum of the variables respectively. Data source: CHC records.

Table 20 reports the difference in means for utilisation at clinics between the comparison and mini-grid communities using monthly clinic visit indicators. CHCs with access to a mini-grid generally admit more patients than comparison CHCs. Mini-gird CHCs record more total patients per month, more patients over and below five, more birth at the facility, and more ANC and PNC visits. CHC data suggests slightly more deaths at mini-grid CHC, however this difference is not statistically significant. These large differences can partly be explained by the fact that communities with a mini-grid are slightly larger in population size and thus have more potential patients.

Table 20: Mini-Grid and CHC Visits

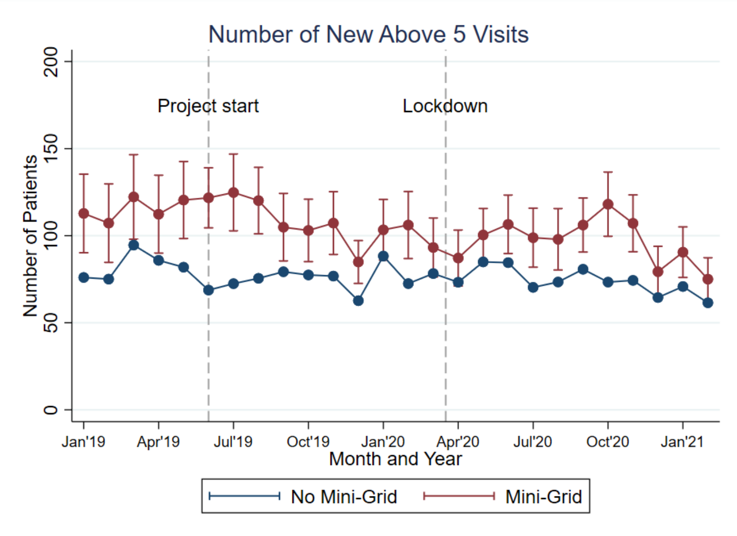
	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N	Mean/SE	N	Mean/SE	(2)-(1)
Total number of visits per month	821	429.35	858	501.40	72.05***
	[53]	(17.10)	[53]	(21.24)	
Total patients above 5	1366	100.39	1387	136.39	36.01***
	[54]	(6.90)	[54]	(7.65)	
Total patients under 5	1333	102.59	1384	118.06	15.47**
	[54]	(7.08)	[54]	(6.10)	
Total infants brought for vaccinations	1094	77.64	1118	87.73	10.10
	[54]	(5.90)	[54]	(6.02)	
Patients for family planning	1316	32.34	1338	38.61	6.27
	[54]	(3.90)	[54]	(2.91)	
Number of births at facility	1349	12.36	1369	15.56	3.20***
	[54]	(0.78)	[54]	(0.81)	
Ante-natal care visits	1349	38.26	1369	47.33	9.07**
	[54]	(2.89)	[54]	(3.05)	
Post-natal care visits	1349	17.33	1369	22.91	5.58***
	[54]	(1.42)	[54]	(1.73)	
Death per month	1368	0.536	1382	0.623	0.087
	[54]	(0.091)	[54]	(0.101)	

*Notes: This Table uses data from CHC clinic records from January 2019 to March 2021. The value displayed for t-tests are the differences in the means across the groups. Standard errors are reported in brackets. A mean between 0 and 1 is the share of clinics in the sample that replied 'yes'. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: CHC records.*

Above-5 Visits

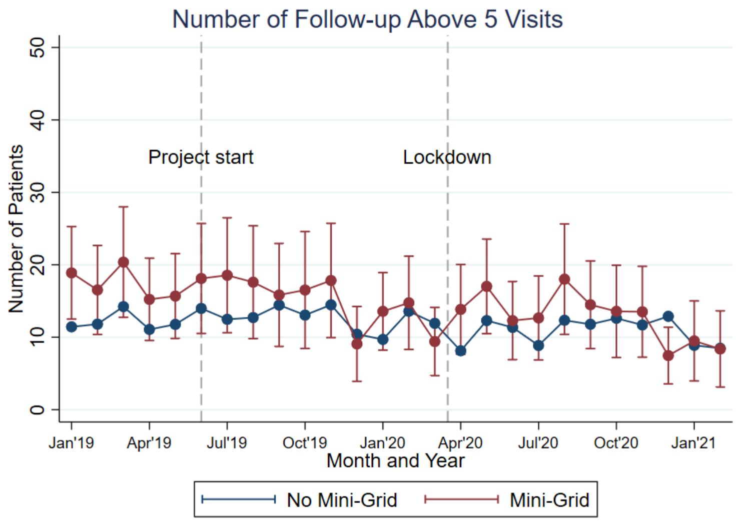
Below we show the evolution of above-5 visits to CHCs for January 2019 to January 2021. Figure 5 below shows the number of new patients above-5 that sought general healthcare. 'New' means that the patients come to the CHC with a certain symptom for the first time. The figure shows that electrified clinics had higher utilization rates for above 5-year olds across the period than un-electrified clinics. There is a slight drop in visits between March to April 2020, which is likely related to the first COVID-19 cases and the imposition of a lockdown. However, the drop does not stand out clearly from other fluctuations within the timeframe. There is no clear difference in the evolution of follow-up visits to CHCs for above 5-year-olds (figure 6). Prior to COVID, utilization in clinics with a mini-grid was slightly higher than facilities in the comparison communities. 'Follow-up' means that patients with a certain health problem return to the CHC after having had visits to treat the same problem.

Figure 5: Evolution of New Above-5 Visits



Notes: The vertical axis represents the average number of patients in this category, per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

Figure 6: Evolution of Follow-Up of Above-5's Visits

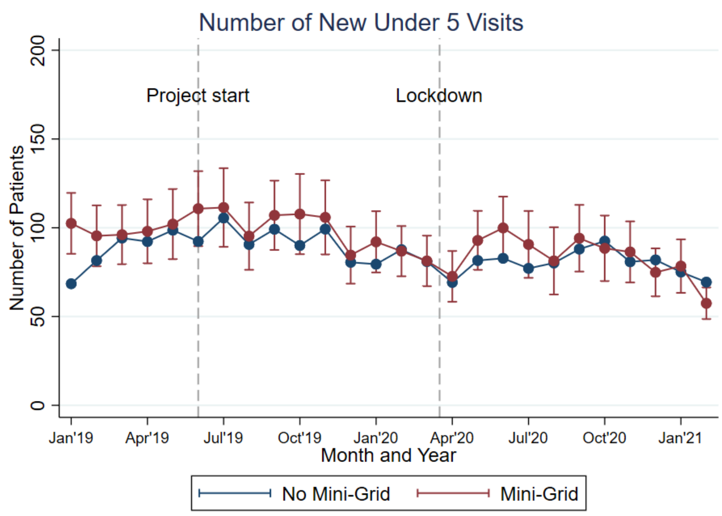


Notes: The vertical axis represents the average number of patients in this category per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

Under-5's Visits

Figures 7 and 8 show the evolution of visits for under-5-year-olds. Prior to COVID, CHCs in communities with a mini-grid tended to have slightly higher utilization rates than facilities in the comparison communities. In January 2019, for instance, RREP facilities received an average of 102 and comparison facilities received 68 new visits from under-five patients. The utilisation of both types of clinics is similar over time. There is a dip in utilisation among both mini-grid and comparison facilities, and utilization rebounds during the months after. There is some suggestion that the post-COVID rebound is larger in electrified clinics.

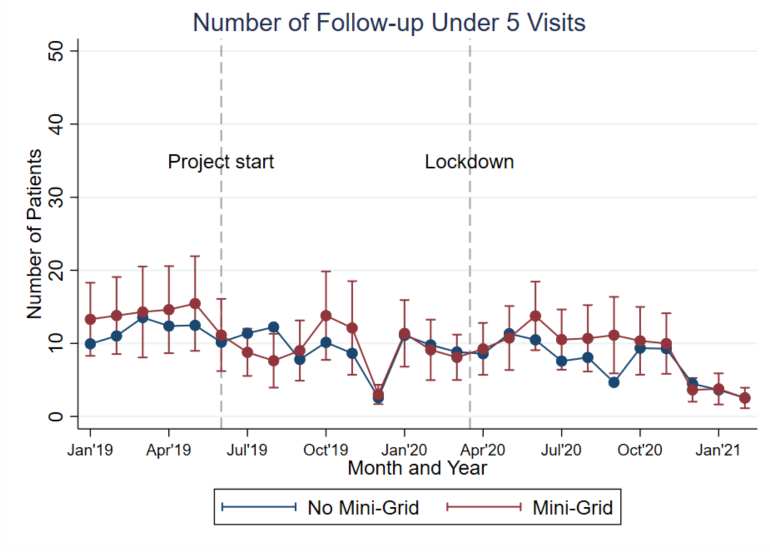
Figure 7: Evolution of New Under-5 visits



Notes: The vertical axis represents the average number of patients in this category, per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

Figure 8, shows the number of follow-up visits for under 5 years old. Utilisation is lower in 2020 compared to 2019 with no clear pattern across electrified and un-electrified clinics.

Figure 8: Evolution of Follow-Ups for Under-5's Visits

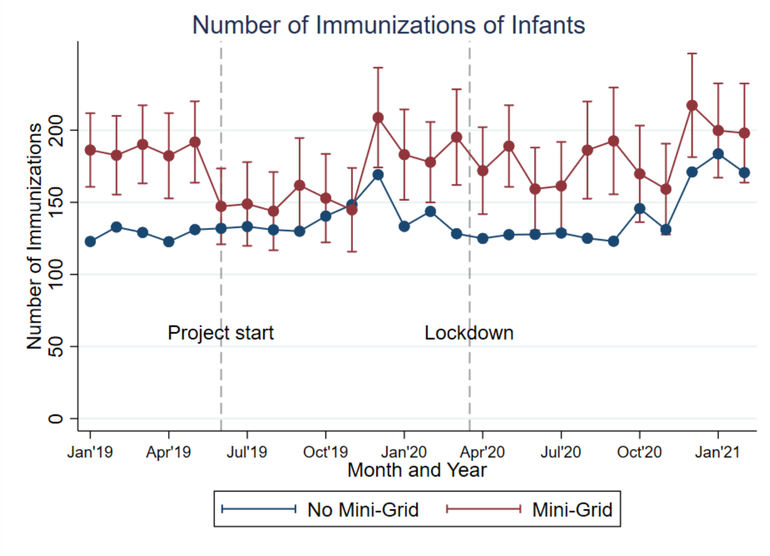


Notes: The vertical axis represents the average number of patients in this category, per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

Immunization of Infants

Figure 9 shows the evolution in immunizations of infants over time. Overall, immunization is higher in clinics that are connected to mini-grids. The number of vaccinations in 2020 appears to be slightly larger than in 2019. While the number of immunizations does not show large variation in the year 2019, there is some decline in 2020, starting around March when the first case of COVID-19 was announced in Sierra Leone, but numbers increase again in the months after.

Figure 9: Evolution of Immunization of Infants in all Communities

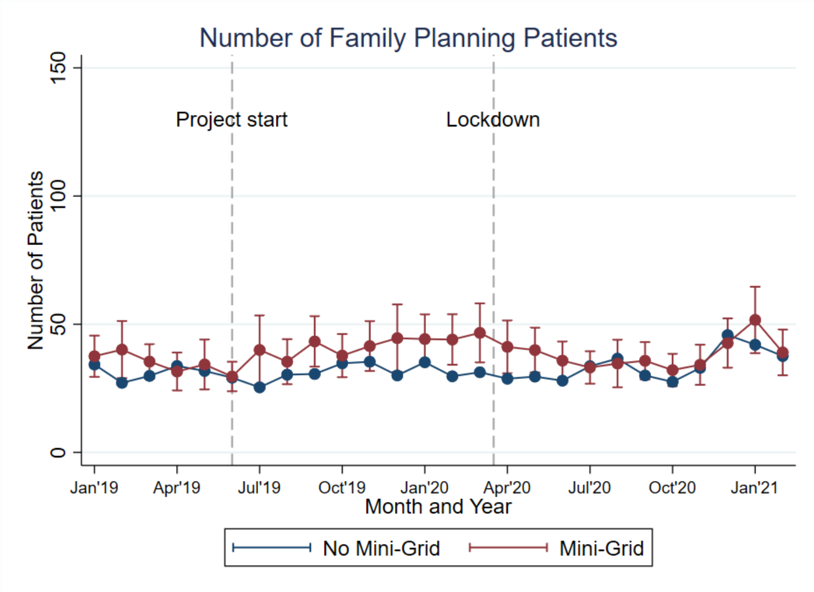


Notes: The vertical axis represents the average number of patients in this category, per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

Family planning visits

Figure 10 shows the evolution in family planning visits. While there was no clear pattern in the evolution of visits in 2019, there is a clear decline in overall male and female visits in 2020. This decline starts between March and April, coinciding with the COVID-19 outbreak in Sierra Leone. There are no marked differences across clinics with and without connection to a mini-grid, except for the first months in 2020, when utilisation is higher in electrified clinics.

Figure 10: Evolution in Family Planning Visits

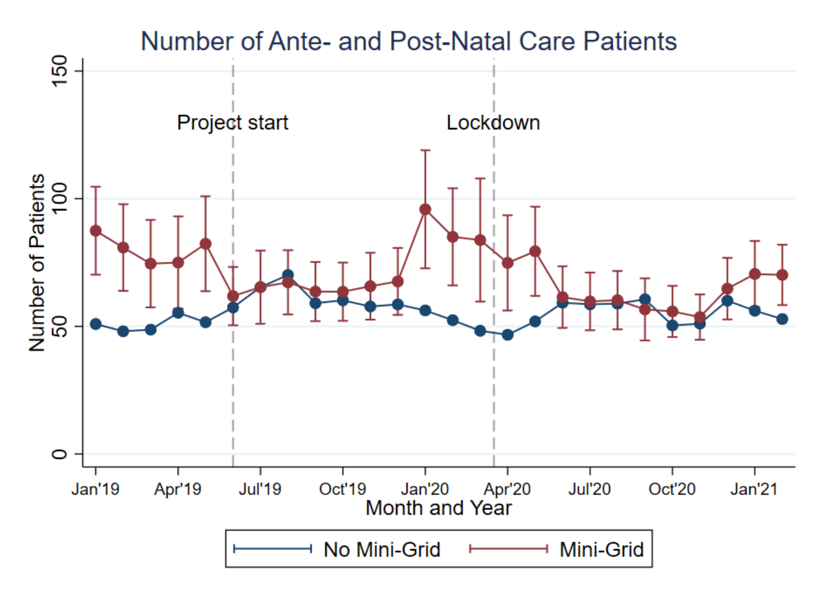


Notes: The vertical axis represents the average number of patients in this category, per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

Maternal health seeking

Figure 11 reports the number of Ante- and Post Natal Care clinic visits. Especially during the period January - May of 2019 and 2020 a clear difference in clinic utilisation rates can be observed. Clinic utilisation rates are higher in electrified clinics.

Figure 11: Evolution in Ante- and Post-Natal Care Visits



Notes: The vertical axis represents the average number of patients in this category, per month. Vertical bars are 95% confidence intervals. The vertical dashed line represents the beginning of COVID-19 lockdown measures in Sierra Leone. Data source: CHC records.

4.5 Education

The evaluation team collected primary school data from the majority of the communities in our sample (91 out of 108). There is at least one school in nearly all communities, although some communities reported not having a school. This entire section will cover school attendance; children who did not return to schools when the schools reopened; and national school exam passing records from the school years of 2018/2019 and 2019/2020.

4.5.1 School year attendance for 2019/2020

This section reports on the total number of students that attend the schools within our sample. Here we report by total schools in all communities, then break down the data by treatment status. Table 21 below includes data from 179 primary schools in our sample. In these schools, the average number of children attending are on average 380 children. The average number of children with disabilities at these schools is 5.9 children.

Table 21: Summary Statistics for 2019/2020 School Year Attendance

Variable	N	Mean	Std. Dev.	Min	Max
Number of students attending	179	379.86	230.15	45	1752
Number of boys attend	179	195.68	124.60	17	983
Number of girls attend	179	184.18	112.85	28	779
Number of disabled students attend	179	5.91	7.30	0	50
Number boy disabled students attend	179	3.00	3.93	0	30
Number girl disabled students attend	179	2.91	3.65	0	20

Notes: This Table shows summary statistics of school record data. Column (1) is the number of schools in the analytical sample. Column (2) is the mean number of students. Column (3) is the standard deviation, and columns (4)-(5) are the minimum and maximum, respectively. Data source: School Records.

Table 22 shows the difference in means between the comparison and mini-grid sites for student attendance in 2019/2020. No significance difference can be found for any of the school attendance outcomes. This might suggest that access to a mini-gird does not impact school attendance rates of local primary school pupils.

Table 22: Mini-Grid and Student Attendance in 2019/2020

	(1)		(2)		Differences;
	Comparison		Mini-Grid		t-test
Variable	N/Clusters	Mean/SE	N/Clusters	Mean/SE	(2)-(1)
Total children attend	62	381.742	117	378.863	-2.879
	[39]	(47.143)	[52]	(23.743)	
Number boys	62	197.710	117	194.598	-3.111
	[39]	(24.698)	[52]	(12.855)	
Number girls	62	184.032	117	184.265	0.233
	[39]	(22.768)	[52]	(11.638)	
Total children with disability	62	4.935	117	6.427	1.492
	[39]	(0.699)	[52]	(0.920)	
Number boys with disability	62	2.371	117	3.333	0.962
	[39]	(0.381)	[52]	(0.467)	
Number girls with disability	62	2.565	117	3.094	0.530
	[39]	(0.372)	[52]	(0.464)	

*Notes: This Table shows the difference in means for the number of students of the respective type between comparison and mini-grid sites. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at community-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: School Records.*

Table 23 is a summary table reporting the average number of students per school that did not return to school when schools reopened following their closure for COVID-19 in 2020. There are a total of 103 schools in our sample, of which 65 stated that some children have not come returned since the schools reopened. On average 13 students did not return to school after COVID-19, while the ratio between boys and girls not returning is relatively equal.

Table 23: Summary Statistics for Students Leaving School

Variable	N	Mean	Std. Dev.	Min	Max
Students who did not come back since COVID-19	65	12.91	29.50	0	228
Number boys not coming back	65	6.15	13.86	0	102
Number girls not coming back	65	6.75	16.17	0	126
Total children with disability who did not come back	65	0.14	0.46	0	3
Number boys with disability who did not come back	65	0.05	0.28	0	2
Number girls with disability who did not come back	65	0.09	0.29	0	1

Notes: This table shows summary statistics of school record data. Column (1) is the number of schools in the analytical sample. Column (2) is the mean number of students. Column (3) is the standard deviation, and columns (4)-(5) are the minimum and maximum, respectively. Data source: School Records.

Table 24 shows the differences in means between mini-gird and comparison communities for students who did not return to school after COVID-19. No significance difference can be found for any of the variables, suggesting that mini-grid access does not impact student attrition from school during COVID-19.

Table 24: Mini-Grid and Student Attrition in 2019/2020

	(1) Comparison		**(2) Mini-Grid**		**Differences; t-test**
Variable	N/Clusters	Mean/SE	N/ Clusters	Mean/SE	(2)-(1)
Students who did not come back since	18	10.78	47	13.72	2.95
COVID-19	[14]	(2.45)	[31]	(5.12)	
Number boys not coming back	18	4.56	47	6.77	2.21
	[14]	(1.01)	[31]	(2.37)	
Number girls not coming back	18	6.22	47	6.96	0.74
	[14]	(1.46)	[31]	(2.88)	
Total children with disability who did not	18	0.11	47	0.15	0.04
come back	[14]	(0.08)	[31]	(0.08)	
Number boys with disability who did not	18	0.00	47	0.06	0.06
come back	[14]	(0.00)	[31]	(0.04)	
Number girls with disability who did not	18	0.11	47	0.09	-0.03
come back	[14]	(0.08)	[31]	(0.05)	

*Notes: This table shows the difference in means for the number of students of the respective type between comparison and mini-grid sites. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at community-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: School Records.*

Table 25 is a summary table reporting the number of students per school that did attend/pass the yearly national exams disaggregated by primary schools (NPSE), junior secondary school (BECE) and secondary schools (WASSCE) exams. One can see that on average 35 students per school attended the National Primary School Examination (NPSE) in 237 survey schools and 29 students passed it.

Table 25: Summary Statistics for Attendance at National School Exams 2018/2019 and 2019/2020

Variable	N	Mean	Std. Dev.	Min	Max
Number of students attending NPSE exams (primary schools)	237	34.54	26.56	0	212
Number of students passing NPSE exams (primary schools)	237	28.85	23.58	0	157
Number of students attending BECE exams (junior secondary school)	110	71.92	59.81	5	430
Number of students passing BECE exams (junior secondary school)	111	57.89	45.43	0	230
Number of students attending WASSCE exams (secondary school)	47	75.49	105.25	0	443
Number of students passing WASSCE exams (secondary school)	47	12.47	37.42	0	250

Notes: This table shows summary statistics of school record data from school year 2018/2019 and 2019/2020. Column (1) is the number of schools in the analytical sample. Column (2) is the mean number of students. Column (3) is the standard deviation, and columns (4)-(5) are the minimum and maximum, respectively. Data source: School records.

Table 26 shows the differences in means between mini-gird and comparison communities for students who did attend/pass the national primary examinations for the school years 2018/2019 and 2019/2020. We find large differences in the mean number of students per school taking and passing the exams in primary schools (the number of observations for other types of schools are too small to make meaningful comparisons). Significantly more pupils attend and pass the national primary school examinations in communities which are connected to a mini-grid than in comparison communities.

Table 26: Mini-Grid and Attendance at National School Exams 2018/2019 and 2019/2020

	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/Clusters	Mean/SE	N/Clusters	Mean/SE	(2)-(1)
Number of students attending NPSE exams (primary schools)	95	31.58	142	36.52	4.94***
	[38]	(4.44)	[49]	(3.189)	
Number of students passing NPSE exams (primary schools)	95	25.72	142	30.94	5.23***
	[38]	(3.69)	[49]	(2.91)	
	[5]	(23.25)	[18]	(1.98)	

*Notes: This table shows the difference in means for the number of students per school of the respective type between comparison and mini-grid sites. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at community-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: School Records.*

However, looking at table 27, which reports the results from Difference-in-Difference estimates on the national primary school examinations, we can see that no significant difference between both groups can be found for the change in outcomes after project implementation. This suggests that benefits from electrification did not directly translate into a higher number of students attending or passing the national primary school examinations. The significant differences observed in table 26 seem to be of exogenous nature and cannot be regarded as a direct cause from access to a mini-grid.

Table 27: Impact of Mini-Grid on Change in School Outcomes

	(1) Students attending NPSE exams	(2) Students passing NPSE exams
Change in towns with mini-grids	3.151	3.520
	(3.055)	(4.042)
Mean difference mini-grid to comparison at baseline	12.467**	11.260**
	(5.317)	(5.301)
Mean difference endline to baseline for comparison	1.253	-1.060
	(2.368)	(3.075)

N	237	237

*Notes: This Table shows the Difference-in-Difference in school outcomes between treatment and comparison communities pre- and post-COVID-19. The baseline measures are from school records of the school year 2018/2019, and the endline measures use the school records of school year 2019/2020. Row 1 shows DID estimates from a regression estimated where the change in an outcome is regressed on a treatment indicator with district fixed effects and standard errors clustered at the community level. Row 2 reports the mean difference between comparison and treatment communities at baseline. Row 3 shows the mean difference in outcomes from baseline to endline periods for the comparison group. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Data source: School Records.*

Table 28 below is a summary statistics table showing how many schools provide or tell their students about alternative educational methods while the schools were closed due to the pandemic. 42 percent of schools mentioned that they did provide or communicate to the students about alternative methods, and the most common method was the use of radio and phone calls.

Table 28: Summary Statistics Alternative Learning Methods

Variable	N	Mean	Std. Dev.	Min	Max
Alternative learning methods provided	2,181	0.48	0.50	0	1
Radio	1,038	0.21	0.41	0	1
Private learning	1,038	0.09	0.28	0	1
Home study materials	1,038	0.83	0.37	0	1
Home learning from family	1,038	0.73	0.44	0	1

Notes: This table shows summary statistics of respondents in our sample that report having children at schools that provided or assisted in notifying students about alternative school methods while schools were closed due to COVID-19. Column (1) is the number of schools in the analytical sample. Column (2) is the mean number of students. Column (3) is the standard deviation, and columns (4)-(5) are the minimum and maximum respectively. Data source: COVID-19 Household Survey.

Table 29 reports the difference in means between mini-grid and comparison sites on learning methods they provided to students while schools were closed. There are few meaningful differences across type of community. Most schools provided alternative methods, and offered home study materials. A slightly higher percentage of schools with mini-grid provided alternative learning methods. This difference is however small, likely in the form of home study materials. At the same time comparison communities provided additional alternative learning methods via the radio.

Table 29: Mini-Grid and Alternative Learning Methods

	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/ Clusters	Mean/ SE	N/ Clusters	Mean/ SE	(2)-(1)
Alternative learning methods provided	804	0.475	1377	0.483	0.008**
	[49]	(0.031)	[55]	(0.021)	
Radio	364	0.262	674	0.200	-0.062**
	[46]	(0.040)	[54]	(0.027)	
Private learning	364	0.072	674	0.088	0.016
	[46]	(0.020)	[54]	(0.013)	
Home study materials	364	0.802	674	0.846	0.043**
	[46]	(0.038)	[54]	(0.020)	
Home learning from family	364	0.714	674	0.746	0.032
	[46]	(0.035)	[54]	(0.022)	

*Notes: This table shows the difference in means for the number of respondents of the respective type between comparison and mini-grid sites. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at community-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: COVID-19 Household Survey.*

4.6 Leaders' Knowledge of COVID-19

This section covers levels of knowledge of COVID-19 among the male and female leaders in the communities, Town Chiefs and Mammy Queens. The data provide insights into where and what misinformation is being spread and what the government and policy-makers should look towards for future information campaigns.

When collecting data from the Town Chiefs and Mammy Queens in the communities, there were some limitations in reaching all target respondents. The evaluation team attempted to contact all communities, but in certain communities the Chiefs and Mammy Queens were not available in person or by phone. Data was collected from 104 Town Chiefs and 91 Mammy Queens

4.6.1 Town Chiefs and Mammy Queens preventative behaviours of COVID-19

Table 30 below reports the summary statistics on the average age of the Community leaders contacted by the evaluation team. It also covers their self-reported preventative behaviours related to COVID-19 and their perceptions of it. On average, community leaders are about 55 years old, and they are washing their hands close to 7 times during the day; 72 percent report that this is more frequent than previously. It is important to note that handwashing frequency can be determined by access to clean water. On average, the distance in minutes to the closest hand washing station is about 3 minutes.

Nearly all the community leaders (98 percent) own a face mask, but only 49 percent reported that they use it. 92 percent of the community leaders state that they are worried about COVID-19, yet only 30 percent feel they are personally at risk of contracting the virus. A similar percentage thinks that their community is at risk of contracting COVID-19. Social distancing behaviours are reported in the last rows of the table and show that 87 percent of community leaders are avoiding handshakes; 43 percent are avoiding hugs; 66 percent are reporting that they are maintaining a social distance of at least 1 meter; and 20 percent report staying at home.

Table 30: Summary Statistics Table of Community Leaders Preventative Behaviours

	N	Mean	Std. Dev.	Min	Max
Age of respondent	194	54.82	12.57	23	90
Reporting regularly washing hands	195	0.68	0.47	0	1
Number times wash hands in day	194	6.82	4.16	1	25
Minutes walking distance to clean water	194	2.98	5.17	0	60
Owns face mask	195	0.98	0.14	0	1
Reporting covering with mask or cloth	195	0.49	0.50	0	1
Worried about COVID	195	0.92	0.26	0	1
Personal Risk Contracting COVID	195	0.30	0.25	0	0.5
Community Risk Contracting COVID	195	0.31	0.24	0	0.5
Reporting avoiding handshakes	195	0.87	0.34	0	1
Reporting avoiding hugs	195	0.43	0.50	0	1
Keeping social distance >1 meter	195	0.66	0.47	0	1
Staying at home	195	0.20	0.40	0	1

Notes: This table shows summary statistics of community leader data. Column (1) is the number of town chiefs in the analytical sample. Column (2) is the mean number of town chiefs. Column (3) is the standard deviation, and columns (4)-(5) are the minimum and maximum respectively. When looking at the observations, if some are fewer than others that means that the town chief responded as not knowing, therefore their observation is missing. Data source: Leader Survey.

Table 31 reports the difference in means between mini-grid and comparison sites on community leaders characteristics and COVID-19 preventative behaviours. Mini-grid communities seem to be significantly further located from clean water, which might indicate a higher remoteness. Moreover, all leaders in comparison communities own a face mask (indicated by the standard error of zero), while this is not the case for mini-grid communities. Nonetheless, significantly more leaders in mini-grid communities cover their mouth with a facemask or cloth. Overall, we can see that there are no statistically significant differences for most of the variables and means in both groups are very similar.

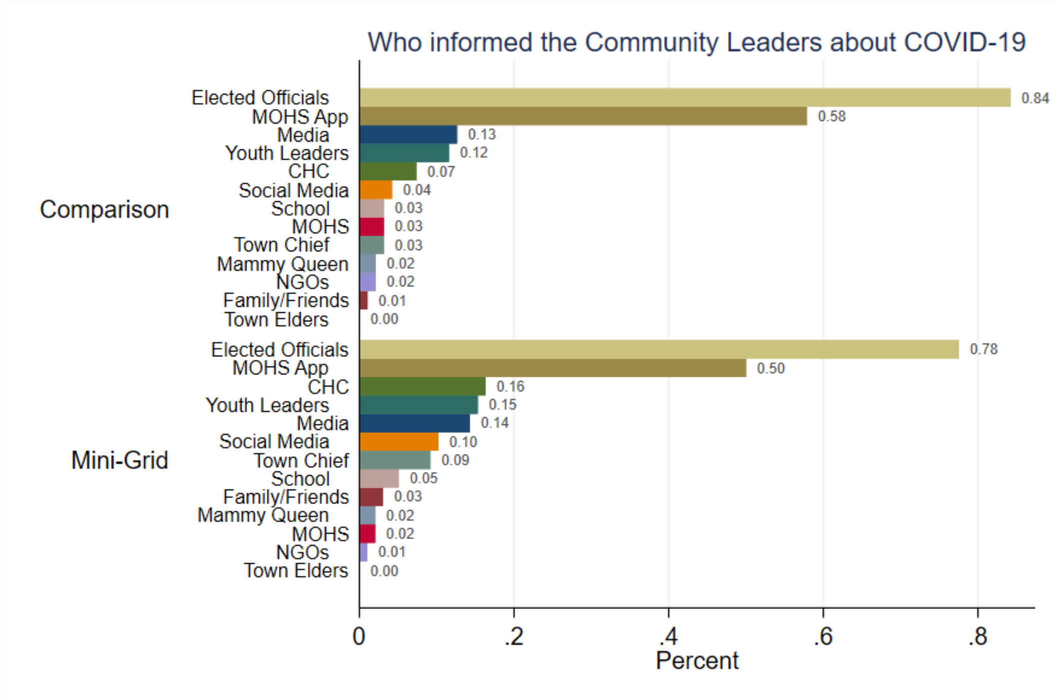
Table 31: Mini-Grid and Community Leaders Preventative Behaviours

	(1) Comparison		(2) Mini-Grid		Differences; t-test
Variable	N/Clusters	Mean/SE	N/Clusters	Mean/SE	(2)-(1)
Age of respondent	95	54.75	99	54.89	0.14
	[54]	(1.37)	[54]	(1.17)	
Reporting regularly washing hands	96	0.63	99	0.73	0.09
	[54]	(0.05)	[54]	(0.05)	
Number times wash hands in day	96	6.88	98	6.78	-0.10
	[54]	(0.53)	[54]	(0.45)	
Minutes walking distance to clean water	96	1.45	99	3.44	1.99*
	[54]	(1.10)	[54]	(0.69)	
Owns face mask	96	1.00	99	0.96	-0.04**
	[54]	(0.00)	[54]	(0.02)	
Reporting covering with mask or cloth	96	0.42	99	0.56	0.14*
	[54]	(0.06)	[54]	(0.05)	
Worried about COVID	96	0.92	99	0.92	0.00
	[54]	(0.03)	[54]	(0.03)	
Personal Risk Contracting COVID	96	0.31	99	0.29	-0.01
	[54]	(0.03)	[54]	(0.03)	
Community Risk Contracting COVID	96	0.32	99	0.31	-0.01
	[54]	(0.03)	[54]	(0.03)	
Reporting avoiding handshakes	96	0.89	99	0.85	-0.04
	[54]	(0.04)	[54]	(0.05)	
Reporting avoiding hugs	96	0.46	99	0.39	-0.06
	[54]	(0.06)	[54]	(0.06)	
Keeping social distance >1 meter	96	0.67	99	0.66	-0.01
	[54]	(0.06)	[54]	(0.05)	
Staying at home	96	0.19	99	0.21	0.03
	[54]	(0.05)	[54]	(0.04)	

*Notes: This table shows the difference in means for the number of leaders of the respective type between comparison and mini-grid sites. The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at community-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Data source: Leader Survey.*

Figure 12 reports how the community leaders were informed of COVID-19. The most common source of information about COVID-19 are elected officials and the Ministry of Health app. A substantial proportion of community leaders were also informed about COVID-19 by media outlets through radio, newspapers or the tv, by youth leaders or the local CHC. Overall, no significance difference can be found between both groups, except for the number of community leaders informed by the local CHC. Significantly, more community leaders in mini-grid communities have been informed by their local CHC about COVID-19 than in comparison communities.

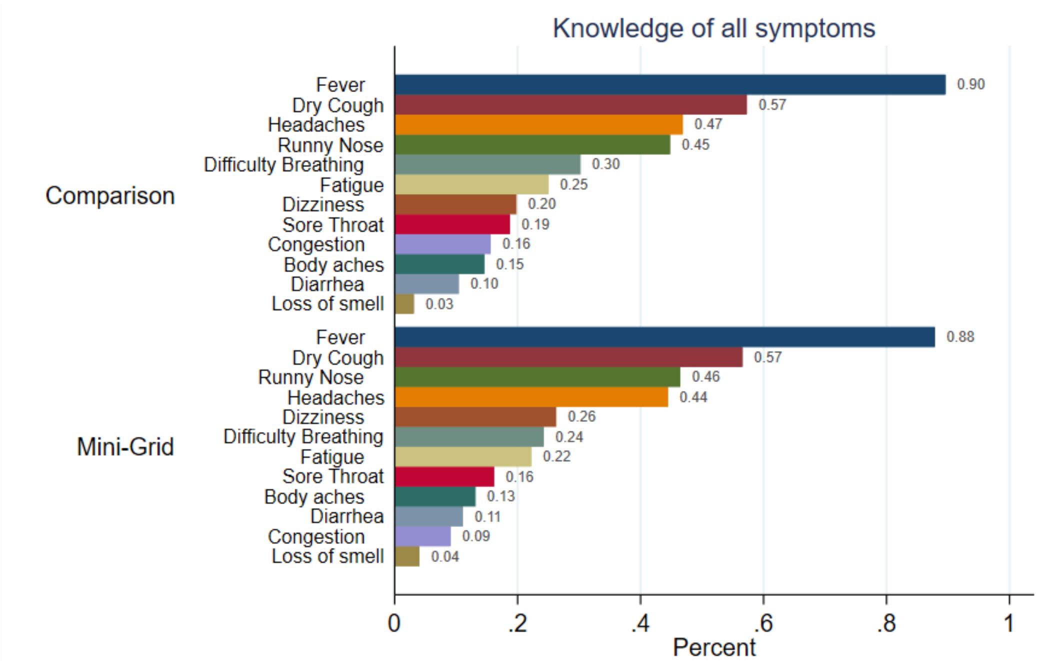
Figure 12: Who Informed the Community Leaders about COVID-19



Notes: The horizontal axis shows the percent of respondents who provided this response. Multiple answers were possible. Data source: Leader Survey

Figure 13 below reports the percentage of community leaders who know the main symptoms of COVID-19. Nearly all respondents knew that fever is a possible symptom. 57 percent of the community leaders named dry cough, while around half of the leaders also identified headaches and a runny nose as possible symptoms. Loss of taste and smell is only known by around 3 to 4 percent of community leaders. Overall, no significant difference between community leaders from mini-grid and comparison communities can be found.

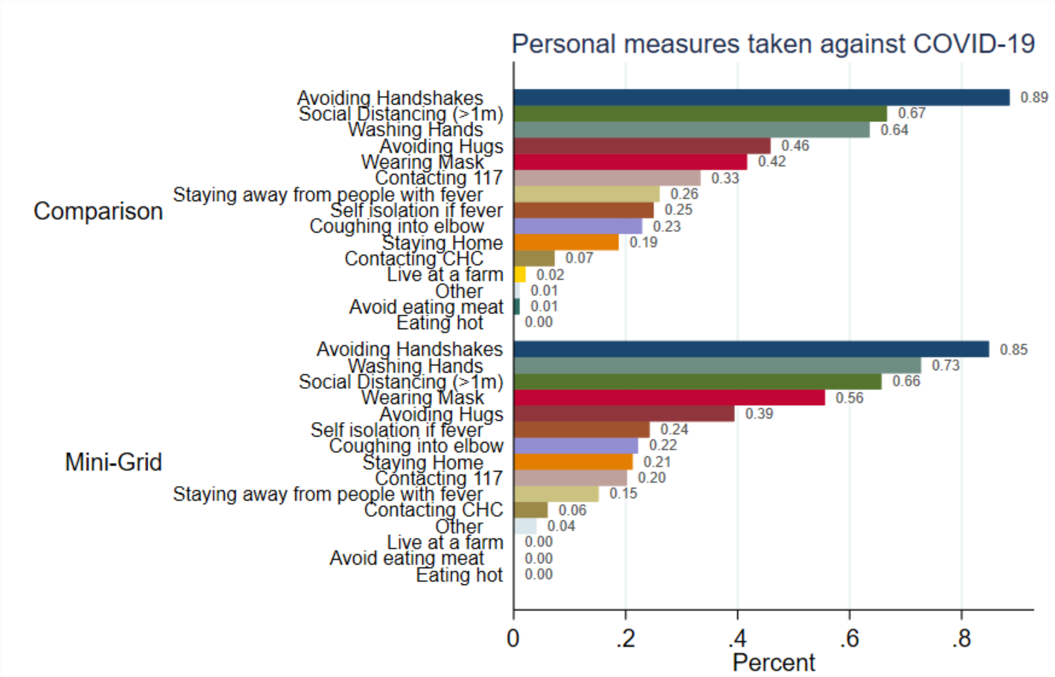
Figure 13: Knowledge of Main Symptoms of COVID-19



Notes: The horizontal axis shows the percent of respondents who provided this response. Multiple answers were possible. Data source: leader survey

Figures 14 reports the personal preventative measures community leaders take in response to COVID-19. Most community leaders respond that they avoid handshakes to prevent the spread of COVID-19. A substantial proportion also keeps a minimum distance of at least 1 meter and washes their hands regularly. Avoiding hugs and wearing a mask is also a common strategy. Very few leaders to no leaders are living at a farm, avoid eating meat or eat hot food in response of COVID-19. Significantly more community leaders contact 117 or stay away from people with fever in comparison communities than in mini-grid communities. On the other hand, a significantly higher proportion of community leader in mini-grid communities wears a mask in to prevent the spread of the virus. No significant differences can be found for the other variables.

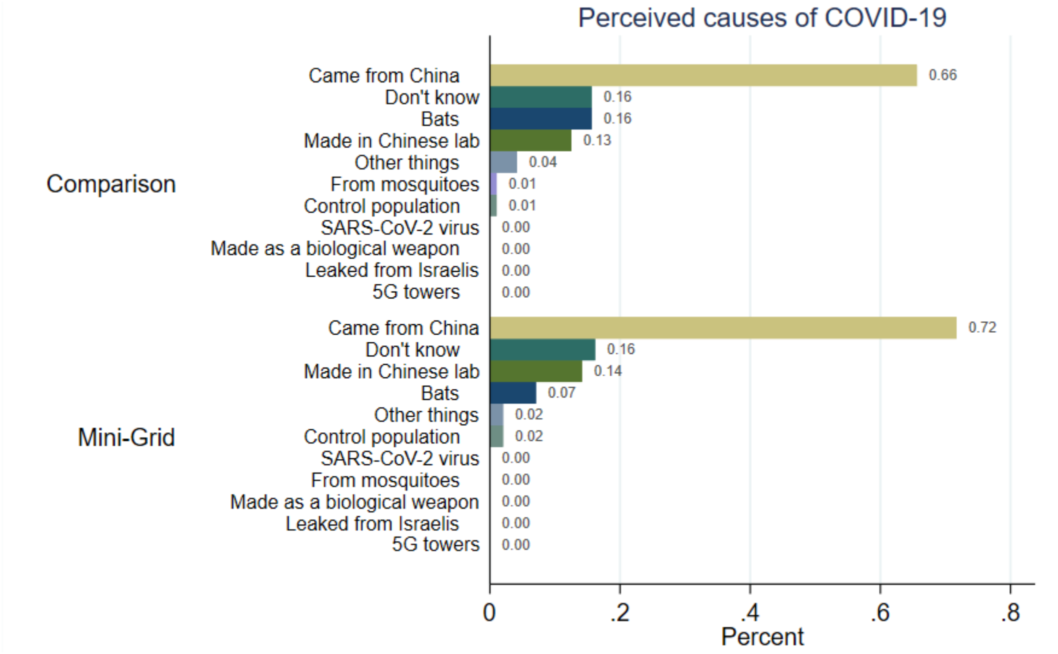
Figure 14: COVID-19 Personal Preventative Measures Taken



Notes: The horizontal axis shows the percent of respondents who provided this response. Multiple answers were possible. Data source: leader survey

Figure 15 shows the perceived causes of COVID-19 among community leaders. Most commonly community leaders believed that COVID-19 came from China. A substantial proportion answered that they don't know, that it came from bats or that it was made in a Chinese lab. A statistical significantly higher proportion of respondent in comparison communities believed that COVID-19 came from bats. Beyond that, no statistically significant difference in means between both groups is found.

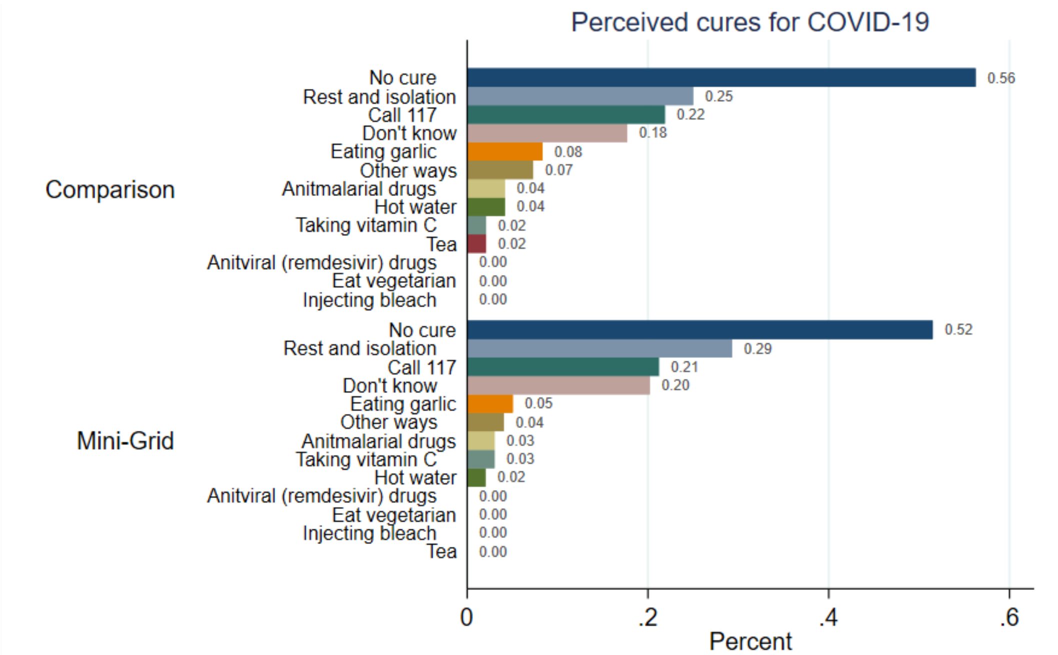
Figure 15: Perceptions of Causes of COVID-19



Notes: The horizontal axis shows the percent of respondents who provided this response. Multiple answers were possible. Data source: leader survey

Figure 16 below shows what community leaders believe to be the cure for COVID-19. The most common response was that there is no known cure: this was correct at the time the data was collected. Overall, no significant difference between both groups can be found for the answers provided.

Figure 16: Perceptions of Cure for COVID-19



Notes: The horizontal axis shows the percent of respondents who provided this response. Multiple answers were possible. Data source: leader survey

5 Conclusion

This report examines how access to power supply through functioning RREP mini-grids influences households economic and health resilience in face of a global pandemic. As data, this report uses both pre-COVID surveys and post COVID household phone surveys, clinic and school records. Enumerators asked questions regarding the household's economic situation, food security measures, COVID-19 knowledge and coping strategies, health, education as well as COVID-19 awareness of community leaders. Throughout the report results are reported as general summary statistics over the whole sample, differentiated results across respondents in communities with and without access to a min-grid and as Difference-in-Difference estimates comparing changes between mini-grid communities over time.

We find that the COVID-19 pandemic significantly impacted households' economic situation and food security. Survey data shows significantly lower average wage income and weekly food expenditures from pre- to post-COVID periods across both groups. In addition, there are significant differences in the food security (both food expenditures and whether respondents had to reduce portions) between the pre- to post-COVID periods. To cope with COVID, respondents report to have consumed savings, sold assets and borrowed more money. This links to findings from other low income countries, see Egger et al (2021).[15] Overall, there are no differences with respect to access to mini-grids. The same holds for schools and clinics. While appears local clinics benefitted from increased energy access; they have more hours of electricity each day, and more appliances in stock, there are however no meaningful changes in utilisation rates over time due to electrification.

Together these results signal more than access to energy alone is needed to transform local economies. Arguably evaluating impacts over a longer time horizon may show increases in economic activities dependent on electricity. The COVID pandemic set rural economies back, perhaps muting any positive change resulting from increased energy access. The data suggests that at least any positive gains made before the onset of COVID did not put communities with access to mini-grid on a different path. At the same time, recent empirical work calls in to question whether electrification alone fundamentally changes economic outcomes. Available studies suggest impacts limited if productive complementary investments in access to (energy dependent) technologies and markets are absent. In a recent project in Kenya for example, Lee, Miguel, and Wolfram (2020) show that large scale rural electrification had few discernible impacts on economic outcomes.[16] This suggests that the government and international donors and practitioners should prioritize complementary investments to allow increased energy access to translate in economic gain, and in case of crisis, in economic resilience.

6 Appendices

6.1 Approach to Measuring Ability to Respond to COVID-19

This section describes how the key thematic impact domain indicators are measured. The Key Indicators are grouped into five domains: 1) household economic outcomes; 2) health; 3) COVID-19 knowledge and preventative behaviours; 4) education; and 5) leaders' knowledge of COVID-19.

6.1.1 Measuring Thematic Impact Domains

This report assesses the current RREP outcome indicators across the five domain outcomes prior and during to the RREP interventions: 1) household economic outcomes; 2) health; 3) COVID-19 knowledge and preventative behaviours; 4) education; and 5) leaders' knowledge of COVID-19. The indicators and survey measures were selected based on two principles: that the Key Indicators a) comprehensively capture impacts of the COVID-19 crisis and response on a household-level, CHC-level and school-level; and b) enable interpretation of *how* COVID-19 leads to these changes. These indicators were obtained using three instruments, targeting different actors within a given community.

[15] Egger et al. (2021) Falling living standards during the COVID-19 crisis, Science Advances 2021; 7 : eabe0997, https://www.science.org/doi/pdf/10.1126/sciadv.abe0997

[16] Lee, K., E. Miguel and C. Wolfram, 2020. Experimental Evidence on the Economics of Rural Electrification, Journal of Political Economy, 128(4) https://doi.org/10.1086/705417

Table 32: Key Indicators and Resource Streams

Domain	Key indicators	Description	Resource Stream
Household Economic Outcomes	Income	Wages earned from other activities like small businesses, service provision (bike rider), employment (teacher, civil servant)	HH COVID-19 Response Survey
	Coping Mechanisms	Loss in demand, sold or borrowed assets to cope, difficulty accessing customers	HH COVID-19 Response Survey
	Food security	Food expenditure, days consumed all meals, quantities of rice/cassava/oil/fish and Maggi bought	HH COVID-19 Response Survey
Health	Quality of services offered	Number of electrified appliances, opening hours, number of drugs and vaccines stored in refrigeration, waiting time for patients, working hours head nurse	CHC Survey Baseline
	Health seeking behaviour	Number of patients for general health care, number of patients for family planning, number of patients for pre- and post-natal care to women, number of infants for immunization, institutional delivery	CHC Records, HH COVID-19 Response Survey
	Health	Self-reported number of stillbirths and maternal deaths	HH COVID-19 Response Survey
COVID-19 Knowledge and preventative behaviours	Knowledge of COVID-19	Knowledge on main symptoms of COVID-19 and asymptomatic cases	HH COVID-19 Response Survey
	Health Seeking Behaviour	Self-reported instances of visiting the clinic during any pregnancy to take care of their baby in the last 12 months	HH COVID-19 Response Survey
Education	Attendance	Children registered and attending school	School registers
	Alternative Methods	Children supposed to take national exam before March, school provided alternative methods (radio, TV, online materials, private lessons, home study materials, phone calls)	HH COVID-19 Response Survey/ School survey
	Passing the NPSE exam	Records from the NPSE exam on children who took it, and passed	School registers
Leaders' Knowledge	Spread of information	Questions on who told the leaders, and who they trust information from	Leader survey
	Knowledge	Knowledge of main symptoms of COVID-19 and asymptomatic cases	Leader survey
	COVID-19 preventative behaviours	Self-reported behaviours such as washing hands, mask wearing, and keeping distance from others	Leader survey

6.1.2 Description of Key Indicators

We first describe how the Key Indicators relate to the high-level outcome domain indicators for each outcome domain. We then describe the specific survey measures that are used to construct these Key Indicators. While describing how our key Indicators relate to outcome domain, we review *why* electrification might change Key Indicators - therefore reviewing the assumptions in the theory of change.

Domain 1: Household Economic Outcomes

Relation of Key Indicators to Outcome Domain
The COVID-19 crisis and response are directly linked to household economic outcomes. We measure economic impacts through an in-depth household phone survey covering income, coping mechanisms and overall food security of the household. During the crisis, Sierra Leone went through a country-wide lockdown where many businesses had to close their shops and the population was forced to stay inside during these days. We capture the differences in income from before the lockdown and after in a panel frame analysis to understand better how Sierra Leoneans are coping with the pandemic and the government's response to it. Food security is an important factor in understanding how the population is handling the COVID-19 crisis. We look at this by how many meals respondents are forced to skip and who in the household are receiving fewer meals.

Electrification can alter how businesses and households are maintaining their income or coping with the COVID-19 crisis. Once the lockdown had been lifted, those who have access to electricity are able to stay open late.

Key Indicator A: Income
To measure income at the household level, we ask questions inside the household survey regarding their weekly wages (for a wage-employed respondent) or profits (for a self-employed respondent) and benchmark this from before March when the first lockdown happened. During each phase of the survey we ask for their last week's wages/profits, as well as their wages in a separate week of the previous month. This enables us to see how COVID-19 in the country is continuously affecting households.

Key Indicator B: Coping Mechanisms
To measure coping mechanisms from the COVID-19 pandemic, our household survey asks questions to the respondents about selling their physical assets; having to consume their savings; or needing to borrow money. Each of these questions shows us how dependent our respondents are on their environment and enables us to report their economic status at the time of the survey over time.

Key Indicator C: Food security
To measure food security among our sample, we ask questions about food expenditure and meals skipped during the last week. For food expenditure, we can see if households are beginning to spend less on food for their household members. We analyse this alongside the meals that are skipped. The meals skipped break down further by adults and children to see which demographic is losing more nutrition.

Domain 2: Health

Relation of Key Indicators to Outcome Domain
The COVID-19 crisis and response can drastically affect health outcomes. We measure health outcomes through a) CHC administrative records and CHC surveys and b) household surveys. COVID-19 can affect health-seeking behaviour and health both directly and indirectly. There can be a positive impact on health-seeking behaviour through an increase in the need for healthcare due to people being infected with the virus. The crisis can also negatively affect health-seeking directly due to fear of getting infected in health facilities, lack of trust in the healthcare system, or a loss of income, making healthcare unaffordable.

Electrification can also modify health-seeking behaviour. Improved (electrified) hospitals may stay open later and be better able to provide important pre- and post-natal care to women. When hospitals are better equipped, pregnant women may be more willing to deliver their babies at hospitals.

Key Indicator Set A: Quality of Services Offered
To measure the quality of services offered in CHCs, we ask CHC staff how many working electrified appliances there are in the centre. These can include refrigerators, freezers, blood pressure machines, blood banks, and sterilization equipment. We ask specifically if CHCs own a refrigerator or a freezer, and whether they store drugs and/or vaccines in refrigeration, and if so, which ones. We ask staff how long patients have to wait on average in the waiting room upon arrival in the CHC. Finally, we ask how many hours the head nurse has worked in the past three days and take the average to estimate the number of hours worked per day.

Key Indicator Set B: Health Seeking Behaviour
To measure health-seeking behaviour, we use record data collected in CHCs. We use five different types of CHC registers:

1. The 'Above-Five Treatment Register' notes every patient who visits the clinic for general health issues. These problems can be one of the following: malaria, anaemia, diarrhoea, eye infection, hypertension, indigestion, malnutrition, acute respiratory infection/pneumonia, skin infection, sexually transmitted infection, worm infestation, or 'others'. There is a distinction between 'new' and 'follow-up' patients. A new patient is someone who is visiting the clinic for the first time for a specific medical issue. A follow-up patient is someone who has recently been diagnosed and visits again.
2. The 'Under-Five Treatment Register' is analogous to the Above-Five Treatment Register, except it does not include hypertension, indigestion, and sexually transmitted infection. Again, there is a distinction between new and follow-up patients.
3. The 'Family Planning Register' tracks all patients who come for family planning for the first time or who are recurring patients. Patients who visit for family planning receive contraceptives. We add up new and follow-up visits to obtain the total number of patients for family planning.
4. The 'Under-Two EPI Register' documents the children who receive vaccines in the CHCs and what vaccines they have administered. We obtain from this the number of infants brought to the CHC to receive vaccinations.
5. Finally, we obtain information on the number of ante- and post-natal care visits from the 'Mother and Neonate Health Register'.

We also obtain measures on health-seeking behaviour from the COVID-19 Response Household Survey. We ask the respondents if any woman has been pregnant in their household in the past year. We then ask whether this woman sought any healthcare for ANC, vaccinations, and general health during their pregnancy. Next, we ask them how many visits to the CHC were conducted in the past week for pregnant women and how many of these took place at night. Then, we ask the respondent if any woman in their household gave birth in the past year, and if so, whether this woman sought any sort of post-natal care, vaccinations or general health care after she gave birth. We ask where the baby was delivered and whether the women went to the CHC for pre- and postnatal care or elsewhere. We also ask how many times this woman visited the CHC in the past week and if any of these visits took place at night. Finally, we ask how much this woman spent in total on pre- and postnatal care. This data should be interpreted with caution as it was sometimes the head of household reporting on the pregnant woman's behalf.

Key Indicator Set C: Health
To measure the number of stillbirths and maternal deaths, we ask respondents if any woman in their household had a stillbirth in the past year and if any women in their household passed away during childbirth in the past year.

Domain 3: Knowledge of COVID-19 and preventative behaviours

Relation of Key Indicators to Outcome Domain
Community-level COVID-19 responses are determined greatly on the knowledge and behaviours of the respondents in the communities. The number of people who are aware and understand the virus can greatly impact how the community copes and responds to outbreak. We measure COVID-19 behaviour through a) self-reported answers on knowledge of COVID-19 and b) self-reported health-seeking behaviour of pregnant women and women who have given birth in the past 12 months at the time of surveying. This enables us to see whether the population is accurately informed about COVID-19 and whether this translates into the health behaviours for pregnant women.

As mentioned in Domain 2, electrification can modify health-seeking behaviour. Clinics with electricity may stay open later and be better able to provide important pre- and post-natal care to women. When hospitals are better equipped, pregnant women may be more willing to deliver their babies at hospitals. They can also be the main focal point for new information about the virus due to their ability to charge devices.

Key Indicator Set A: Knowledge of COVID-19
To measure the knowledge of COVID-19 among our respondents, we ask questions in the household survey focusing on knowledge of symptoms and overall knowledge about COVID-19 without prompting.

Key Indicator Set B: Health Seeking Behaviour

To measure health-seeking behaviours in pregnant women, we ask questions about their pregnancy. We ask them about what visits they are taking, how often they are going, what time they go, and if they have given birth, we ask where.

Domain 4: Education

Relation of Key Indicators to Outcome Domain
The COVID-19 crisis and response may affect students' school attendance, which can have long-term effects on their long-term educational outcomes. We measure education impacts through a) school records on student attendance and national exam records and b) household surveys. COVID-19 can affect learning outcomes directly and indirectly. The crisis could also leave children with limited or no learning materials resulting in no educational inputs for months. The schools were closed from March through July.

Key Indicator Set A: Attendance
To measure attendance, we collected the school attendance records for the school year 2019/2020 disaggregated by boys and girls. This was further disaggregated by students with disabilities.

Key Indicator Set B: Alternative School Methods used during lockdown
To measure what methods the schools are providing or sharing with their students, we ask respondents in the COVID-19 household survey about their children's learning; and in the school survey, we ask the principals about their approach to out-of-school learning. The respondents are asked if their children's schools provide any alternative methods of education during lockdown, if so, which methods. We then ask the principals if there was out-of-school learning offered, and if so, which methods.

Key Indicator Set C: Students taking the National Primary School Examination (NPSE)
To measure the number of students taking the NPSE all respondents were asked if their children were scheduled to take the yearly exams in March, and if yes, whether they are still schedules to take them at the end of the year.

Domain 5: Leaders' Knowledge of COVID-19

Relation of Key Indicators to Outcome Domain
Both the government's COVID-19 official response and emergency communication, and unofficial communication and rumours, may affect how community leaders inform their community members. This is widely dependent on what information is available for the leaders. We measure the leaders' knowledge through a) questions on the spread of COVID-19 related information in the leader survey and b) the leaders' knowledge about the virus. Depending on how the leaders are receiving their information, they may have more or less of an accurate understanding of what is happening related to COVID-19, which they then pass on to their community members.

Electrification can provide access to information in an easier manner in the mini-grid communities than the comparison communities. If leaders and community members are obtaining their information through calling friends or family, being able to charge a phone is a determinant for this action.

Key Indicator Set A: Spread of Information
To measure how information is shared within communities, we ask questions about how leaders were first told about COVID-19 and by whom. We then ask which sources they trust for information related to COVID-19.

Key Indicator Set B: Knowledge
To measure the level of knowledge that the leaders of the communities possess, we ask questions related to knowledge of symptoms and asymptomatic cases. The answers are not prompted and thus capture unbiased responses from the leaders.

Key Indicator Set C: Preventative Behaviours
To measure how the leaders are practising COVID-19 preventative behaviours, they are asked about what they are practising in response to COVID-19. The answers are not prompted and thus accurately capture the measures the leaders have been taking.

6.2 Approach to Reporting Baseline Findings

6.2.1 Approach to Survey Response Bias

In this section, we detail our strategy for dealing with common forms of survey response bias. Given the ethnic and linguistic diversity of Sierra Leone, we ensure that in our analysis, we consider various forms of interviewer bias- be it the place of birth, ethnicity, or first language.

Interview language bias & bias vs. measurement error

Krio was the default language for conducting all surveys. However, because enumerators were assigned geographic areas where they had linguistic specialism, enumerators and respondents sometimes matched on a non-Krio primary language, and then the interview was conducted in that language. This means respondents who speak major languages (i.e. Mende / Temne) as a first language are more likely to have the interview conducted in their primary language than respondents from minor languages. If the enumerator and respondent did not share a primary language, and the respondent did not speak Krio, a trusted person was recruited to translate. Both of these situations - speaking in a mother language or speaking through a translator - deviate from the default option of Krio and may engender different responses.

We do not expect large "language effects" as language would most likely affect responses through sensitive questions where trust/familiarity is important; our survey data does not hinge on sensitive questions. Moreover, it is important to distinguish between "measurement error" and "bias". Measurement error occurs when the level of an outcome captured in a survey differs from the true value of the outcome; every question on every survey contains some degree of measurement error. However, "bias" comes into the picture when respondents in treatment and comparison respond to questions differently. There is no reason to expect that we will have more measurement errors in treatment compared to comparison communities. This means we have no reason to expect language bias errors.

The same logic can be applied to other factors that may create measurement errors, such as a) respondent and interviewer of a different gender; b) respondent and interviewer from a different region; or c) respondent and interviewer from different class backgrounds. While all of these might introduce a certain degree of measurement error, we can expect these measurement errors to be equal in treatment and comparison and therefore create no bias.

6.2.1 Baseline Sampling Regime

Respondents were selected at baseline using probability sampling to obtain a group of respondents that are representative of the whole town. A main tenet of probability sampling is that every unit has the same probability of being selected for the survey. This would not be achieved through a simple random sample that utilized a "random walk" procedure. In a random walk strategy, selected respondents are a product of where one enters the town or begins their "random walk", which is usually the centre of town or some other important building. This cannot be considered a random part of town. To avoid this problem, we used a town census to develop a full list of households and randomly sampled households from this list.

Our use of probability sampling means that we can assume that our household survey is representative of the village population. One issue that could potentially challenge the representativeness of our survey is non-response. Non-response can create a bias if non-response patterns are different across treatment and control. We can test for this pattern by regression treatment status on non-response in a given variable. If there are differences across treatment and control, we can analyse *which* kinds of people are not responding to better interpret our findings.

6.3 Governance of Survey

UNOPS leads on the design and management of the study for the COVID-19 response. UNOPS appointed Wageningen University and Research (WUR) and its partners, including Yale University and the International Growth Centre (IGC), to undertake the research deliverables.

Wageningen University has received additional funds from the International Growth Centre and the Applied Research Programme on Energy for Economic Growth (EEG) led by Oxford Policy Management (funded by the UK Government through UK Aid). This has enabled the length of the survey and the period covered by the survey to be extended (i.e. 6 months as opposed to 3 months), while also increasing Value for Money (VfM).

UNOPS also engages the Monitoring and Evaluation (M&E) department of the Ministry of Energy in Sierra Leone as one of the key stakeholders involved in the design and conduct of the surveys for the RREP. The Government has been engaged and its recommendations are included in the evaluation approach throughout the process. The RREP Project Board performs a critical accountability role for the project as a whole. The evaluation team regularly updates the Project Board on all the activities under the overall RREP M&E workstream of the project.

Table 33: Overview of Baseline Governance

Partner Name	Roles and responsibilities
Wageningen University and Research (WUR)	WUR is the evaluation manager for this impact evaluation. The WUR team is led by Maarten Voors, Research Coordinator. It employs several key personnel, including the Research Coordinator, the Research Associate, the Qualitative Researcher, Field Manager, Field Coordinator, and Enumerators. WUR is responsible for the following activities: - Designing and delivering the evaluation strategy - Training interviewers and piloting research tools - Analysis for primary data and reporting - Data collection, processing and cleaning - Secondary data collection - Sharing key findings and lessons learned - Quality assurance and data quality - Validation workshops
Yale University	Yale University is responsible for designing and developing the data collection tools, an evaluation design, as well as providing guidance to all team members on research methodology and implementation. It will also lead on data analysis and cleaning. Yale University contributions are overseen by the Team Leader, Mushfiq Mobarak. Yale University is responsible for the following activities: - Development and finalization of data collection tools - Evaluation design - Training of enumerators - Analysis of all baseline of all data collections - Support with reporting - Data cleaning - Development of infographics
International Growth Centre (IGC)	IGC is responsible for providing the Research Manager to oversee research design. The Research Manager, Niccolo Meriggi, will be based full-time in Sierra Leone. IGC is responsible for: - Inputs into research design, methodology, data collection tools. - Data analysis from a local context - Facilitate building the evidence base for maximum policy impact. - Liaise with stakeholders (e.g., GoSL, UNOPS, FCDO, Inensus), and between Key Personnel and field teams.

This section provides an overview of the methodology and data sources developed and used. Section 2.1 explains the approach to delivering the field work. Section 2.2 provides an overview of data cleaning processes. Section 2.3 explains the different streams of evidence employed to feed into the analysis. Section 2.4 explains the approach to measuring the impact of the thematic impact domains. Section 2.5 briefly covers the analytical approach used to report on findings.

6.3.1 Research Team Composition and Training

The table below provides an overview of the approach to delivering the fieldwork.

Table 34: Approach to Internal Quality Assurance

Methodological Issue	Delivery approach
Enumerator Training	WUR recruited 2 Research Associates, 2 Field Managers and 19 enumerators (26% female) for the primary data collection conducted by phone. All enumerators were trained on: - Basic enumerating skills - Interacting with human subjects - Ethical responsibilities - Purpose of the impact evaluation - Handling tablets and Open Data Kit (ODK) Collect - Best practices for field research A considerable part of the training time was spent on each survey questions, analysing their purpose, meaning, expectations, reading, and translations to Krio and other local languages. Enumerators were provided with Training Manuals, Scripts, Deployment Guides, and any other materials needed for the proper performance of their assigned tasks. One training took place for each data collection process.
Fieldwork Supervision	The Field Managers supervised all logistics and operational requirements prior to and during data collection. Responsibilities included coordinating training and meeting venues, complying with all COVID-19 measures, and providing all logistical support. The Field Managers supervised the teams of Enumerators and were responsible for coordinating with the Research Associates to ensure timely data uploads to the Data Manager, and quality comparison of collected data. They also liaised with the Research Associate for personnel and logistics requirements. Two Field Managers supervised all enumerators. All staff was based full-time in Freetown during data collection periods.
Enumerator Incentives and Retention	The Impact Evaluation Team lead by WUR instituted a system of awards, both monetary and nonmonetary in the form of certificates, given to Enumerators with consistently high performance at the end of the field work. The performance was measured in three criteria: First, based on the quality of the data; second, the number of census surveys that the enumerator averaged throughout the duration of the office work; third, WUR asked the Field Managers, who had experience supervising all Enumerators at some point in the office work, to give recommendations on who they thought were the best Enumerators in terms of their professional decorum, and level of enthusiasm.
Quality Control	The quality comparison was managed from Freetown by a team of Research Associates. Checks were made every second day and several course corrections were made. These took place during feedback meetings each week in Freetown. Data were uploaded after each day of work to ensure there was no missing or lost data.

6.4 Data Quality and Cleaning

The table below provides an overview of the data governance processes.

Table 35: Data Governance Processes

Data Governance Process	Description
Data Storage	Great care was placed in making sure that the data was properly organized into specialized repositories. Raw data, coding files, clean data, and other outputs were placed in separate file repositories. All raw data was stored in a "raw data" repository, organized into subfolders for the different surveys (household, school, CHC, etc.); all cleaning code files were stored in a "build" repository, and all clean data was stored in a "clean" repository. This ensured that work flows were efficiently systematized. For example, cleaning code in the "build" repository imported the raw data from the "raw" repository, processed it, and saved it into the "clean data" repository. This way, the data was be cleaned without overwriting the pre-existing raw data.
Version Control	Each file was allocated a version number indicated at the top of each cleaning file. When changes were made, the changes were recorded and noted by the analyst as comments in the file, along with the team member's name and the date. The version number enabled the team members to track the changes that other team members had made. In addition, the cleaned files were periodically be moved into an "archive" folder, and a copy was made. The copy was then made part of the "active" cleaning file. Each copy was given a date in the name of the file so the team could quickly and accurately reference them. Having a historical record of changes also ensured that past data cleaning could be replicated in the case of a mistake in the code. In such a case, once the data analyst team spotted it, they could check which version the change was made and at which date, then go to that version and reconstruct the previous dataset.
Peer Review	All data analysts communicated all changes made, and each analyst reviewed those changes after each version. In addition, every cleaning code produced a log file that results in a full report printed at the end of the code. Log files were saved in their own repository and ensures that data analysts could review the changes even when the statistical software we used was not accessible. Log files display all commands, inputs, and outputs from the code for the data analysts to review.
Communications	The data analysts communicated over Slack, an online work platform through which team members sent messages to one another and shared snippets of code for each person to review and provide feedback. Using Slack as a platform for communication led to more efficient workflows. The analysts separated their operations into different "workspaces" for specialized tasks. In addition, all work was easily be communicated to the Principal Investigators (PIs) for feedback, troubleshooting, and high-level decisions.

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The views expressed in this Working Paper do not necessarily reflect the UK Government's official policies.