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ESSAYS IN DEVELOPMENT ECONOMICS: POVERTY, RELIGION, & MENTAL HEALTH

A DISSERTATION SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ECONOMICS AT TRINITY COLLEGE DUBLIN

BY

Danish Us-Salam

SUPERVISED BY

Andrea Guariso & Selim Gulesci

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For my parents, Asma Naeem and Naeem Us-Salam

Declaration

I solemnly affirm that the dissertation I am submitting for evaluation for the Ph.D. degree at Trinity College Dublin is purely my original work, except where I have explicitly specified that it is the contribution of others. The third chapter draws on work that was carried out jointly with Benjamin Avuwadah, Chiara Dell'Aira, Christine Nabulumba, and Sarah Baird.

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Danish Us-Salam

Summary

This dissertation includes three standalone chapters, each focused on augmenting our knowledge of three issues in the literature on asset transfers, religion, and mental health.

The first essay (Chapter 1) investigates whether a women-targeted asset transfer program can lift households out of poverty in a post-pandemic context (Sierra Leone). Using a randomized controlled trial, we assess the program's effects on income, food security, non-food consumption, and asset ownership among the targeted ultra-poor households. Two years after the program, our findings indicate that the program led to significant improvements in these outcomes across the entire sample. However, we observe a larger impact in districts with lower Ebola incidence rates. We attribute this variation in treatment effects to the infrastructural damage and lack of community support caused by the Ebola crisis, which may have constrained the program's potential in the hardest-hit areas. Our results highlight the importance of considering the local context when designing and implementing asset transfer programs in post-pandemic settings and suggest that complementary efforts to rebuild infrastructure can enhance the effectiveness of such interventions.

The second essay (Chapter 2) studies the health effects of religious practices in the month of Ramadan, one of the central pillars of Islam. Ramadan requires Muslims to fast daily from dawn to sunset and thus may have physiological and psychological consequences. To establish causality, we use two rounds of a large-scale survey in Bangladesh and exploit the variation in the day on which households were interviewed. This paper reports four main results: (i) households decrease aggregate consumption levels across all income groups, (ii) Ramadan serves as a negative health shock which is larger in absolute terms for households in the bottom 50% of wealth consequently pushing them closer to the WHO malnourished guideline, (iii) the adverse health shock on households isn't translated into a similar shock for children under 5 in the same households and (iv) finally a net zero effect on subjective well-

being. Together, our results suggest that voluntary adherence to religious practices changes individual behavior in ways that have negative implications for physiological health but no implications for psychological health.

The third essay (Chapter 3) investigates adolescent girls' mental health in Uganda during the COVID-19 pandemic. The paper adds to the existing evidence base by drawing on 3 rounds of panel data (2019–2021) to assess changes in adolescent mental health among 468 young women aged 13–19 years residing in rural to semi-urban villages in Uganda before and during the pandemic. Using fixed effects models, we find increases in symptoms of moderate-to-severe depression as measured by both the Patient Health Questionnaire-8 during the pandemic and accompanying lockdown measures. We also find that adolescent girls who faced a higher COVID-19 burden exhibit stronger declines in mental health. Our findings shed light on the impacts of the pandemic on young women's mental health in an LMIC context and suggest the need for age-, gender-, and vulnerability-targeted policies that ensure that the pandemic does not undo current progress toward a more gender-equitable world.

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I dedicate this thesis to my father - Naeem Us-Salam who wanted to be an economist but couldn't pursue it as a career. He was there when I embarked on my economics journey during my undergraduate studies but didn't get to see how far I've come. Wherever you are, I am certain you are filled with pride. I miss your presence, your words of wisdom, and your unwavering faith in me. Every page of this thesis carries a piece of you, a piece of the dream you once had. Through me, your dream has found its voice, its expression, and its fulfillment. You are missed, deeply, every day.

Contents

Chapter 1

Beyond the Outbreak: Asset Transfers and Economic Resilience in Post-Ebola Sierra Leone

1 Introduction

Extreme poverty remains a pressing global issue, particularly in countries with pandemics like the Ebola outbreak. The Ebola-affected countries, including Liberia, Sierra Leone, Guinea, and the Democratic Republic of Congo (DRC), already faced high levels of extreme poverty before the pandemic, with over 40% of their populations living on less than $1.90 a day (World Bank, 2021)[1]. The Ebola outbreak significantly disrupted these economies, amplifying existing poverty levels and creating multiple constraints for the ultra-poor. The outbreak directly impacted health outcomes and created a cascade of indirect effects, such as reduced agricultural production, disrupted trade, and decreased foreign investment Guinea (2014). These circumstances have created a complex web of constraints for the ultra-poor, including limited access to healthcare, education, and income-generating opportunities, which can reinforce poverty traps Banerjee and Duflo (2013). Identifying policies that can tackle these constraints in post-pandemic settings is therefore critical.

In post-Ebola Sierra Leone, disrupted healthcare and education systems, along with weakened social cohesion and institutional capacities, have made it even more challenging for the poor to overcome these barriers and escape poverty traps Fu et al. (2017). These poverty traps can be persistent and, over time, can lead to impaired decision-making and may put households at risk of further economic distress (Mani et al. (2013); Haushofer and Fehr (2014)). Addressing the constraints in this context requires a multi-dimensional approach that can simultaneously tackle multiple issues and help people build resilience against future shocks.

One promising avenue for multi-dimensional interventions lies in the agriculture and

[1]World Bank Open Data Global Development Data. Accessed on March 23, 2023 from https://data.worldbank.org/indicator/SI.POV.DDAY

livestock sectors, which have the potential to improve livelihoods, enhance food security, and foster inclusive economic growth. The agricultural sector in Sierra Leone, which employed about 60% of the population and contributed around half of the country's GDP before the Ebola outbreak, has been significantly affected by the crisis. However, investing in this sector can substantially benefit the poor, particularly smallholder farmers, by increasing productivity and market access Gunjal and Senahoun (2016). Similarly, the livestock sector offers significant opportunities for poverty reduction and economic development. Livestock can be a valuable asset for poor households, providing a source of income, nutrition, and resilience against shocks Gunasekara et al. (2020).

This study adds to the growing body of evidence that seeks to understand the effectiveness of asset transfer programs in reducing extreme poverty. Research on asset transfer programs shows the impact on various household well-being dimensions such as consumption, food security, self-employment, and wages, among others. (Banerjee et al. (2015); Bandiera et al. (2017)). On the other hand, research on the impact of these programs in conflict and post-pandemic settings is still limited except for Bedoya et al. (2019), who evaluated an ultra-poor graduation program in Afghanistan and found significant and large impacts across all dimensions of household wellbeing.

We examine whether an asset transfer intervention can alleviate poverty in post-pandemic settings, with a focus on Sierra Leone—a country severely affected by the Ebola pandemic—where the majority of recipients are women. The asset transfer program provides a package to lift the ultra-poor out of poverty, including livestock transfer, skills training, and supplementary services. In our experiment, we randomly assigned 721 poorest households across five districts to either a treatment or a control group. Women in the treatment households received a one-time package of livestock—usually two pigs (one male and one female)—along with skills training and coaching on rearing and selling the pigs profitably. Control households did not receive any program components. We assess the program's income, food security, non-food consumption, and asset ownership. Additionally, we investigate the program's varying effects on districts more severely impacted by the Ebola pandemic. We measure these outcomes two years after the asset transfer took place.

We find that our asset transfer program causes significant improvements in the well-being of ultra-poor households in the study districts across multiple dimensions. Two years after the program, households in all districts improved their monthly total income by USD 23, whereas income from pig-rearing activities improved by USD 17 per month relative to the control group. The share of severely food-insecure households decreased by 14.3 percentage points from 60% in the control group. Asset ownership improved by 0.17 standard deviations for the treated household. These impacts are driven by households being more involved in the rearing and selling of livestock (pigs).

We also investigated the heterogeneity of the program by the incidence of Ebola. While the program's overall impact is positive across all districts, the benefits are more pronounced in areas with lower Ebola incidence rates; upon further investigation, we believe that the observed difference in treatment effects between districts with high and low Ebola incidence rates is linked to the slow progress of infrastructure and community support rebuilding in the aftermath of the Ebola crisis. The lack of adequate infrastructure in the hardest-hit areas may have hindered the full potential of the asset transfer program, emphasizing the importance of combining such interventions with concerted efforts to restore and improve essential infrastructure in post-pandemic settings. This suggests that the lingering effects of the Ebola crisis may have dampened the program's potential to alleviate poverty in the hardest-hit regions, underscoring the need for additional support in these areas to maximize the effectiveness of such interventions.

The cost-benefit analysis of our asset transfer program reveals a higher benefit-cost ratio than similar experiments conducted in various countries. This cost-efficiency can be attributed to several factors, such as the absence of health components, consumption support, reduced frequency of household visits, and the selection of relatively inexpensive livestock (pigs). We advocate for the adoption of simpler asset transfer experiment designs while simultaneously cautioning against overly simplistic designs that run the risk of yielding inconsequential results.

Our study makes three main contributions to the literature. First, we find positive and significant impact of such a program in a post-pandemic context in Sierra Leone, a country still grappling with the socioeconomic consequences of the Ebola outbreak at the time of implementation. Our findings demonstrate significant program impacts during this recovery period, highlighting the potential for asset transfer programs to be effective in less stable, post-crisis environments. Prior evidence on the efficacy of asset transfer programs has largely emerged from more stable contexts (Banerjee et al. (2015); Blattman et al. (2014)), but our study expands upon this existing literature by investigating the program's outcomes in a challenging, post-pandemic setting. By documenting the positive impacts of the asset transfer program in Sierra Leone's unique context, our research contributes to a more nuanced understanding of the potential for such programs to foster economic resilience and support recovery in the aftermath of the crisis. The only other study we could find is Bedoya et al. (2019), which evaluated an ultra-poor graduation program (TUP) in conflict-prone Afghanistan.

Second, our study focuses on districts where the incidence of Ebola varied significantly. This heterogeneity is crucial to consider, as the Ebola outbreak substantially impacted the livelihoods of individuals in the affected areas. Differences in the incidence of Ebola across districts can be ascribed to factors such as healthcare accessibility, community engagement, awareness, and population density, all of which have been demonstrated to influence the spread of infectious diseases like Ebola Alexander et al. (2015). By accounting for this variation in disease incidence, our research offers valuable insights into the program's differential impact across areas with distinct levels of outbreak exposure. This nuanced understanding enables policymakers to tailor asset transfer programs to the specific needs of communities recovering from the aftermath of public health crises.

Lastly, one key aspect of our research is the evaluation of a comparatively simpler asset transfer program, as opposed to the typical, multifaceted asset transfer programs that often encompass numerous components. By focusing on a more streamlined program, our analysis can hone in on the specific elements driving the observed impact. This methodology aligns with recent calls for parsimonious designs in impact evaluations, which promote a deeper understanding of the causal mechanisms at work Banerjee and Duflo (2019). Consequently, our findings can help inform the design and implementation of future asset transfer programs, enhancing their efficacy in fostering economic resilience and addressing poverty-related challenges.

The rest of the paper is organized as follows: Section 2 describes the study setting, targeting, and sample characteristics. Section 3 describes the program, Section 4 discusses the experimental design and evaluation strategy, Section 5 presents the integrity of the design, Section 6 discusses the results, and Section 7 concludes.

2 Study setting, targeting, and sample characteristics

2.1 Study setting

In Sierra Leone, a country with a significant Muslim majority, the consumption of pig meat has been increasing over the years. This rise in demand is intriguing, given the Islamic prohibition against pork consumption. Yet, studies have shown that Sierra Leone Muslims engage in cultural and religious practices that include the consumption of pig meat, reflecting a unique blend of religious and local customs Kargbo (1992). This increasing demand for pig meat, despite the religious restrictions, underlines a complex interplay between religious beliefs and dietary preferences in Sierra Leone.

Continuing from this observation, the Christian and Muslim distinction in Sierra Leone creates differing contexts for pig farming as a livelihood. In our study sample where 45% are Christian and the remainder are Muslims, these two groups represent contrasting scenarios in terms of the viability of pig farming. For the Christian minority, pig farming presents an ideal setup, as there are no religious dietary restrictions against pork consumption. This demographic is more likely to consume pork, offering a stable market for pig meat and a viable economic opportunity for farmers within these communities. On the other hand, the Muslim majority, despite the noted increase in pork consumption, still predominantly adheres to Islamic dietary laws that forbid pork. This creates a less ideal setup for pig farming within Muslim communities, as the market for pork is not as extensive or consistent, potentially leading to economic uncertainties for those involved in pig farming. Therefore, the religious makeup of the population in Sierra Leone directly impacts the feasibility and profitability of pig farming, with Christians providing a more favorable market for pork products than their Muslim counterparts.

The local pig markets in Sierra Leone, however, are currently hampered by inadequate infrastructure. Pig farming in the country faces numerous challenges, such as high piglet mortality rates, lack of credit facilities, and poor market facilities, all of which significantly undermine productivity Gogra and Conteh (2019). These limitations highlight the need for programs that promote pig breeding and support the development of pig farming infrastructure. By addressing these issues, there is an opportunity to enhance the supply of pig meat, thereby meeting the rising demand and supporting the growth of this sector.

The rising demand for pig meat in Sierra Leone, even among the Muslim population, presents a unique opportunity for economic development and poverty alleviation. Addressing the infrastructural challenges in local pig markets and introducing programs aimed at empowering the poor through pig rearing can transform the economic landscape. Such initiatives promise not only to meet the growing demand for pork but also to uplift the livelihoods of many in Sierra Leone, fostering socio-economic growth in communities where poverty has long been a challenge. By providing pigs as a resource and imparting knowledge on their upkeep, the program would enable impoverished individuals to generate a sustainable income.

Sierra Leone recorded the first Ebola case on 24th May 2014; on 7th November 2015, the World Health Organization declared the end of Ebola in Sierra Leone. The outbreak had significant and long-lasting socioeconomic consequences on the affected districts. The epidemic resulted in over 14,000 confirmed cases and more than 3,900 deaths, representing a case fatality rate of approximately 28% WHO (2016). The economic fallout from the crisis was substantial, with real GDP to have

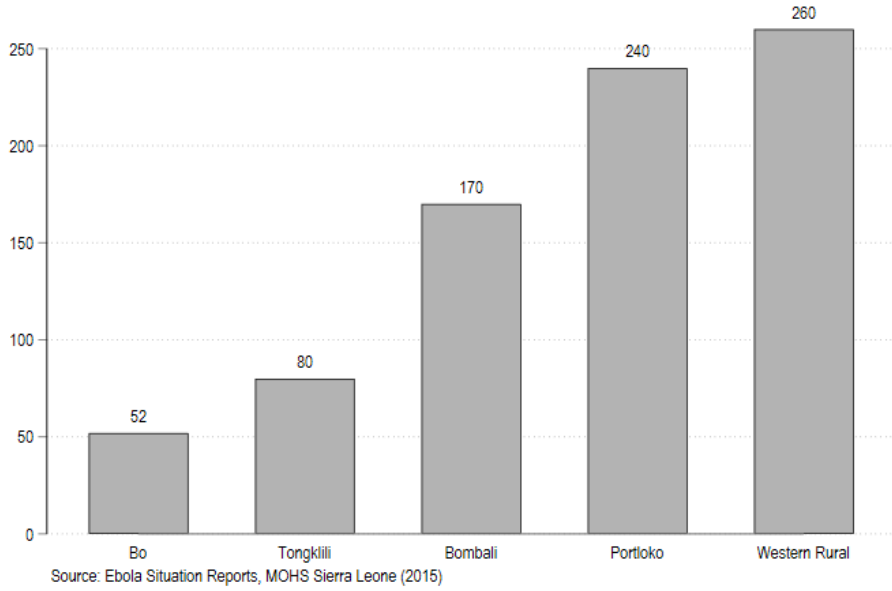


Figure 1: Ebola Incidence Rate (per 100,000 individuals) in study sites

contracted by -21.5% in 2015 Fu et al. (2017).

We study poor households in five districts of Sierra Leone. Figure 1 below shows the incidence rate of Ebola per 100,000 individuals for districts in Sierra Leone where the project was implemented. The data indicates a significant variation in the incidence rate across the different districts. For example, the Western Rural district has the highest incidence rate at 260 per 100,000 individuals, while the district of Tonkolili has the lowest at 80 per 100,000. The districts of Bo and Bombali also have relatively low incidence rates at 52 and 170 per 100,000, respectively. On the other hand, the district of Portloko has an incidence rate of 240 per 100,000 which is higher than Bo and Bombali but lower than Western Rural.

2.2 Targeting & Sample characteristics

The Sierra Leone asset transfer program we study was implemented under the Department for International Development (DFID), supported "Poverty & Food Security" program. The program was implemented by BRAC Sierra Leone's Agriculture, Food Security, and Livelihood Department between 2015 and 2017 in 5 districts of Sierra Leone, covering 25 villages, and aims to reduce poverty and hunger among ultra-poor households by increasing incomes and improving their livelihoods. This was achieved by transferring a productive asset combined with training, mentoring, and distribution of inputs to manage the productive asset better.

The program staff at BRAC Sierra Leone first identified the poorest villages in each district subject to proximity to a livestock market, veterinary services, and availability of livestock input services. Once the villages were selected, the project staff visited the villages and conducted a scoping exercise to identify eligible households for the program. In some instances, help from village leaders was taken to identify eligible households. Specifically, the project staff went from door-to-door in each of the 25 villages during August - September 2015 with a short questionnaire to identify households that met the following criteria:

- Household is female-headed or dependent on women's income;
- Household has some prior experience in pig rearing;
- Household has low income and is food insecure;
- Households show a willingness to become a pig farmer.

However, upon reaching our quota of rural communities, it was revealed that only 38% of households met the second criterion of the program; prior experience in pig rearing, while over 95% showed a willingness to be involved in pig rearing. As such, the second criterion of the program was relaxed, and the revised list of eligible households included a mix of households, both with and without prior experience in pig rearing, but met all other three criteria of the program (except for 12% households which were not entirely women headed / dependent). The scoping exercise resulted in 721 households eligible to participate in the program. These households were then approached again to participate in a baseline survey that took place during September - October 2015. After the baseline survey, a random sample of households was selected to be in either treatment or control groups, stratified by the district.

The scoping exercise effectively identified the most impoverished households in the targeted region. As illustrated in Table 1, a staggering 97% of the eligible households were classified as severely or moderately food insecure. Additionally, in 88% of the households, the primary respondent was a woman. Economic conditions in these households were dire, with approximately 96% earning less than $1.90 per day per capita, placing them below the international poverty line. Despite these challenges, there were promising indicators in education and livelihood opportunities. School enrollment among school-age children was relatively high at 82%, suggesting a strong commitment to education within the community. Furthermore, a willingness to rear pigs was observed, indicating the potential for livestock-based interventions to improve livelihoods. However, access to credit remained a significant barrier, with only 4% of households reporting access to loans from formal or informal sources. The majority of households in the sample relied on agricultural activities as their primary source of livelihood, emphasizing the importance of targeted interventions in the agricultural sector to boost productivity and enhance resilience to shocks.

Our study sample effectively mirrored the demographic composition of both rural and urban areas in Sierra Leone. The household possessions reported in the Demographic and Health Survey 2013 (DHS) reflected closely our study sample. Specifically, agricultural land ownership, a key indicator of resource availability, was reported by 62% of households in the DHS 2013 survey, compared to an elevated figure of 81% in our sample. Furthermore, a comparison of technology ownership reveals a convergence between the DHS survey and our sample; ownership of a mobile telephone was 55% (versus our 61%), while the ownership of a radio was 59% (versus our 55%). Indicators of mobility and entertainment were also similar, with 8% and 7% households in the DHS survey reporting ownership of a bicycle and a car, respectively (versus our 11% and 9%), and 14% reported owning a television (versus our 15%). The main economic activity, agriculture, was reported by 56% of households in the DHS survey, compared to a slightly lower 43% in our study sample. Despite these slight variations, the overall statistics provide a compelling case for the efficacy of the targeting exercise conducted by project staff members, which yielded a sample that is highly representative of the broader population of Sierra Leone.

Table 1: Household Socioeconomic Conditions at Baseline

Panel A: Household Characterstics	Mean	SD
Primary respondent is women	0.883	0.321
Household is Christian	0.449	0.498
Household Size	7.216	2.587
School-age Children are going to School	0.822	0.310
Household has a disable person	0.143	0.350
Panel B: Income & Assets		
Income per Capita (USD), Month	20.889	35.843
Household is below the Poverty Line	0.959	0.196
Household is Severely Food Insecure	0.523	0.500
Household is Moderately Food Insecure	0.444	0.497
Household borrowed money (last 6 months)	0.036	0.187
Household Owns Homestead Land	0.846	0.361
Household Owns Agriculture Land	0.840	0.366
Household Owns a Mobile Phone	0.610	0.488
Household has Prior Pig Rearing Experience	0.383	0.486
Household wants to be involved in Pig Rearing	0.983	0.128
Panel C: Economic Activities		
Household involved in Other Livestock	0.010	0.098
Household involved in Agriculture (Self)	0.148	0.356
Household involved in Agriculture (Commercial)	0.430	0.495
Household involved in Petty Trading	0.431	0.495
Household has Other Business	0.103	0.304
Number of Sampled Households	721	

Notes. This table is constructed using baseline data (2015). School-age is 6 to 19 years old. The exchange rate is the World Bank rate 1 USD = 5080.75 Leones (2015). In Panel C, the economic activities refer to 1 if at least one household member is involved in the respective income-generating activity. The poverty line threshold for Sierra Leone is USD 1.90 (2011 PPP) per day per capita, from the poverty and equity brief of the World Bank.

3 Program Description

In response to the issues identified in the introduction section, the project "Reducing Poverty and Huger of Vulnerable People through Improved Pig Production and Income Generation" funded under the Department for International Development (DFID), was implemented by BRAC Sierra Leone to reduce poverty and hunger by increasing incomes and improving the livelihoods of households. The project was implemented in five rural districts of Sierra Leone - Bo, Port Loko, Makeni, Tonkolili, and Western Rural. A total of 721 households were identified that satisfied the program's selection criteria. This includes a preference for female-headed households, a preference for households with some experience in pig rearing, a willingness to become a pig farmer, and households with low-income food security and education status.

The program provided the treatment group with **three mandatory** components (transfer of pigs, in-person training, and fortnightly visits) and **one optional** component (program inputs such as pigs feed, rearing tools, and pig shed). Overall, the treatment group was provided with the following:

1. A 7-day general training on pig rearing and entrepreneurship which included the following modules:

    - Breeding and genetics: This module focused on the principles of pig breeding, emphasizing genetic selection for traits like disease resistance, growth rate, and reproductive efficiency. Participants learned about breeding techniques, genetic diversity, and the importance of maintaining a healthy gene pool to ensure the sustainability and productivity of their pig farms.
    - Nutrition and feeding: This segment provided comprehensive knowledge about the nutritional needs of pigs at different stages of their growth. It covered feed composition, cost-effective feeding strategies, and the importance of a balanced diet for optimal growth and health. The module also touched on local sourcing of feed ingredients to reduce costs and support

local agriculture.

- Health and management: Here, the focus was on preventative health care, disease recognition, and treatment. Farmers were educated on common pig diseases, vaccination schedules, and biosecurity measures to prevent the spread of diseases. The module also included best practices in pig farm management, such as sanitation, housing, and waste disposal.
- Pig rearing and management: This module encompassed the practical aspects of pig rearing, including housing design, breeding practices, and day-to-day management. It aimed to provide hands-on skills to enhance the efficiency and productivity of pig farms, focusing on humane and sustainable rearing practices.
- Marketing and business management: This crucial module aimed to equip participants with skills in market analysis, pricing, and marketing strategies. It also covered aspects of business planning, record-keeping, and financial management, enabling farmers to effectively manage and grow their pig-rearing enterprises.

2. Transfer of pigs (one male and one female)
3. Other Program inputs (pig feed, rearing tools, pig shed)
4. Fortnightly monitoring visits by the program staff to evaluate the asset and provide any advice necessary; typically on best practices to manage the asset.

The program's distinctiveness in Sierra Leone stemmed from its holistic approach, combining technical training with entrepreneurship. It was uniquely tailored to the socio-economic conditions of Sierra Leone, particularly addressing the needs of vulnerable, often female-headed, households. The focus on pig rearing as a viable income source was strategic, considering the existing familiarity some households had with this practice and the market demand.

Additionally, the emphasis on local sourcing for feed and materials resonated with the local context, fostering sustainability and community integration. The program also acknowledged the challenges specific to rural Sierra Leone, such as limited access to markets and education, by providing tailored marketing and business management training. This approach not only aimed to increase household incomes but also to empower communities, enhance food security, and foster long-term economic resilience.

3.1 The Choice of Pigs over Other Livestock

The decision to select pigs as the asset transfer of choice in this intervention was influenced by several factors. Primarily, the Sierra Leonean economy is heavily dependent on agriculture, with smallholder farmers constituting the majority of the agricultural labor force FAO (2014). Nevertheless, these smallholder farmers often face constraints in terms of access to essential resources and infrastructure, leading to suboptimal yields and incomes. Furthermore, the 2014-2015 Ebola outbreak inflicted severe economic repercussions on Sierra Leone, causing numerous households to lose their primary income sources WHO (2014).

The implementation of pig-based asset transfer programs was envisioned as a means to assist Ebola-affected individuals in rebuilding their livelihoods and enhancing their economic well-being. In line with the post-Ebola recovery objectives of the government of Sierra Leone, the provision of alternatives to bush meat (meat of wildlife species) was deemed a priority GoSL (2015). Lastly, given their ability to subsist on a diverse range of diets and thrive in a variety of environments, pigs are considered a suitable livestock option for smallholder farmers facing resource and infrastructural limitations Thorpe and Jemaneh (2008).

Table 2: The Economics of Livestock Reproduction: Gestation, Birth, and Puberty

Livestock	Gestation Period (in months)	Birth (per pregnancy)	Pubertal Development (in months)
Pig	3	8-12	5-7
Sheep	5	1-2	6-8
Goat	5	1-2	4-6
Cattle	9	1	115-24

It is also crucial to consider the overall life cycle of pigs which is significantly shorter when compared with other livestock making them ideal for short-term impacts.

Table 1 above compares the pregnancy time, the number of births per pregnancy, and the time to reach puberty for several types of livestock, including pigs, sheep, goats, cattle and cows. As seen in the table, pigs have the shortest pregnancy time of 3 months, the highest number of births per pregnancy (8-12) and the shortest time to reach puberty of 5-7 months. These factors make pigs a valuable asset for smallholder farmers, as they can provide a sustainable source of income through the sale of meat and manure, and reproduce quickly which can lead to a rapid increase in the number of pigs and, therefore an increase in income. Additionally, pigs are hardy animals that can withstand the harsh conditions of many low-income countries, making them a suitable choice for smallholder farmers.

4 Experimental Design & Evaluation Strategy

The present study seeks to evaluate the impact of an asset transfer program in rural districts of Sierra Leone. The impact evaluation was carried out utilizing a randomized controlled trial (RCT) design, implemented by BRAC Sierra Leone, covering five rural districts in the country, namely: Western Rural, Bo, Bombali, Portloko, and Tonkolili. Initial evaluation for this project was done by the Independent Evaluation Research Cell (IERC) which is an independent sub-entity within BRAC that evaluates BRAC programs.

The sample selection process involved identifying 721 eligible households, which underwent a baseline survey during September - October 2015. Subsequently, a private lottery was conducted, stratified by district, to randomly assign 392 households to the treatment group, which received the entire program, and 329 households to the control group, which did not receive any of the program components, as shown in Table 3. The asset transfer program lasted for 12 months. Its impact was estimated through a follow-up survey conducted during November - December 2017, approximately one year after program completion and two years after the asset transfer. The results of this study provide an estimate of the program's impact on ultra-poor households by comparing the outcomes of the treatment and control groups two years post-asset transfer.

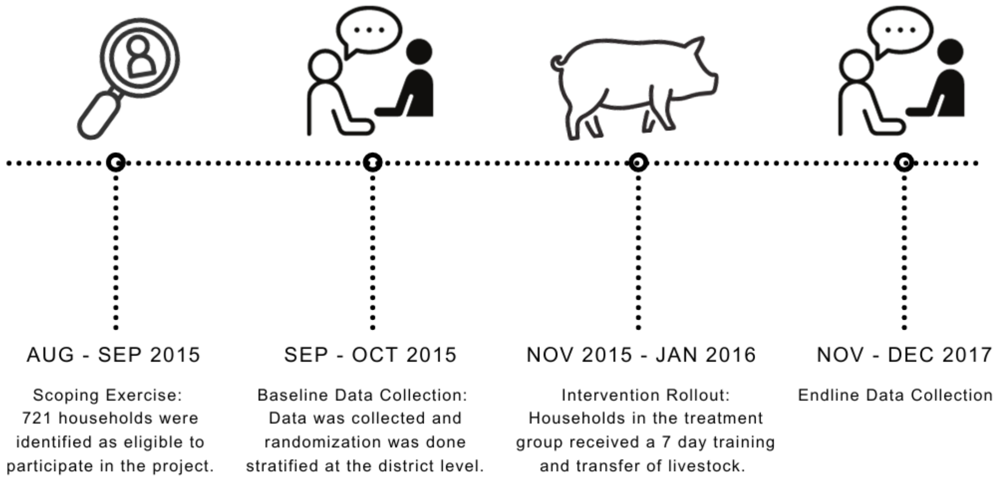


Figure 2: Study Timeline

Table 3: Breakdown of the study sample

District	Control	Treatment	Total
Western Rural	67	78	145
Bo	62	79	141
Bombali	66	79	145
Portloko	70	75	145
Tonkolili	64	81	145
Total	329	392	721

4.1 Primary Outcome Measures

We generate primary outcome measures as follows:

1. **Total Pig Income:** Total income received from selling pigs is calculated as unit production * sale price of pigs or piglets in the last 6 months.

2. **Total Income:** The sum of the revenues from livestock (including income from selling pigs), agriculture, non-agriculture business, and paid labor.

3. **Household Food Insecurity:** A continuous variable constructed using the Household Food Insecurity Access Scale proposed by Coates et al. (2007).

Higher values of the variable mean more food insecurity in the household. A binary (0/1) indicator is also created using the same scale, which equals one if the household is severely food insecure and 0 otherwise.

4. **Total Non-Food Expenditures:** The sum of expenditures on electricity, transport, education, child clothing and footwear, adult clothing and footwear, cosmetics, airtime, household utensils, and furniture/textiles.

5. **Asset Index:** An index generated using polychoric principal component analysis of the ownership of productive and household assets. These assets include homestead land, cultivable land, shop premises, farming tools, a pen for pigs, mattress, bed, sofa, mosquito nets, cellular phones, watch, radio, electric fan, refrigerator, television, iron, bicycle, and motorcycle.

6. **Pig Involve:** Binary (0/1) of whether the respondent in involved in pig rearing at the time of the endline interview.

7. **Pigs Born:** Number of pigs born in the last six months.

8. **Pigs Sold:** Number of pigs sold in the last six months.

9. **Pigs Consume:** Number of pigs used for personal consumption in the last six months.

4.2 Econometric Specification

In order to estimate the average treatment effects of the program, we use the following equation:

$$Y_i = \alpha + \beta_1 T_i + X_i + \sum_{j=1}^{n} V_j + \epsilon_i \qquad (1)$$

Here, Y_i is the outcome of interest for household i at follow-up, T_i is a dummy variable equal to 1 if the household is assigned to the treatment group and 0 otherwise. β is the estimate of the average impact of the intervention at follow-up. Since randomization is stratified by district, we include V_j, which is a dummy variable equals to 1 if household i comes from district j (from a total of 5 districts). Since all of our variables are at the household level, we do not cluster standard errors. Lastly, X_i refers to the baseline value of the outcome for household i.

As a robustness check and to select controls in a more principled way and test the sensitivity of our results, we use the double-lasso methodology proposed by Belloni et al. (2014). The method works in two steps: first, it uses lasso regression to find out which variables are good at predicting the outcome of interest; then, it uses another lasso regression to see which variables influence the main variables we are interested in. This two-step process helps to make sure important variables are not left out.

4.3 Quantile and Heterogenous Treatment Effects

Households may be different regarding their ability to farm pigs which may lead to heterogeneity in program effect. We test for that using quantile treatment effects on monthly total income, monthly pig-rearing income, household assets index, and monthly non-food expenditures. We estimate the following quantile treatment effects (QTE) specification:

$$\Delta_{QTT}(\tau) = q_1(\tau|R = 1) - q_0(\tau|R = 0) \tag{2}$$

where $(\tau|R = 1)$ is the τ-th quantile of potential outcomes Y_D under treatment. This model assumes complete adherence to the randomized assignment in order to estimate the effects of the treatment on those who received it. Considering that the program has almost perfect compliance, this simplification in the analysis is reasonable and does not pose a risk of introducing bias.

To measure differential impacts by baseline characteristics, we employ two approaches one for binary and the other for discreet indicators. For the binary indicator, we estimate the following standard specification:

$$Y_i = \alpha + \beta_1 T_i + \gamma Z_i + \delta T_i * Z_i + \sum_{j=1}^{n} V_j + \epsilon_i \tag{3}$$

Where Z_i is a binary indicator measured at baseline i.e. Ebola in this study. We define Ebola as 1 if the total incidence rate in the district is over 150 (per 100,000 individuals) as of October 2015. The parameters of interest are then β, which measures the treatment effect for districts with lower Ebola incidence (i.e., less than 150 per 100,000 individuals) and δ for the differential treatment effect for districts with higher Ebola incidence relative to those with a lower Ebola incidence.

For discrete indicators like the number of pigs at baseline, we use a doubly robust CATE methodology proposed by Lee et al. (2017). This method is designed to provide unbiased treatment effect estimates even if one part of the model (either the outcome model or the treatment assignment model) is misspecified. Consequently, the resulting estimator is more reliable when there are concerns about the correct specification of the model. Moreover, the doubly robust method is particularly useful for capturing complex and nonlinear relationships between treatment and outcomes across different subgroups. In contrast, including a continuous interaction term in a regression assumes a linear relationship between the interaction term and the treatment effect, which might not capture more complex or nonlinear patterns in the heterogeneity.

4.4 Multiple Hypothesis Testing

We examine multiple outcomes in our study, which increases the likelihood of generating false positives. In this paper, we study six primary outcomes, 4 mechanism outcomes, and a lot of other outcomes used to support the results we get in our primary outcomes. With 10 outcomes and assuming a test significance level of 0.05,

$$1 - P(1 - 0.05)^{10} = 0.40 \tag{4}$$

We have a 40% probability of observing at least one significant results, even if all of the tests are actually not significant. To control for the false discovery rate (FDR), for all outcomes, we report the adjusted p-values after controlling for the family-wise error rate at the 95 percent level using the step-down bootstrap algorithm provided by Romano and Wolf (2010). The adjusted p-values from the bootstrap method are based on 1000 replications.

5 Design Integrity

5.1 Baseline Balance

To ensure baseline balance, we employ the same empirical specification used for the outcome analysis (equation 1), which compares baseline treatment and control households while controlling for randomization stratification and baseline value of the outcome. The results of this comparison are presented in Table 4, which indicates that there are no statistically significant or economically meaningful differences across groups for all main outcome indicators at baseline. However, out of the 20 variables that could potentially influence our primary outcomes of interest, we observe statistically significant differences for the primary respondent being a woman at the 1% level and engagement in other livestock at the 5% level. Specifically, treatment households are 8.2 percentage points more likely to have a woman as a primary respondent and 1.8 percentage points more likely to be engaged in the rearing of livestock other than pigs. These differentials may lead to an under or over-estimation of treatment effects. To address this issue, we include these variables as covariates in a robustness regression for the primary outcomes presented in the appendix. We find that the results with and without these covariates do not differ in sign or significance. In Table A1 of the Appendix, we also assess baseline balance on the sample retained at follow-up and find results similar to those in Table 4.

Since this project was implemented in districts that are very different from each other with respect to the Ebola incidence rate, it is crucial to examine whether the main outcomes are consistent across different regions with varying levels of Ebola incidence. Any pre-existing significant differences in the project outcomes between these regions could potentially bias our analysis of heterogeneity. In order to address this issue, in Table A2 we interacted the treatment status with a binary indicator Ebola, which equals 1 for districts with an Ebola incidence rate of over 150 (per 100,000 individuals). We find no statistically significant pre-existing differences (except for gender and involvement in salaried employment by the household) in districts with higher incidence rates of Ebola across groups for all the main outcome indicators at baseline.

Table 4: Baseline Balance Test (Full Sample)

	(1) Control Mean/SE	(2) Treatment Mean/SE	T-test Difference (1)-(2)	Normalized difference (1)-(2)
Household Characterstics				
Primary Respondent is Women	0.839	0.921	-0.082***	-0.255
	(0.020)	(0.014)		
Age of the Respondent	37.331	38.153	-0.822	-0.074
	(0.608)	(0.565)		
Household Size	7.204	7.227	-0.023	-0.009
	(0.145)	(0.129)		
School-age Children are going to Shool	0.804	0.838	-0.034	-0.110
	(0.017)	(0.015)		
Household has a disable person	0.155	0.133	0.022	0.064
	(0.020)	(0.017)		
Consumption and Food Security				
Food Insecurity Scale	12.125	11.832	0.294	0.055
	(0.317)	(0.256)		
Household is Moderately Food Insecure	0.443	0.444	-0.000	-0.001
	(0.027)	(0.025)		
Household is Severely Food Insecure	0.526	0.520	0.006	0.011
	(0.027)	(0.025)		
Perceived Poverty	0.964	0.957	0.007	0.035
	(0.010)	(0.010)		
Total Household Non Food Expenditures (USD)	37.925	40.571	-2.646	-0.103
	(1.457)	(1.273)		
Household Engaged in Productive Activities				
Pig Rearing	0.036	0.051	-0.015	-0.071
	(0.010)	(0.011)		
Other Livestock	0.000	0.018	-0.018**	-0.182
	(0.000)	(0.007)		
Self Agriculture	0.161	0.133	0.028	0.081
	(0.020)	(0.017)		
Commercial Agriculture	0.435	0.423	0.011	0.023
	(0.027)	(0.025)		
Wage Employment / Day Labor	0.100	0.092	0.008	0.029
	(0.017)	(0.015)		
Salaried Employment	0.198	0.245	-0.047	-0.114
	(0.022)	(0.022)		
Petty Trader	0.410	0.446	-0.036	-0.073
	(0.027)	(0.025)		
HH Assest Ownership Index (Polychoric PCA)	0.018	-0.031	0.049	0.038
	(0.076)	(0.060)		
HH Number of Income Generating Activities	2.157	2.229	-0.072	-0.065
	(0.058)	(0.058)		
Monthly Household Income				
Total Household Income (USD)	129.443	135.871	-6.428	-0.048
	(7.468)	(6.751)		
N	329	392		

Notes: Outcomes are listed on the left, and described in detail in Table A1. For each outcome we report the mean of the control group, treatment group, the difference between the two, and normalized differences. The value displayed for t-tests is the differences in the means across the groups. All regressions include strata fixed effects. All missing values in variables were replaced by the mean of either the treatment or the control group.***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

5.2 Compliance & Contamination

We track monitoring data collected by BRAC Sierra Leone program staff on all program beneficiaries throughout the implementation. Table 5 summarizes the treatment compliance results as reported in the survey. We find the program successfully delivered its components according to the randomized assignment. At follow-up, 96% of the treatment household reported receiving the 7-day training, compared to 5% in the control group. Among those who received training, 95% in the treatment group also received the asset transfer (pigs), compared to only 5% in the control group. The remaining three components (pig rearing tools, pig shed, and pig feed) were optional program components and were given only if demanded by the beneficiary. This data suggest high compliance with the randomization assignment and successful implementation of the program. It also reveals differential household preferences for optional program components, probably because households either had those components or did not feel the need.

Table 5: Compliance

	Control		Treatment	
	N	Mean	N	Mean
Received Training	330	5%	391	96%
Received Pigs	330	5%	391	95%
Received Pig Rearing Tools	330	2%	391	50%
Received Pig Shed	330	3%	391	33%
Received Pig Food	330	4%	391	84%

Notes: As reported by the main respondent in the endline survey.

Given that both treatment and control households reside in the same districts, we also examined the possibility of contamination that may arise due to control households infiltrating the treatment or the treatment households sharing program components with households in the control group. To examine the extent of contamination, we report in Table 5 the mean values of the five key program components for the control group. We find that control households received minimal to no program components. To further investigate this matter, in the follow-up survey, we enquired about the source of program components from respondents who confirmed receiving any program components and found that the vast majority of control households reported obtaining program components from other non-governmental organizations or agencies, indicating that there was minimal spillover from our treatment households to the control households in the same district [not shown in Table 5].

In Table A8 of the appendix, we present local average treatment effect (LATE) estimates on our primary outcomes and find them highly comparable with our intention-to-treat estimates (ITT) from equation 1 in Table 6. This indicates that program compliance was effectively achieved. Specifically, taking this together with Table 5 suggests that all treated households received the program components, while the control group households remained untreated. These findings provide robust evidence of the successful intervention implementation, underscoring the absence of contamination and other external factors that could compromise the validity of our study results.

5.3 Attrition

The private lottery assigned 392 households to treatment and 329 households to the control group. The endline survey was successfully completed among 380 treatment households (97%) and 299 control households (91%). In Table A3 of the appendix, we check for the difference in attrition rates between treatment and control groups and find the difference to be statistically significant. Specifically, households in the control group are 6.1 percentage points more likely to be attrited than those in the treatment group. In the same table, we also compare attrition rates in districts with high and low Ebola incidence and find households in the control group residing in low Ebola incidence rate districts to be 11.7 percentage points more likely to attrit at the endline compared to households in the treatment group in the same districts. The overall attrition in districts with a high Ebola incidence is 2.5% and insignificant. As differential attrition can bias impact estimates, we report upper and lower bounds estimates by trimming the tails of the distribution following the methodology proposed by Lee (2009).

6 Results by Outcome Group

6.1 Income

Table 6 presents the impact on total monthly income and monthly income from pig-rearing activities. Total monthly income increased by USD 23 (FWER-corrected p-value < 0.01) or 16% of the control group. Almost 75% of this increase is explained by the increase in income from being involved in pig-rearing activities, which went up by USD 17 (FWER-corrected p-value < 0.01) or 99% of the control group. We further investigate this in Table A4-1 and Table A4-2 of the appendix. We find that households in the treatment group are getting most of their income from pig-rearing activities. We also find a 64% and 74% decrease in income from being engaged in agriculture for self and other business activities for treated households relative to the control households as shown in Table A4-1. This result could reflect that households in the treatment group spend more time in pig-rearing activities, thus leaving less time for their previous income-generating activities. We confirm this explanation in Table A4-2 and find households in the treatment group to be 16.4 percentage points (86% of the control group) significantly more likely to be involved in pig rearing after the program, 11 percentage points (60% of the control group) less likely to be involved in agriculture activities for self and 2.3 percentage points (69% of the control group) less likely to be involved in other business activities. We interpret this finding as a substitution effect of the program that encourages households in the treatment group to be more involved in pig rearing and consequently leads them away from activities that are less profitable.

6.2 Food Security

We measure food security using the household food insecurity access scale by Coates et al. (2007). This scale is a continuous indicator with lower values meaning less food insecurity. In Table 6, we find significant impacts on our food insecurity scale, which decreases by 0.265 points (FWER-corrected p-value < 0.01) or 168% relative to the control group. This decrease in food insecurity translates into a 14.3 percentage point (FWER-corrected p-value < 0.0005) decreased probability of being severely food insecure relative to the control group households. In Table A5-1 of the appendix, we also look at other measures of food security and find improvements in several areas. Specifically, the likelihood that all household members have enough variety of foods to choose from for their meals increases by 5.2 percentage points or 44% (FWER-corrected p-value < 0.05) relative to the control group. Similarly, we find 13.8 percentage points (FWER-corrected p-value < 0.01) fewer households where any household member had to go to sleep hungry because of insufficient food. The number of households where any household member had to go through the whole day without eating anything decreased by 4 percentage points or 45% (FWER-corrected p-value < 0.01) relative to the control group. While we don't directly measure the quantity of food and calorie-based measures of food security, specific consumption of food items in the last seven days suggests treatment households consuming significantly more cereals, fruits, and vegetables relative to the control group (Table A5-2).

6.3 Non Food Expenditures

The increase in total income as a result of the program is expected to increase non-food expenditures as well. As Table 3 shows, monthly non-food expenditures increased by USD 5 (FWER-corrected p-value < 0.01) or 25% relative to mean non-food expenditures in the control group. The increase in total income explains almost 22% of the increase in non-food expenditures. We further explore this in Table A7 of the appendix and find the increase in non-food expenditures to be driven primarily by expenditures in child education, child welfare, and adult welfare. We define child and adult welfare as the sum of expenditures on clothing and footwear. These results suggest an annual increase of 31 USD in child education, 16 USD in child welfare, and 7 USD in adult welfare for treatment households relative to those in the control group. These findings are consistent with previous research on resource transfer interventions that target women, which has shown that interventions that target women are associated with improved education and health outcomes for children (Yoong et al. (2012)).

Table 6: Impact on Income, Food Security, Non Food Expenditures and Assets

VARIABLES	(1) HH Total Income	(2) HH Pig Income	(3) HFIAS	(4) Severed FIS	(5) Non Food Exp	(6) Assest Index
Treatment Effect	23.287***	17.359***	-0.265***	-0.143***	5.138***	0.177**
	(5.023)	(3.007)	(0.067)	(0.035)	(1.275)	(0.073)
Control Mean	144	17.49	0.158	0.600	20.40	-0.320
% Control Mean	16.17	99.25	168.2	23.82	25.19	55.33
Romano-Wolf [pval]	0.000	0.090	0.000	0.000	0.000	0.016
Wilcoxon Rank-sum [pval]	0.000	0.000	0.000	0.000	0.000	0.1251
Observations	679	679	679	679	679	679
Lower Bound	14.048**	10.042**	-0.337***	-0.178***	2.535	0.034
	(6.839)	(1.967)	(0.102)	(0.047)	(2.104)	(0.113)
Upper Bound	29.319***	20.416***	-0.051	-0.111**	7.287***	0.260**
	(7.059)	(2.146)	(0.092)	(0.046)	(2.357)	(0.113)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010), upper and lower bounds following the procedure suggested by Lee et al. (2017), and p-values from the Mann-Whitney-Wilcoxon (rank-sum) test that is robust to the presence of outliers. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure. Non-Food Exp is monthly nonfood expenditures expressed in USD terms. The asset index is constructed using polychoric principal component analysis (PCA) on the number of assets owned.

6.4 Assets

We also study the program's impact on the accumulation of durable assets. For asset ownership, we use an index estimated through polychoric principal component analysis (PCA). As Table 6 shows, we find an increase in the index of durable assets by 0.177 standard deviations (FWER-corrected p-value < 0.05) for households in the treatment group. This represents an increase of 55% relative to the control group. In Table A6 of the appendix, we further investigate asset accumulation and find that a higher proportion of households in the treatment group hold pig pens (95% vs 60%), radios (67% vs 58%), and fans (14% vs 9%) compared to similar households in the treatment group. The overall increase in asset ownership in our study is similar to results reported in Banerjee et al. (2015) and Bedoya et al. (2019). It is however important to note that the nature of assets that go in the construction of the asset index may be different across studies. Lastly, in Table A6 of the appendix, we find a decrease in the ownership of agricultural land (5 percentage points) and farming tools (6 percentage points) among households in the treatment group relative to those in the control group. As we explain later, we believe this is due to the increased involvement in pig-rearing activities and, therefore, signals a lack of need for those items.

6.5 Mechamisms

To dissect the impact of the program and explore potential mechanisms, In Table 7, we look into the mechanism through which the program may have improved our main outcomes among those who participated in the program. To do this, we look at involvement in pig-rearing activities at the time of the endline interview, the total pigs born, sold, and consumed in the last six months. We find that households in the treatment group are 16 percentage points (FWER-corrected p-value < 0.05) more likely to involve in pig-rearing activities, which represents an increase of 86% relative to households in the control group. Moreover, the total number of pigs born, sold, and consumed in the last six months is positive and significantly higher (FWER-corrected p-value < 0.05) in the treatment group relative to the control group, which explains the increase in our primary outcomes in Table 6.

The results of the study show that only 37% of households in the treatment group were involved in pig-rearing activities at the endline. This may be due to various challenges faced by households in managing a higher number of pigs. Despite the training provided by the program, households may have lacked the resources and knowledge necessary to manage more pigs. For instance, they may not have had sufficient space or the financial means to purchase the inputs required for pig-rearing at a large scale, such as feed and medicine. In Figure 3, we provide evidence in support of this explanation by showing conditional average treatment effects for each level of pigs owned at baseline. We use the doubly robust conditional average treatment effect method proposed by Lee et al. (2017) to generate the conditional average treatment effects (CATE) plots in Figure 3. This method works well even if some assumptions about the data or the model aren't exactly correct and don't suffer from the curse of dimensionality. Each specification in Figure 3 controls for stratification dummies and the baseline value of the outcome. The dotted horizontal line in Figure 3 refers to the average treatment effect. All monetary amounts are expressed in USD terms.

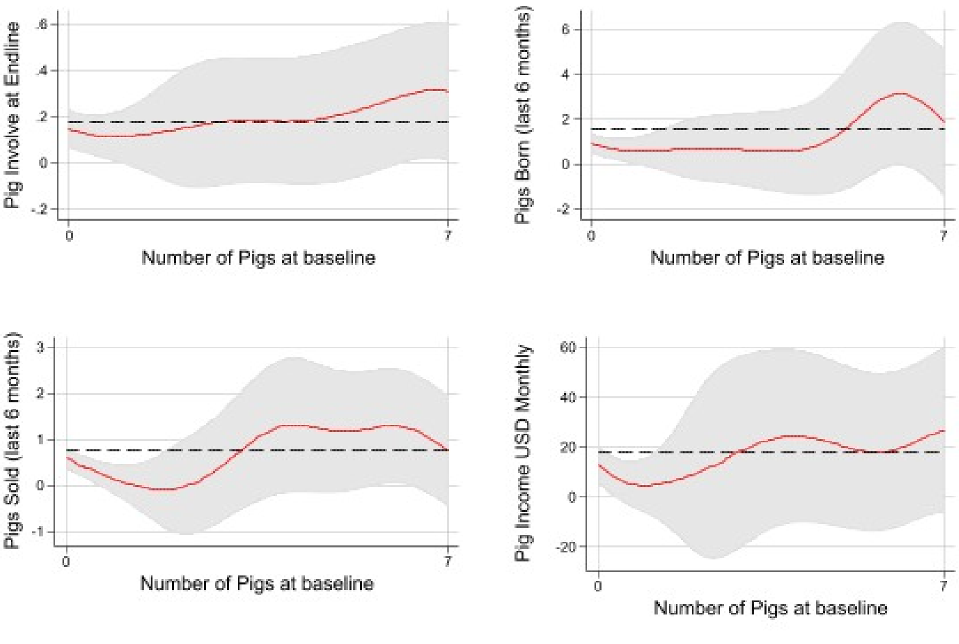
We find that households with higher prior experience in rearing pigs (proxied by the number of pigs at baseline) are more likely to be involved in pig rearing at ending, rear and sell more pigs and consequently have higher income from pig rearing compared to those with a lower number of pigs at baseline. It is possible that treated households with lower pig-rearing experience at baseline may have shifted to other income-generating activities that they find easier to manage by the endline. These findings suggest that programs aimed at promoting pig-rearing activities should also focus on providing households with the necessary resources and knowledge to manage a higher number of pigs, particularly for those with little prior experience. Such efforts could lead to higher participation rates and greater household income gains.

Table 7: Mechanisms

	(1) Pig Involve	(2) Pigs Born	(3) Pigs Sold	(4) Pigs Consume
Treatment Effect	0.164***	1.573***	0.750***	0.072***
	(0.028)	(0.262)	(0.117)	(0.027)
Control Mean	0.190	0.763	0.263	0.0400
% Control Mean	86.09	206	284.8	179
Romano-Wolf [pval]	0.000	0.000	0.000	0.007
Wilcoxon Rank-sum [pval]	0.000	0.000	0.000	0.000
Observations	679	679	679	679
Lower Bound	0.131***	0.668**	0.380**	-0.008
	(0.041)	(0.295)	(0.155)	(0.033)
Upper Bound	0.198***	1.759***	0.840***	0.085**
	(0.046)	(0.419)	(0.169)	(0.037)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010), upper and lower bounds following the procedure suggested by Lee et al. (2017), and p-values from the Mann-Whitney-Wilcoxon (rank-sum) test that is, robust to the presence of outliers. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. Pig Involve is a binary indicator (1/0) which equals 1 if the household is involved in pig rearing at the time of the follow-up interview. Variables in column (2), (3), and (4) refers to the number of pigs born, sold, and consumed by the household in the last 6 months.

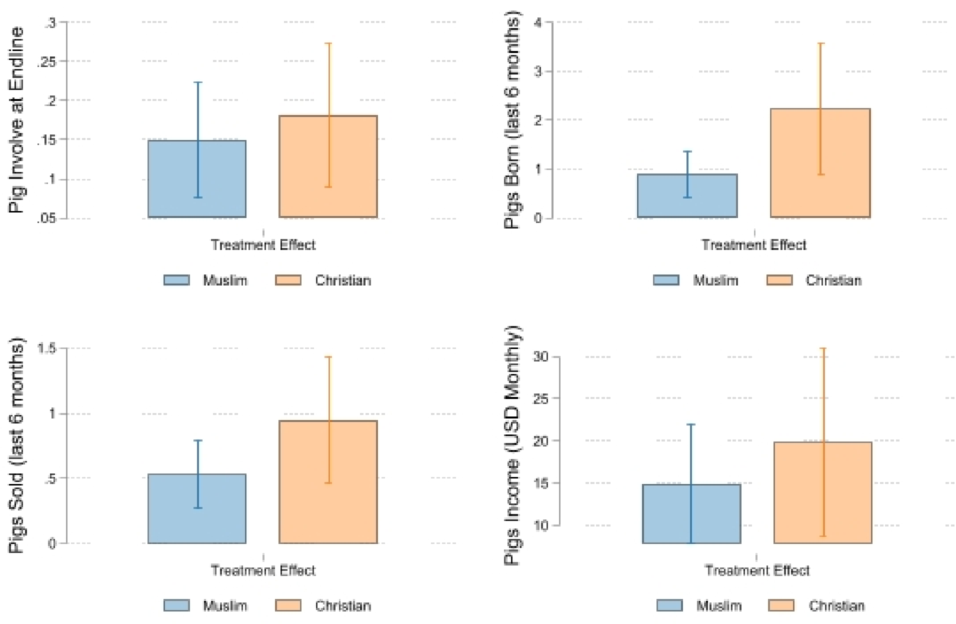
Figure 3: Conditional Average Treatment Effect on Mechanisms by Number of Pigs at Baseline



Another possible explanation for the low level of interest in continuing to rear pigs is the possibility of preference heterogeneity across households. While the program successfully increased the number of pigs born, sold, and consumed by households in the treatment group (Table 7), it is possible that not all households had the same preferences or attitudes toward pig rearing. Some households may have preferred other income-generating activities or had cultural or religious objections to pig rearing. We do find some evidence to support these claims in our data.

In Figure 4, we explore conditional average treatment effects by religion, equalling 1 if the household is Christian and 0 if the household classified themselves as Muslims at baseline. We find that Christian households are more likely to be involved in pig rearing at endline, rear, and sell more pigs in the last six months and consequently have more income from pigs. Such differences in activity levels and income suggest a significant degree of preference heterogeneity between Christian and Muslim households. This distinction can largely be attributed to the religious obligations inherent in each group. This also underscores the importance of taking into account the socio-cultural and religious backgrounds of the beneficiaries in designing and implementing asset transfer programs.

Figure 4: Conditional Average Treatment Effect on Mechanisms by Religion (1 = Christians, 0 = Muslims)

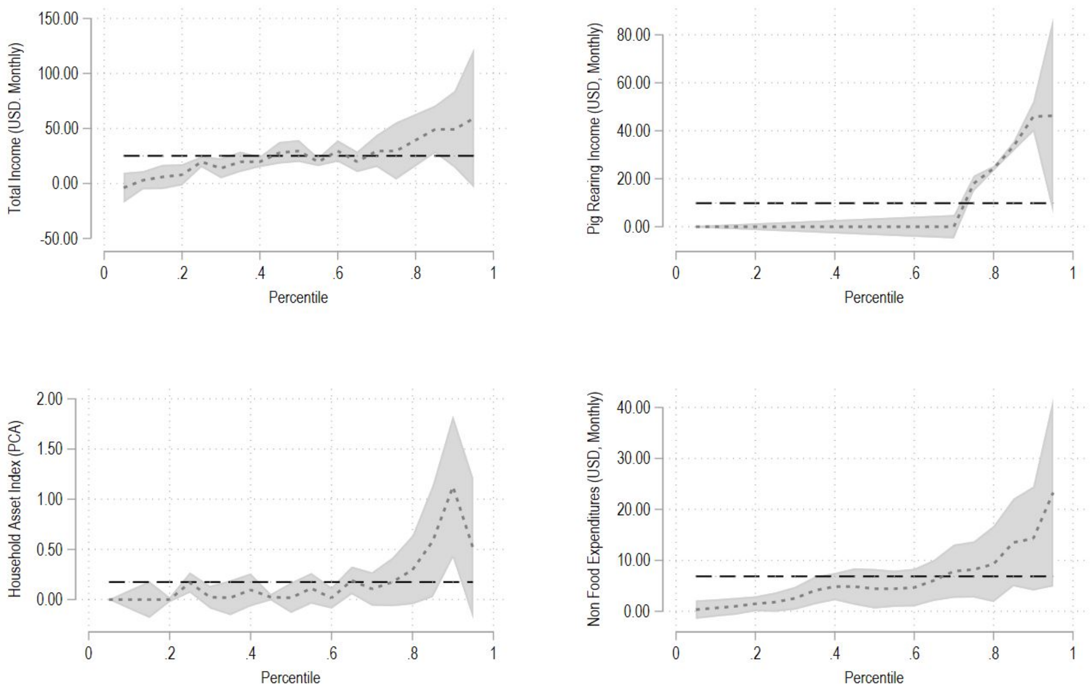


6.6 Quantile Treatment Effects

The impact of asset transfer programs is typically heterogeneous for various reasons. First, if there's a risk of falling into poverty, the effects may vary depending on how close a household is to that tipping point. Then differences in things like prior experience in livestock ownership or entrepreneurship skills can affect program outcomes, even if we can't see these differences directly.

In Figure 5 we present treatment effects on total income, pig-rearing income, household asset index, and non-food expenditures at each percentile. We find treatment effects on all outcomes to be nonnegative at each centile, but they become significantly larger at higher centiles. For total income, the effect on the 90th centile is roughly 40 times that on the 10th centile. We see a similar pattern for all other outcomes in Figure 5, where the effects become largely for higher centiles. Therefore, for our study population, there is significant variation in the effect of the treatment. Most likely, there will be a variety of factors that could explain these differences.

Figure 5: Quantile Treatment Effect on Main Outcomes



6.7 Heterogeneous Treatment Effects by Incidence of Ebola

Given the Ebola epidemic in Sierra Leone, it is essential to investigate whether districts with a higher incidence rate of Ebola experienced different impacts from the program compared to districts with a lower incidence rate. To investigate further into this heterogeneity, we created an Ebola incidence variable taking the value of 1 for districts with an Ebola incidence rate of over 150 (per 100,000 individuals) and 0 otherwise. In Table 8, we report the results of a standard OLS regression with an interaction dummy and find that the impact of the pig transfer program differed significantly between districts with higher and lower incidence rates of Ebola. Specifically, while the overall impact of the program on our main outcomes is positive and significant (Table 6), treatment households in districts with a higher Ebola incidence have significantly less total income and pig income relative to treatment households residing in a district with a lower Ebola incidence rate. These differences are large in magnitude and both economically and statistically significant. In Table 8, we find the interaction (Treatment x Ebola) on total income to be -20.21 USD (p-value < 0.05) and on pig income to be USD -5.3 (p-value < 0.01).

The treatment effect on food insecurity index is negative but not statistically significant for households in the high Ebola incidence districts, suggesting that the overall decrease in food insecurity on our main outcome is primarily being driven by households residing in districts with a low Ebola incidence. The household asset index goes up by 0.22 SD for treatment households in the high Ebola incidence districts, whereas, for those in the low Ebola incidence districts, it is positive but imprecisely estimated. We explore this further in Table A9 of the appendix and find no difference in the choice of asset ownership among treatment households living in these districts.

The lower treatment effect on main outcomes for treatment households in the higher Ebola incidence districts suggests that the asset transfer program isn't working for them as expected. If that's the case, these households wouldn't be able to rear pigs as efficiently as treatment households residing in low Ebola incidence districts. We checked this hypothesis in Table 9. Once again, we find the interaction term to be significant and negative across all outcomes. Treatment households in high Ebola incidence districts are 16.9 percentage points (p-value < 0.01) less likely to be involved in Pig Rearing at the endline and have lower levels of pigs born, sold, and consumed (all significant at least 5% level) relative to treated households in the low Ebola incidence district.

While we cannot be entirely sure about the true reasons responsible for the heterogeneity of the program by the incidence rate of Ebola, we present summary statistics that signal some of the reasons discussed above. In Table 10, we present mean values for households interviewed in districts with low and high Ebola incidence at endline. Firstly, the percentage of households who identified themselves as Muslims at endline is 11% higher in high Ebola districts relative to households in the low Ebola districts. Certain religious obligations may have hindered these households from fully engaging in pig-rearing activities.

Secondly, we asked households how accessible or available is pipe-borne water and borehole water to them. We present response summaries to these questions in Table 10. Access to pipe-borne water is low in both types of districts, whereas access to borehole water is significantly less in districts with high Ebola incidence. Similarly, access to any government agency providing support to pig rearers is only 7% in high Ebola districts compared to 14% in low Ebola incidence districts. This lack of infrastructure and community support may also explain the low treatment effects of the program in districts with high Ebola incidence. Finally, we explore reasons for pig rearing not being a profitable activity in both types of districts. For households who report pig rearing not being profitable in the last 6 months, we ask for potential reasons. We find lack of market demand, financial support, and poor quality products to be the primary reasons for the pig rearing activity not being profitable as reported by households at the endline.

It's important to point out that the higher incidence of Ebola in certain districts isn't exogenous, its relationship with the differences we see in the program's success across districts might be influenced by other factors that are also related to the incidence of Ebola. To ensure that religious differences weren't affecting our results, we included religion in our analysis and found that the program's effectiveness was similar regardless of the religious makeup of the district. This suggests that religion isn't driving the differences we see in Tables 8 and 9. However, because Ebola's occurrence is intertwined with many local factors, we should be cautious when interpreting these findings. The impact of Ebola on our program's outcomes is complex and may not be entirely clear-cut.

Table 8: Heterogeneous Treatment Effect on Income, Food Security, Non-Food Expenditures and Assets by Incidence of Ebola

VARIABLES	(1) HH Total Income	(2) HH Pig Income	(3) HFIAS	(4) Severe FIS	(5) Non Food Exp	(6) HH Assest PCA
Treatment Effect (Ebola=0)	35.728***	25.166***	-0.536***	-0.294***	5.331***	0.107
	(7.813)	(4.185)	(0.097)	(0.059)	(1.998)	(0.092)
Treat x Ebola	-20.216**	-12.697**	0.438***	0.246***	-0.314	0.113
	(10.278)	(5.859)	(0.134)	(0.073)	(2.633)	(0.139)
Treatment Effect (Ebola=1)	15.512**	12.470***	-0.098	-0.048	5.017***	0.221**
Control mean Ebola=1	150.1	23.27	0.155	0.521	14.97	-0.172
Control mean, Ebola=0	133.4	7.515	0.163	0.736	29.77	-0.575
Observations	679	679	679	679	679	679

Notes: This table reports standard OLS estimates. We use treatment status as our instrument and exposure to the program as our independent variable for the IV specification. We define exposure to the program as a binary variable (1/0) that equals 1 if the beneficiary got both of the mandatory components of the program i.e. training and pigs. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure.

Table 9: Heterogeneous Treatment Effect on Mechanisms by Incidence of Ebola

	(1) Pig Involve	(2) Pigs Born	(3) Pigs Sold	(4) Pigs Consume
Tretment Effect (Ebola=0)	0.267***	2.282***	1.085***	0.163***
	(0.046)	(0.471)	(0.179)	(0.048)
Treat x Ebola	-0.169***	-1.154**	-0.545**	-0.149***
	(0.058)	(0.572)	(0.235)	(0.058)
Treatment Effect (Ebola=1)	0.099***	1.128***	0.540***	0.014
Control mean Ebola=1	0.237	0.947	0.300	0.0421
Control mean, Ebola=0	0.109	0.445	0.200	0.0364
Observations	679	679	679	679

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. Pig Involve is a binary indicator (1/0) which equals 1 if the household is involved in pig rearing at the time of the follow-up interview. Variables in column (2), (3), and (4) refers to the number of pigs born, sold, and consumed by the household in the last 6 months.

Table 10: Infrastructure Access & Community Support by Incidence of Ebola

	Low Ebola Incidence		High Ebola Incidence		
	N	Mean	N	Mean	(p-value)
Religion					
Percentage of Christians (rest are Muslims)	266	51%	413	40%	0.004
Infrastructure Access					
Pipe Borne Water	266	11%	413	15%	0.193
Bore Hole Water	266	92%	413	78%	0.000
Community Support					
Any government service for pig rearers	266	14%	413	7%	0.002
Any NGO support for pig rearers	266	75%	413	73%	0.676
Reasons for pig rearing not being profitable					
Lack of Market / Demand	35	14%	43	19%	0.616
Too many Competitors	35	0%	43	7%	0.114
Lack of Financial Support	35	26%	43	63%	0.001
Lack of Technical Inputs (vaccine)	35	14%	43	14%	0.967
Poor / Small Quality Products	35	31%	43	70%	0.001
Poor Management Skills	35	23%	43	5%	0.016
Poor Transportation	35	6%	43	2%	0.445

Notes: As reported by the main respondent in the endline survey.

7 Robustness Checks

We perform five types of robustness checks on our primary outcomes. First, to check whether our results are driven by the presence of outliers, we use Rank-sum statistics to test the equality of distributions of our primary outcomes over the treatment and control groups (Boos et al. (2013). We report these in Tables 6 and 7, respectively. This test employs a nonparametric approach that uses the data distribution instead of the actual outcome value and is, therefore, robust to the presence of outliers. Except for the asset index, the p-values we get from the rank-sum tests are similar to those we get from our main specification and therefore do not change any of our results.

Second, we remove all regression covariates (5 district stratification dummy variables to assess whether possible unanticipated stratification imbalances influence results. Results are presented in Table 10 of the appendix. We find small changes in point estimates for primary outcomes and a slight increase in standard errors when we remove stratification dummies. Given our main results are highly significant, this reduction in precision does not change any of our results.

Third, we control for baseline imbalances to see if they explain differences between treatment and control at endline. We find (Table A11) that adding baseline covariates does not change the main results. Fourth, we utilize a double-lasso method (Belloni et al. (2014) to choose controls. Adding baseline covariates chosen by the double lasso algorithm decreases our coefficient estimates (Table A12) but does not affect the sign and significance of our results.

Finally, we test the sensitivity of our results using alternate specifications of the regression adjustment model. Specifically, we use the p-hack specification check proposed by Brodeur et al. (2020) and use all possible combinations of the baseline controls to determine if varying the choice of controls influence our estimated treatment effects. Figures 5, 6, and 7 of the appendix plot the distribution of treatment effects and t-statistics from all specifications for total income, household asset index, and non-food expenditures. We find significant treatment effects for 100%, 96.5%, and 100% of the specifications for total income, asset index, and non-food expenditures respectively. Overall, these results suggest that our treatment effect estimates from the primary specification are highly robust.

8 Cost-Benefit Analysis

The analysis presented in this paper so far shows significant economic gains for the program. However, the per capita cost of the program in 2015 was USD 1,523, which is 6.5 times the minimum wage in Sierra Leone and thus significant. Therefore, it is vital to estimate if the potential benefits of the program outweigh the costs. Table 11 presents the program costs, economic benefits, and estimated returns from the program using a similar framework and assumptions presented in Banerjee et al. (2015). To estimate the cost-benefit ratio, we use a 5% social discount rate, in line with World Bank / IMF guidance IMF (2010). We also check the sensitivity of our results to different discount rates and assumptions about how long the benefits of the program last.

In line with Banerjee et al. (2015), studies reporting cost-benefit analysis of asset transfer programs typically use consumption gains as the primary welfare measure. We don't have a consumption measure in this study and therefore use total income from all income-generating activities as our welfare measure. Given household consumption is typically higher than income, our estimates, while comparable, are conservative relative to other studies. Reported total program costs inflated to year 2 at 5% social discount rate is USD 1,811 per recipient, shown in line 1. To measure total annual income benefit, we multiply our treatment effect on Income in Table 6 by 12. We assume that income impacts one year after the program are equal to those observed two years after the program (lines 2 and 3). Line 4 presents the present value of all future income benefits at a 5% discount rate, assuming the benefits of the program last for 10 years. The benefit-cost ratio (line 6) is calculated by dividing the net present value of future benefits (line 5) and total program costs (line 1). We find the benefit-cost ratio to be 3.52 (line 6), i.e., for every dollar spent, the program generates 3.52 dollars in household income benefits. We test the sensitivity of these results under different conditions and find the benefit-cost ratio to be more than 1 under all scenarios.

We also extend the cost-benefit analysis to districts with different levels of Ebola incidence. In doing so, we discovered a significant divergence in the benefit-cost ratios.

The ratio was notably higher for districts with a low incidence of Ebola, implying a higher return on investment in these areas. However, it is essential to interpret these findings with caution. A lower benefit-cost ratio in high Ebola incidence districts does not necessarily imply the program's failure. On the contrary, it could reflect the program's critical role in mitigating the epidemic's adverse economic effects. Without the program, the economic situation in these areas might have been significantly worse. In other words, the program's impact may have been "absorbed" in buffering against the epidemic's intensity rather than yielding observable economic gains. Consequently, the cost-benefit ratio in these districts, while lower, may still be positive, highlighting the program's essential role during a public health crisis.

The analysis presented in Table 11 does not consider any non-monetary benefits that may have occurred as a result of the program. These may include productivity gains in other income-generating activities or increased psychological well-being due to improved income. Therefore, the potential benefits of this program most likely outweigh the cost per beneficiary, given benefits will accrue in the future while cost is time-bound.

Table 11: Cost-Benefit Analysis

		Sierra Leones	Current USD	USD PPP
	Total Program Costs (per beneficiary)			
	Program Inputs Costs	873,643	172	464
	Salaries of Implementing Organization Staff	910,608	179	484
	Staff & Beneficiary Training	187,392	37	100
	Program Staff Travelling	201,869	40	107
	Administration Costs (Materials, Rent, Stationary etc)	222,931	44	118
	Salaries of Support Staff	346,074	68	184
	Scoping exercise and orientation workshops	123,312	24	66
	Total Costs, calculated as if all incurred immediately at beginning of year 0 i.e. 2015	2,865,828	564	1,523
	Total Costs, Inflated to Year 1 at 10.9% inflation rate in 2016	3,178,203	626	1,689
	Total Costs, Inflated to Year 2 at 18.2% inflation rate in 2017	3,756,636	739	1,996
1	Total Costs, social discount rate adjustment at 5%	3,407,380	671	1,811
	Total Benefits			
2	Year 1, Total Annual Income	1,419,765	279	754
3	Year 2, Total Annual Income	1,419,765	279	754
4	Year 3 - 10 Total Annual Income discounted to year 2 at 5% discount rate	9,161,608	1,803	4,869
5	Total Benefits (2) + (3) + (4)	12,001,138	2,362	6,377
	Total Benefits / Total Costs Ratio at 5% discount rate			
6	Assuming benefits last for 10 years	3.52		
	Assuming benefits last for 5 years	1.97		
	Assuming benefits last for 3 years	1.23		
	Total Benefits / Total Costs Ratio at 10% discount rate			
	Assuming benefits last for 10 years	3.35		
	Assuming benefits last for 5 years	2.05		
	Assuming benefits last for 3 years	1.33		
	Cost-Benefit Ratios at 5% discount rate (Low Ebola Incidence Districts)			
	Assuming benefits last for 10 years	5.41		
	Assuming benefits last for 5 years	3.02		
	Assuming benefits last for 3 years	1.89		
	Cost-Benefit Ratios at 5% discount rate (High Ebola Incidence Districts)			
	Assuming benefits last for 10 years	2.35		
	Assuming benefits last for 5 years	1.31		
	Assuming benefits last for 3 years	0.82		

Notes: Household income includes total income from all income-generating activities. Social discount rate of 5% is applied as per World Bank guidance note (World Bank 2013). Cost estimates are provided by BRAC Sierra Leone. The exchange rates used is provided by the World Bank 1 USD = 5080.75 SL (2015). All monetary amounts are PPP-adjusted USD terms.

8.1 Comparing benefits with other studies

In the analysis provided in Table 11, the interpretation warrants caution due to the numerous assumptions employed to generate the benefit-cost estimates. Nevertheless, our study yields a markedly higher benefit-cost ratio than other investigations. Table 12 reports the cost-per-beneficiary and benefit-cost ratios of our study, with eight comparable experiments conducted in various countries, each employing similar assumptions for calculating benefit-cost ratios. All estimates presented assume a 5% discount rate and a program benefits duration of 10 years.

The Purchasing Power Parity (PPP) adjusted cost per beneficiary in our program amounts to USD 1,811, demonstrating a significant reduction compared to the alternative experiments reported in Table 12. Several distinguishing factors contribute to the cost-efficiency of our study, such as the absence of health components, consumption support, reduced frequency of household visits, and the selection of relatively inexpensive livestock compared to conventional options like cows and goats. As asset transfer programs typically exhibit similarities, the cost per beneficiary should reflect a consistent pattern; however, this is not observed. Our findings highlight the need for more transparent cost documentation methods to enable future programs to minimize expenses without sacrificing benefits. Moreover, multifaceted programs incorporating a variety of benefits for the beneficiaries, in addition to livestock, should theoretically exhibit larger benefit-cost ratios compared to their simpler, more economical counterparts. This observation, however, is not substantiated by the benefit-cost estimates in Table 12. Further research is necessary to ascertain whether achieving comparable or superior benefit levels through cost-effective programs can inform the future design of initiatives that concentrate on components with the most substantial impact.

It is also essential to note that the timing of the evaluation plays a significant role in determining the observed benefit-cost ratios. Some of the programs with lower benefit-cost ratios in Table 12 were evaluated after 3 or 4 years, in contrast to our study, where the evaluation took place after two years. It is possible that the benefits of these programs may have diminished over time, resulting in lower benefit-cost ratios when assessed at a later stage. This further emphasizes the importance of understanding the persistence and evolution of program impacts over different time horizons.

Table 12: Comparing benefits with 8 other countries

	Evaluation	Welfare Measure	Cost per beneficiary (USD PPP)	Benefit / Cost Ratio
Us-Salam (2023)				
Sierra Leone	2 years	Total Income	1,811	3.52
Bedoya et al (2019)				
Afghanistan	2 years	Consumption	6,469	2.32
Bandiera et al (2017)				
Bangladesh	4 years	Consumption + Assets	1,363	1.86
Banerjee et al (2015)				
Ethiopia	3 years	Consumption + Assets	4,157	2.6
Ghana	3 years	Consumption + Assets	5,408	1.3
Honduras	3 years	Consumption + Assets	3,090	-1.98
India	3 years	Consumption + Assets	1,455	4.33
Pakistan	3 years	Consumption + Assets	5,962	1.79
Peru	3 years	Consumption + Assets	5,742	1.46

Notes: All calculations assume a social discount rate of 5% and that program benefits last for 10 years. *Source: Banerjee, Abhijit, Esther Duflo, Nathanael Goldberg, Dean Karlan, Robert Osei, William Parienté, Jeremy Shapiro, Bram Thuysbaert, and Christopher Udry. "A multifaceted program causes lasting progress for the very poor: Evidence from six countries." Science 348, no. 6236 (2015): 1260799. ** Source: Bedoya, Guadalupe, Aidan Coville, Johannes Haushofer, Mohammad Isaqzadeh, and Jeremy P. Shapiro. No household left behind: Afghanistan targeting the ultra poor impact evaluation. No. w25981. National Bureau of Economic Research, 2019. *** Source Bandiera, Oriana, Robin Burgess, Narayan Das, Selim Gulesci, Imran Rasul, and Munshi Sulaiman. "Labor markets and poverty in village economies." The Quarterly Journal of Economics 132, no. 2 (2017): 811-870.

9 Conclusion

This study contributes to the growing literature on the effectiveness of asset transfer programs in lifting households out of poverty, particularly in post-pandemic contexts. We provide empirical evidence from a randomized controlled trial in Sierra Leone, a country that faced substantial economic disruption due to the Ebola crisis. Our study is different from other evaluations in that it takes place in a post-pandemic context and evaluates a program that is relatively simpler compared to other more complex and expensive asset transfer programs.

The findings of this study suggest that women-targeted asset transfer programs can be a powerful tool for improving income, food security, non-food consumption, and asset ownership among ultra-poor households. However, we found the program's impact to be heterogeneous across districts, with more significant effects observed in areas with lower Ebola incidence rates. This underscores the importance of considering the local context when designing and implementing asset transfer programs in post-pandemic settings. The observed variation in treatment effects is believed to be attributed to the infrastructural damage and lack of community support stemming from the Ebola crisis, which may have constrained the program's potential in the hardest-hit areas.

The benefit-cost analysis demonstrates a higher benefit-cost ratio than similar experiments conducted in various countries. Several factors contribute to the cost-efficiency of our program, such as the absence of health components, consumption support, reduced frequency of household visits, and the selection of relatively inexpensive livestock. This aligns with calls for simpler programs as proposed by Banerjee and Duflo (2019). Previous research have aimed to evaluate specific components of a typical ultra-graduation program. For instance, Banerjee et al. (2018) in Ghana focused solely on providing assets (goats) to determine if it would yield a similar impact, which it did not. We contend that while such research is vital for comprehending the underlying mechanisms of program effectiveness, it is equally important to recognize the significance of training households in managing the transferred livestock. We advocate for simpler programs, yet caution against oversimplification.

These results highlight the need for more transparent cost documentation methods and further research to ascertain whether achieving comparable or superior benefit levels through cost-effective programs can inform the future design of initiatives that concentrate on components with the most substantial impact.

Overall, our study has important policy implications. In addition to targeting ultra-poor households for asset transfer programs, this study highlights the need for greater attention to contextual factors, such as the incidence of epidemics and social and cultural norms, and how these factors may affect the implementation and success of development programs. Complementary efforts to rebuild infrastructure, enhance community support, and strengthen local institutions may further amplify the benefits of asset transfer programs in post-pandemic settings. Future research should explore the long-term effects of these programs, as well as their potential to foster resilience among vulnerable populations in the face of future shocks.

10 Appendix

Baseline Balance (Retained Sample)

Table A1: Baseline Balance (Retained Sample)

Variable	(1) Control Mean/SE	(2) Treatment Mean/SE	T-test Difference (1)-(2)	Normalized difference (1)-(2)
Primary Respondent is Women	0.846	0.924	-0.078***	-0.247
	(0.021)	(0.014)		
Age of the Respondent	37.455	38.284	-0.829	-0.074
	(0.643)	(0.574)		
Household Size	7.194	7.184	0.010	0.004
	(0.154)	(0.130)		
School-age Children are going to Shool	0.798	0.836	-0.038	-0.121
	(0.019)	(0.016)		
Household has a disable person	0.157	0.134	0.023	0.065
	(0.021)	(0.018)		
Food Insecurity Scale	11.943	11.887	0.056	0.010
	(0.327)	(0.260)		
Household is Moderately Food Insecure	0.458	0.445	0.013	0.027
	(0.029)	(0.026)		
Household is Severely Food Insecure	0.515	0.518	-0.003	-0.007
	(0.029)	(0.026)		
Perceived Poverty	0.960	0.955	0.005	0.023
	(0.011)	(0.011)		
Total Household Non Food Expenditures (USD)	37.809	40.277	-2.468	-0.096
	(1.514)	(1.290)		
Pig Rearing	0.040	0.047	-0.007	-0.035
	(0.011)	(0.011)		
Other Livestock	0.000	0.018	-0.018**	-0.182
	(0.000)	(0.007)		
Self Agriculture	0.151	0.137	0.014	0.039
	(0.021)	(0.018)		
Commercial Agriculture	0.455	0.424	0.031	0.063
	(0.029)	(0.025)		
Wage Employment / Day Labor	0.097	0.092	0.005	0.017
	(0.017)	(0.015)		
Salaried Employment	0.191	0.242	-0.051*	-0.124
	(0.023)	(0.022)		
Petty Trader	0.408	0.447	-0.039	-0.079
	(0.028)	(0.026)		
HH Assest Ownership Index (Polychoric PCA)	-0.012	-0.028	0.015	0.012
	(0.083)	(0.061)		
HH Number of Income Generating Activities	2.146	2.221	-0.075	-0.067
	(0.063)	(0.059)		
Total Household Income (USD)	130.536	134.449	-3.913	-0.029
	(8.068)	(6.876)		
N	299	380		

Notes: Outcomes are listed on the left. For each outcome we report the mean of the control group, treatment group, the difference between the two, and normalized differences. The value displayed for t-tests is the differences in the means across the groups. All regressions include strata fixed effects. All missing values in variables were replaced by the mean of either the treatment or the control group.***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

10.1 Interacting Ebola with Treatment Status at Baseline

Table A2: Interacting Ebola with Treatment Status at Baseline

	Women	Age	HH Size	S/C Ratio	HH Disable	HFIAS	Moderate FIS	Severe FIS	Perceived Poverty	Non Food Exp
Treated	0.026	0.362	-0.066	0.038	-0.071	-1.249**	-0.003	0.000	-0.006	3.534
	(0.026)	(1.387)	(0.308)	(0.034)	(0.053)	(0.598)	(0.050)	(0.051)	(0.006)	(2.640)
Treat x Ebola	0.088**	0.808	0.132	-0.008	0.072	1.362*	0.015	-0.020	-0.004	-1.203
	(0.042)	(1.706)	(0.397)	(0.046)	(0.057)	(0.730)	(0.069)	(0.070)	(0.024)	(3.623)
Observations	721	721	721	721	721	719	719	719	721	721
R-squared	0.152	0.045	0.007	0.019	0.100	0.287	0.141	0.145	0.048	0.133

	Pig Rearing	Other Livestock	Self Agri	Comm Agri	Day Laborer	Salaried Emp	Petty Trader	Asset Index	IGA	Total Income
Treated	0.023	0.012	-0.091*	-0.044	0.041	0.095**	0.007	-0.092	-0.069	18.790**
	(0.016)	(0.009)	(0.055)	(0.050)	(0.034)	(0.042)	(0.053)	(0.154)	(0.108)	(8.193)
Treat x Ebola	-0.014	0.009	0.091	0.052	-0.080*	-0.074	0.058	0.057	0.231	-17.218
	(0.027)	(0.013)	(0.057)	(0.066)	(0.044)	(0.060)	(0.071)	(0.195)	(0.154)	(16.918)
Observations	721	721	721	721	721	721	721	721	713	721
R-squared	0.080	0.012	0.200	0.212	0.022	0.045	0.075	0.083	0.107	0.105

Notes: Outcomes listed in Table A2 are similar to and follow the same order as those in Table A1. Some of the variable names have been changed for aesthetic purposes. The coefficient on Treated refers to the difference in mean values of the outcome at baseline between Treatment and Control groups for districts with a low Ebola incidence (i.e. Ebola = 0). The coefficient on "Treat x Ebola" reports the differential effect between Treatment and Control groups in high Ebola incidence districts relative to Treatment and Control groups in a low Ebola incidence district. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level OLS regressions with robust standard errors.

10.2 Attrition Analysis

Table A3: Attrition

	(1) =1 if HH attrited	(2) =1 if HH attrited
Treated	-0.061***	-0.117***
	(0.018)	(0.033)
Treat x Ebola		0.092**
		(0.039)
Constant	0.091***	
	(0.016)	
Observations	721	721
Attrition for Ebola=1		-0.025

Notes: OLS regressions with robust standard errors. In Column (1) we report estimates of regression attrition status on treatment assignment. In Column (2) we report estimates of interacting attrition status with our Ebola indicator that equals 1 for districts where the incidence of Ebola is more than 150 (per 100,000 individuals) and 0 otherwise. The coefficient on "Treated" in Column (1) refers to the difference in attrition rates between Treatment and Control groups whereas the coefficient on "Treated" in Column (2) refers to the difference in attrition rates between treatment and control for districts with a low Ebola incidence (i.e. Ebola = 0). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels.

10.3 Impact on Income & Revenues from Productive Activities

Table A4-1: Impact on Income & Revenues from Productive Activities, Monthly

	(1) Other Livestock	(2) Agri Comm	(3) Agri Self	(4) Petty Trade	(5) Salaried	(6) Day Laborer	(7) Other Business	(8) Charcoal/Wood	(9) Other
Treatment Effect	-0.032	4.909*	-8.602***	4.332	1.894	1.361	-3.227**	-1.189	-1.352
	(0.631)	(2.629)	(1.856)	(3.601)	(2.746)	(1.121)	(1.581)	(1.003)	(2.519)
Control Mean	0.722	16.74	14.44	28.75	8.936	2.263	4.363	2.231	13.63
% Control Mean	-4.391	29.33	-59.55	15.07	21.20	60.15	-73.96	-53.29	-9.918
Romano-Wolf [pval]	0.956	0.062	0.000	0.243	0.238	0.253	0.054	0.226	0.502
Observations	679	679	679	679	679	679	679	679	679
Lower Bound	-0.615	-0.061	-9.033***	-0.193	-4.828	-0.983	-4.363***	-1.731	-5.543*
	(1.272)	(3.633)	(2.852)	(5.326)	(3.254)	(1.223)	(1.521)	(1.071)	(3.197)
Upper Bound	-0.024	7.304*	-8.457***	5.753	4.524	1.605	-3.148*	-1.039	-0.911
	(0.646)	(3.783)	(2.678)	(5.497)	(3.178)	(1.310)	(1.671)	(1.000)	(2.880)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010) as well as upper and lower bounds following the procedure suggested by Lee et al. (2017). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms.

10.4 Impact on Involvement in Income & Revenue Activities

Table A4-2: Impact on Involvement in Income & Revenue Activities

VARIABLES	(1) Other Livestock	(2) Agri Comm	(3) Agri Self	(4) Petty Trader	(5) Salaried	(6) Day Laborer	(7) Other Business	(8) Charcoal/Wood	(9) Other
Treatment Effect	-0.002	0.087***	-0.114***	-0.015	0.008	-0.008	-0.023**	-0.009	-0.029
	(0.007)	(0.029)	(0.019)	(0.031)	(0.021)	(0.016)	(0.011)	(0.012)	(0.026)
Control Mean	0.0100	0.213	0.190	0.393	0.0767	0.0500	0.0333	0.0267	0.163
% Control Mean	-18.80	40.56	-59.74	-3.880	10.11	-16.67	-69.01	-32.89	-17.89
Romano-Wolf [pval]	0.806	0.004	0.000	0.734	0.448	0.599	0.046	0.438	0.235
Observations	679	679	679	679	679	679	679	679	679
Lower Bound	-0.006	0.046	-0.119***	-0.040	-0.023	-0.029	-0.033***	-0.016	-0.063**
	(0.010)	(0.044)	(0.031)	(0.049)	(0.025)	(0.019)	(0.010)	(0.014)	(0.030)
Upper Bound	-0.002	0.112**	-0.111***	0.000	0.024	-0.006	-0.022*	-0.008	-0.024
	(0.008)	(0.046)	(0.031)	(0.047)	(0.023)	(0.018)	(0.012)	(0.012)	(0.030)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010) as well as upper and lower bounds following the procedure suggested by Lee et al. (2017). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All variables in Table A4-2 are binary (1/0), equalling 1 if the household is involved in the said income-generating activity.

10.5 Impact on Food Security

Table A5-1: Impact on Food Security

	(1) Enough Food	(2) Food Variety	(3) Smaller Meal	(4) Two Meals	(5) Sleep Hungry	(6) No Food Day
Treatment Effect	0.025	0.052**	-0.036	0.034	-0.138***	-0.040**
	(0.024)	(0.024)	(0.024)	(0.027)	(0.033)	(0.019)
Control Mean	0.127	0.117	0.880	0.170	0.447	0.0867
% Control Mean	19.45	44.31	-4.120	19.83	-30.90	-45.68
Romano-Wolf [pval]	0.254	0.030	0.129	0.142	0.000	0.034
Observations	679	679	679	679	679	679
Lower Bound	0.001	0.015	-0.048	-0.010	-0.178***	-0.063**
	(0.034)	(0.035)	(0.033)	(0.039)	(0.050)	(0.025)
Upper Bound	0.033	0.061*	0.008	0.057	-0.124***	-0.038*
	(0.033)	(0.034)	(0.033)	(0.040)	(0.047)	(0.020)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010) as well as upper and lower bounds following the procedure suggested by Lee et al. (2017). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All variables in Table A5-1 are binary (1/0) and have a recall period of the last 4 weeks. Enough Food is 1 if the household has enough food, Food Variety is 1 if the household has enough variety of food to choose from for their meals, Smaller Meal is 1 if the household member had to eat a smaller meal than needed, Two Meals is 1 if all household members were able to eat at least 2 meals per day, Sleep Hungry is 1 if the household had to go sleep hungry because there was not enough food and No Food Day is 1 if the household had to go through the whole day without eating anything.

10.6 Impact on Food Consumed in the last 7 days

Table A5-2: Impact on Food Consumed in the last 7 days

VARIABLES	(1) Cereals	(2) Pulses	(3) Meat	(4) Dairy	(5) Vegetables	(6) Fruits	(7) Sugar	(8) Oil
Treatment Effect	0.525***	-0.106	0.105	0.060	0.170*	0.176**	-0.114	0.976***
	(0.071)	(0.101)	(0.141)	(0.079)	(0.088)	(0.088)	(0.097)	(0.127)
Control Mean	6.043	2.330	2.223	0.670	3.967	2.057	1.023	4.267
% Control Mean	8.688	-4.538	4.733	8.977	4.288	8.555	-11.16	22.87
Romano-Wolf [pval]	0.000	0.341	0.440	0.325	0.049	0.054	0.231	0.000
Observations	679	679	679	679	679	679	679	679
Lower Bound	0.536***	-0.220*	-0.079	-0.084	0.028	0.029	-0.295**	0.899***
	(0.091)	(0.133)	(0.224)	(0.115)	(0.122)	(0.120)	(0.126)	(0.181)
Upper Bound	0.584***	0.029	0.247	0.123	0.277**	0.269**	-0.042	1.126***
	(0.093)	(0.128)	(0.224)	(0.108)	(0.128)	(0.123)	(0.123)	(0.190)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010) as well as upper and lower bounds following the procedure suggested by Lee et al. (2017). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All variables in Table A5-2 are discreet with values from 1 to 7 representing the number of days the household consumed the specific food item in the last 7 days. Cereals include rice, maize, millet, bread, pasta, and other cereals, pulses include beans, peas, and groundnuts, meat includes meat from fish, chicken, and beef, dairy includes products like milk, yogurt, and cheese, vegetables and fruits include any fruits and vegetables.

10.7 Impact on Household Ownership of Household Assets

Table A6: Impact on Household Ownership of Household Assests

	(1) Homestead Land	(2) Agricultre Land	(3) Farming Tools	(4) Pig Pen	(5) Phone	(6) Radio	(7) Fan	(8) Bicycle
Treatment Effect	0.046	-0.050*	-0.061***	0.355***	-0.003	0.083**	0.045**	0.015
	(0.031)	(0.030)	(0.022)	(0.030)	(0.037)	(0.036)	(0.022)	(0.024)
Control Mean	0.710	0.810	0.930	0.593	0.573	0.580	0.0867	0.103
% Control Mean	6.543	-6.136	-6.530	59.82	-0.580	14.24	51.62	14.77
Romano-Wolf [pval]	0.118	0.099	0.0130	0.000	0.707	0.015	0.009	0.578
Observations	679	679	679	679	679	679	679	679
Lower Bound	0.030	-0.064	-0.068***	0.353***	-0.014	0.061	0.032	-0.018
	(0.041)	(0.039)	(0.026)	(0.031)	(0.042)	(0.042)	(0.031)	(0.028)
Upper Bound	0.095**	-0.024	-0.045	0.380***	0.053	0.128***	0.068**	0.020
	(0.042)	(0.040)	(0.029)	(0.034)	(0.044)	(0.045)	(0.031)	(0.025)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010) as well as upper and lower bounds following the procedure suggested by Lee et al. (2017). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All variables included in Table A5 are binary (1/0) equalling 1 if the household responded yes to the ownership of the respective asset item during the follow-up survey.

Table A7: Impact on Household Non Food Expenditures, 6 months

	(1) Electricity	(2) Transportation	(3) HH Personal	(4) Child Education	(5) Child Welfare	(6) Adult Welfare	(7) Household Items
Treatment Effect	-0.555	1.763	1.093	15.489***	8.042***	3.380***	2.836
	(1.263)	(1.097)	(1.306)	(3.872)	(1.916)	(1.296)	(2.066)
Control Mean	15.41	13.46	13.25	47	14.91	12.50	5.844
% Control Mean	-3.601	13.09	8.253	32.95	53.94	27.04	48.53
Romano-Wolf [pval]	0.866	0.0859	0.320	0.000	0.000	0.0079	0.182
Observations	679	679	679	679	679	679	679
Lower Bound	-2.036	-0.581	-1.959	5.437	4.440	0.105	-1.109
	(1.838)	(1.379)	(1.698)	(5.890)	(3.204)	(1.817)	(2.325)
Upper Bound	0.810	2.823*	2.659	20.618***	9.995***	5.376**	3.947
	(1.630)	(1.534)	(1.918)	(6.176)	(2.648)	(2.292)	(2.416)

Notes: This table reports OLS estimates of treatment effects. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We also report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010) as well as upper and lower bounds following the procedure suggested by Lee et al. (2017). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are 6 months figures expressed in USD terms. Household personal expenditures are the sum of expenditures on cosmetics, hairdressing, and airtime. Child welfare is the sum of expenditures on child clothing and footwear. Adult welfare is the sum of expenditures on adult clothing and welfare. Household items are expenditures on household utensils, furniture, and textiles (sheets, curtains, etc.).

10.8 Local Average Treatment Effects

Table A8: Local Average Treatment Effect on Income, Food Security, Non-Food Expenditures and Assets

	(1) HH Total Income	(2) HH Pig Income	(3) HFIAS	(4) Severe FIS	(5) Non Food Exp	(6) HH Assest PCA
LATE	24.832***	18.507***	-0.283***	-0.152***	5.471***	0.189**
	(5.338)	(3.176)	(0.072)	(0.038)	(1.356)	(0.078)
Mean Control	144	17.49	0.158	0.600	20.40	-0.320
Observations	679	679	679	679	679	679

Notes: This table reports Local Average Treatment Effects (LATE) from an IV specification. We use treatment status as our instrument and exposure to the program as our independent variable for the IV specification. We define exposure to the program as a binary variable (1/0) that equals 1 if the beneficiary got both of the mandatory components of the program i.e. training and pigs. All regressions include strata fixed effects and baseline value of the outcome as control. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure. Non-Food Exp is monthly nonfood expenditures expressed in USD terms. The asset index is constructed using polychoric principal component analysis (PCA) on the number of assets owned.

10.9 Heterogeneity by Household Assets

Table A9: Heterogeneous Treatment Effect on Household Ownership of Household Assets by Incidence of Ebola

	(1) Home Land	(2) Agriculture Land	(3) Farming Tools	(4) Pig Pen	(5) Phone	(6) Radio	(7) Fan	(8) Bicycle
Treatment Effect (Ebola=0)	0.026	-0.019	-0.069**	0.311***	0.011	0.146**	0.012	-0.025
	(0.045)	(0.035)	(0.029)	(0.048)	(0.055)	(0.062)	(0.022)	(0.039)
Treat x Ebola	0.033	-0.050	0.014	0.071	-0.023	-0.103	0.053	0.065
	(0.062)	(0.055)	(0.042)	(0.061)	(0.074)	(0.075)	(0.040)	(0.049)
Treatment Effect (Ebola=1)	0.059	-0.069	-0.055*	0.382***	-0.012	0.043	0.065**	0.040
Control mean Ebola=1	0.642	0.742	0.905	0.558	0.547	0.637	0.121	0.0842
Control mean, Ebola=0	0.827	0.927	0.973	0.655	0.618	0.482	0.0273	0.136
Observations	679	679	679	679	679	679	679	679

Notes: This table reports OLS estimates of treatment effects without strata fixed effects. All regressions control for the baseline value of the outcome. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure.

10.10 Robustness Check: Impact without District Controls

Table A10: Robustness Check: Impact on Main Outcomes Without District Controls

VARIABLES	(1) HH Total Income	(2) HH Pig Income	(3) HFIAS	(4) Severe FIS	(5) Non Food Exp	(6) HH Assest PCA
Treated	24.238***	18.298***	-0.282***	-0.136***	6.472***	0.163**
	(5.287)	(3.492)	(0.077)	(0.038)	(1.566)	(0.081)
Mean Control	144	17.49	0.158	0.600	20.40	-0.320
Romano and Wolf [pval]	0.000	0.000	0.000	0.000	0.000	0.037
Observations	679	679	679	679	679	679

Notes: This table reports OLS estimates of treatment effects without strata fixed effects. All regressions control for the baseline value of the outcome. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure. Non-Food Exp is monthly nonfood expenditures expressed in USD terms. The asset index is constructed using polychoric principal component analysis (PCA) on the number of assets owned.

10.11 Robustness Check: Impact with Baseline Controls

Table A11: Robustness Check: Impact on Main Outcomes With Baseline Controls

VARIABLES	(1) HH Total Income	(2) HH Pig Income	(3) HFIAS	(4) Severe FIS	(5) Non Food Exp	(6) HH Assest PCA
Treated	23.805***	17.749***	-0.267***	-0.141***	4.946***	0.200***
	(5.001)	(2.969)	(0.067)	(0.035)	(1.272)	(0.071)
Mean Control	144	17.49	0.158	0.600	20.40	-0.320
Romano and Wolf [pval]	0.000	0.000	0.000	0.002	0.000	0.006
Observations	679	679	679	679	679	679

Notes: This table reports OLS estimates of treatment effects without strata fixed effects. All regressions control for the baseline value of the outcome. For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. We report FWER-correct pvalues for each outcome following the methodology proposed by Romano and Wolf (2010). ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure. Non-Food Exp is monthly nonfood expenditures expressed in USD terms. The asset index is constructed using polychoric principal component analysis (PCA) on the number of assets owned.

10.12 Robustness Check: Double Lasso

Table A12: Robustness Check: Impact on Main Outcomes With Controls by Double Lasso

	HH Total Income	HH Pig Income	HFIAS	Severe FIS	Non Food Exp	HH Assest PCA
Treated	19.095	16.722	-0.257	-0.136	4.601	0.155
	(4.953)***	(2.980)***	(0.067)***	(0.036)***	(1.265)***	(0.070)*
N	679	679	679	679	679	679

Notes: This table reports OLS estimates of treatment effects. Controls for this regression were chosen by the Double Lasso algorithm and were selected from a complete list of variables in the baseline table (Table 4). For each outcome variable, we report the coefficients of interest and their robust standard errors in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels. All monetary amounts are monthly figures expressed in USD terms. HFIAS is the standardized measure of the Household Food Insecurity Access Scale with a mean of 0 and a standard deviation of 1. Severe FIS is a binary indicator that equals 1 if the household is severely food insecure. Non-Food Exp is monthly nonfood expenditures expressed in USD terms. The asset index is constructed using polychoric principal component analysis (PCA) on the number of assets owned.

10.13 Robustness Check: Specification Curves

Figure 6: Robustness Check: Varying Choice of Controls - Total Income (USD, Monthly)

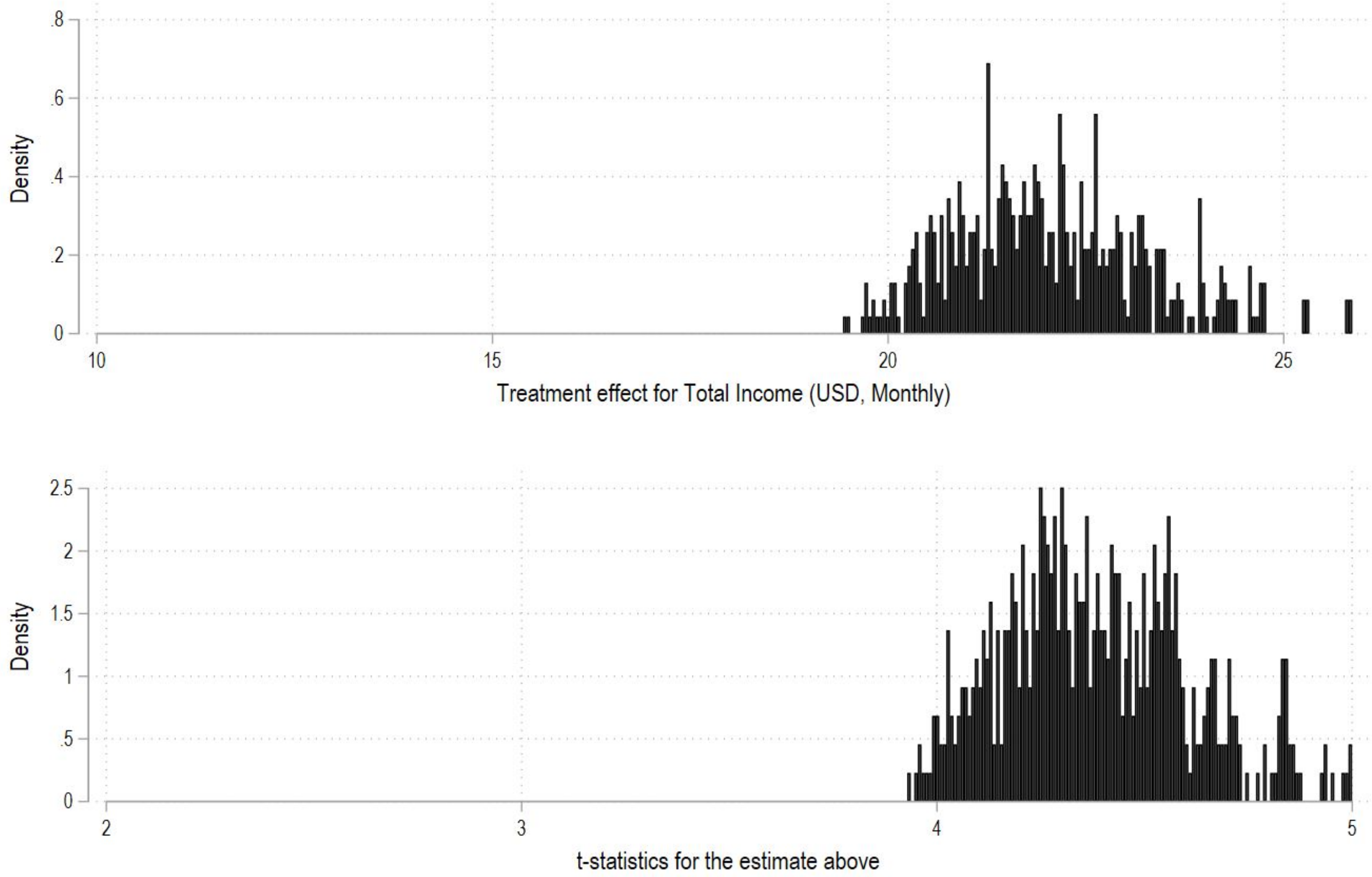


Figure 7: Robustness Check: Varying Choice of Controls - Household Asset Index (PCA)

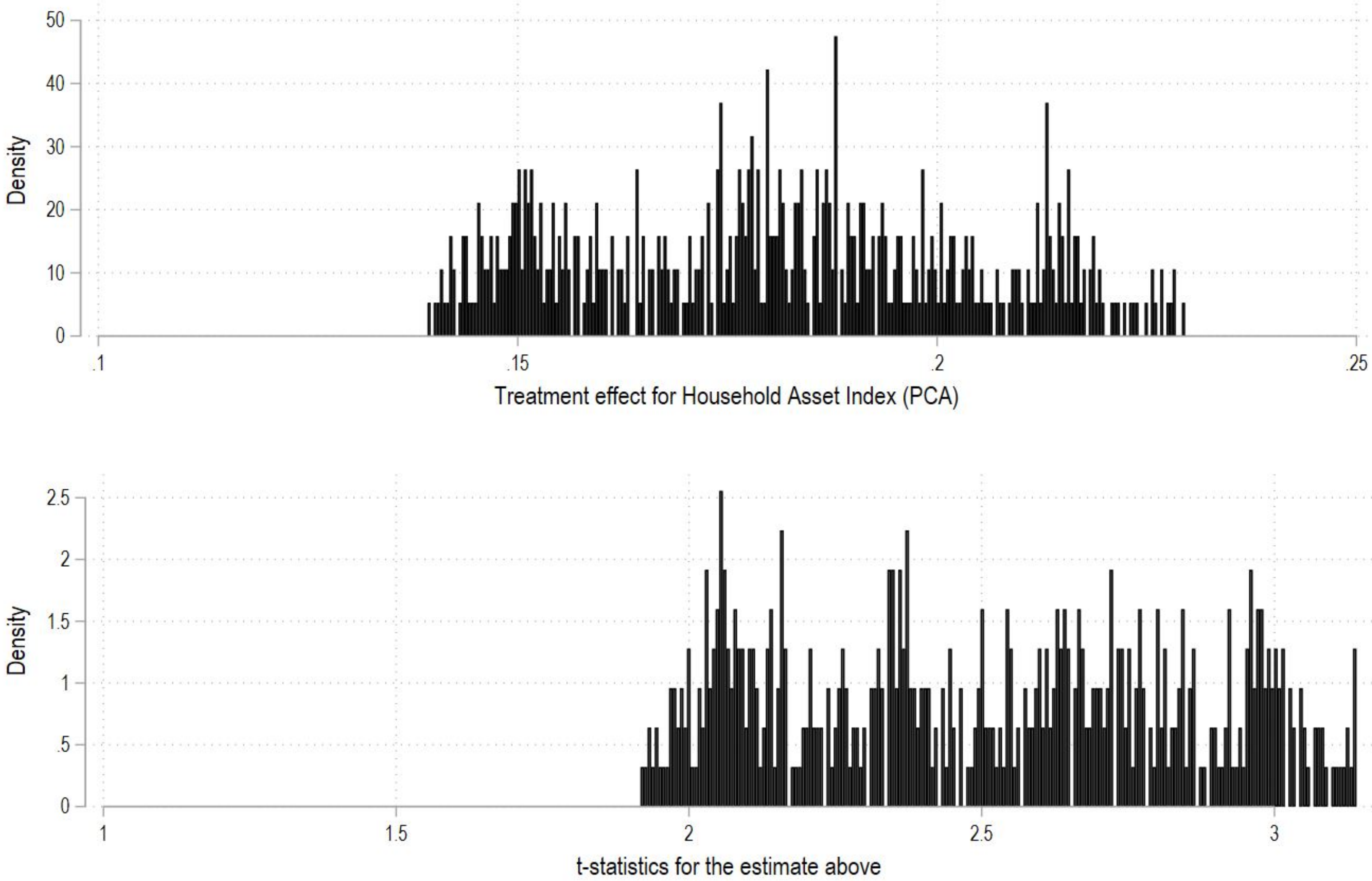
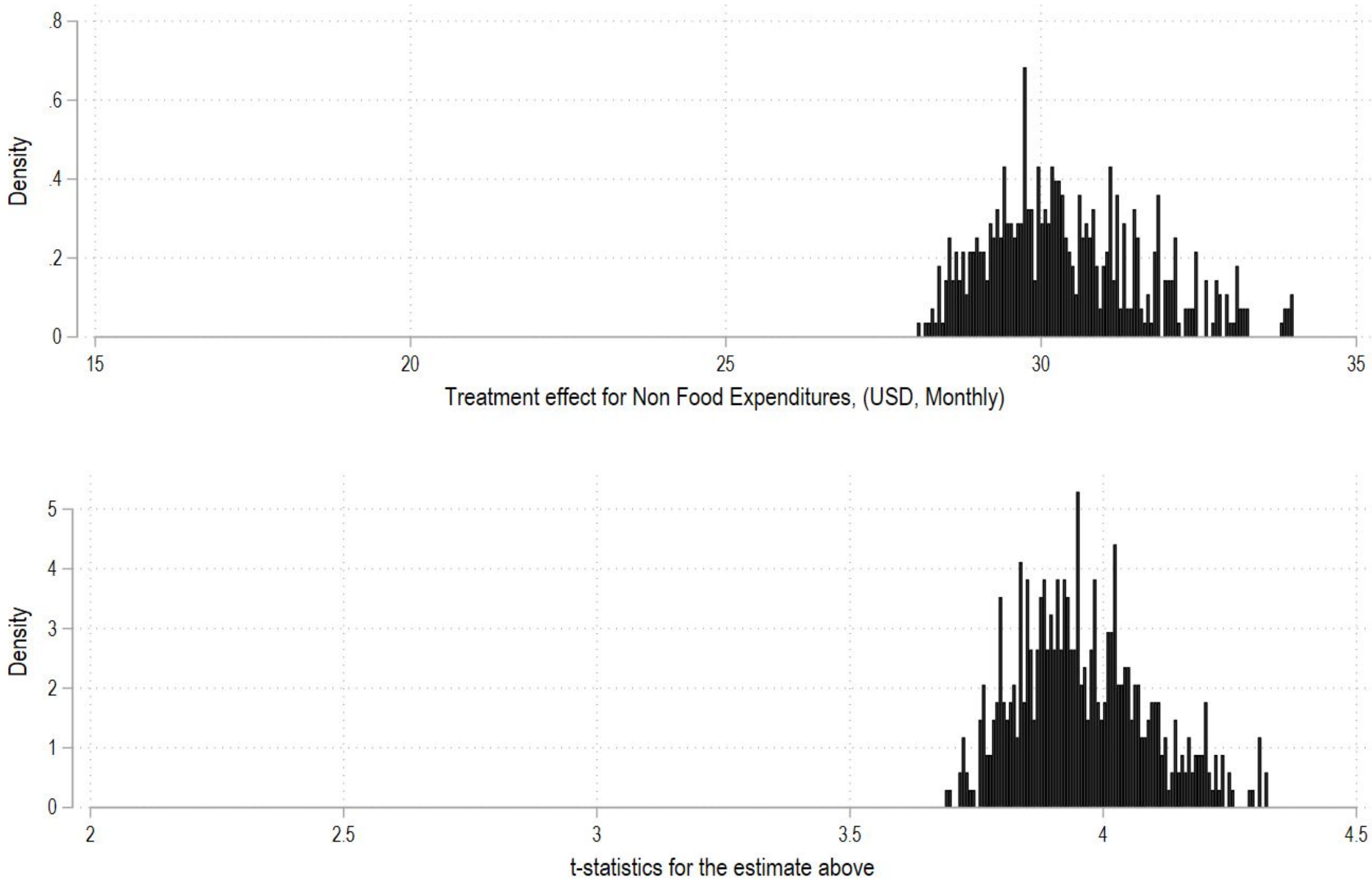


Figure 8: Robustness Check: Varying Choice of Controls - Non Food Expenditures (USD, Monthly)



Chapter 2

Religion at Play: The Impact of Ramadan in Bangladesh

1 Introduction

There has been a long-standing discussion in literature, dating back to the works of Adam Smith and Max Weber, about the connection between religiosity and traits that promote economic success. These traits include diligence, thriftiness, trust, and cooperation. This idea has been explored by various scholars such as Iannaccone (1998) and Iyer (2016). Recent research has linked religiosity with positive outcomes in different areas like physical health, as noted by Ellison (1991), lower crime rates Freeman (1986), reduced drug and alcohol use Gruber and Hungerman (2008), higher income Gruber (2005) and better educational attainment Freeman (1986).

Despite extensive research, the argument that religion directly causes these outcomes is still debated. This is partly because people choose their religion, and this choice might be influenced by personal characteristics that are the actual drivers of these outcomes. Iannaccone (1998) emphasized that proving religion's causal impact is challenging without a 'genuine experiment'. Moreover, religiosity is not a monolithic concept; its impact varies based on several factors. Brett et al. (2008) differentiate between two types of religious exposure: 'organic', which occurs over time such as through upbringing, and 'intentional', which happens through participation in specific programs. Both forms are crucial in the dissemination of religious beliefs, and the nature of religiosity that emerges may depend on the mode of exposure.

Religion and healthcare have been related to one another since the beginning of recorded history Levin and Schiller (1987). However, very little is known about the underlying mechanisms through which religion affects overall health. While it may be tempting to investigate the impact of religion on health outcomes, assessing the role of religion is a difficult task, both conceptually and empirically, primarily because of the multi-dimensional nature of both religion and health. That said, one aspect common to all religions is that they prescribe certain rules of behavior for the followers. These rules may come in the form of devoting time and resources to religious activities, limiting social interactions with non-believers, or imposing dietary restrictions Campante and Yanagizawa-Drott (2015) all of which can affect multiple dimensions of health.

Despite acknowledged conceptual, analytical, and methodological issues Ellison and Levin (1998), overall, the findings of research to date suggest a consistent impact of religion on health at both the individual and national level Levin and Vanderpool (1987). However, since religious behavior is endogenous and could well be affected by health outcomes, causal effects on the relationship between religion and health outcomes are scarce. Moreover, religion's personal and sensitive nature makes it even more challenging to study particular aspects and their possible implications on health.

Studies that have tried to study this relationship suffer from endogeneity issues. Specifically, there are only a couple of high-quality articles in economics and health economics journals that study the link between Ramadan and health, making it a heavily understudied area. Our contribution, therefore, involves presenting the first causal estimates of Ramadan on religiosity, consumption, physiological and psychological health. We do so by focusing on a specific example of religious practice (fasting) that is observed during Ramadan. Ramadan is the ninth month in the Islamic calendar and holds significant importance for Muslims all over the world. Fasting in this month from dawn to sunset is an important religious practice obligatory for Muslims all over the world.

Using data from a large-scale panel survey of Muslim households in Bangladesh, we exploit the variation in the day on which households were interviewed. This provides us with a unique opportunity to deal with causal identification issues that confound the relationship between religious practices and health outcomes. Specifically, we show that households become significantly more religious during Ramadan as measured by the increased number of prayers (out of five daily prayers) and also engage in better hygiene practices. Both of these activities have deep connections with the Islamic religion and form what we refer to as improved religiosity in this paper. This is particularly important because present literature typically assumes the existence of religious behavior (including fasting) during Ramadan. Our result, on the other hand, provides first causal estimates and therefore proof of adherence to religious practice during Ramadan.

Using the same empirical strategy, we also estimate the effect of Ramadan on household per capita consumption levels in the last three days before the interview. We find that households consume significantly less food across all income levels. This result combined with the increased number of prayers suggests that households in our study sample are observing fast in the month of Ramadan. Literature in the religious domain rarely reports consumption levels. Our context provides us with a unique opportunity to report changes in consumption levels in a causal framework.

We also find evidence that during Ramadan, households experience significant reductions in body weight. Body weight loss is one of the most studied outcomes in the empirical (mostly medical literature) studies that analyze individual-level behavior in Ramadan and our findings support investigations done in the past. A meta-analysis Kelishadi et al. (2014) using data from 35 publications showed that fasting in Ramadan was associated with a significant decrease in weight loss (-1.51 Kg in men and -0.92 Kg in women). The authors, however, acknowledge that none of the studies included in the analysis were randomized controlled trials due to the religious nature of Ramadan. In that respect, our results provide the first causal estimates of the effect of Ramadan on body weight in the health economics literature. These reductions in body weight are not the same in magnitude for rich and poor households. Given poor households have lower consumption levels relative to rich households, reductions in body weight result in a much greater probability of being malnourished for poor households. This however doesn't translate into negative subjective well-being or negative health outcomes for children under 5 in the same households.

Beside the literature on religion and health, our study is related to several additional areas. First, we provide causal evidence in support of conceptual models that study the specific mechanisms through which religion influences health (Ellison and Levin (1998), Koenig (1995), Levin and Chatters (2008)). While these models are different in their emphasis, they all agree on the direct effects of religion on physical health through adherence to certain behaviors and activities as prescribed by religion. We also directly relate to the literature that has studied the relationship between fasting during Ramadan and body weight. It has been found that Ramadan fasting is associated with significantly lower levels of weight and fat mass (Rohin et al. (2013), López-Bueno et al. (2015), Sezen et al. (2016), Ongsara et al. (2017)). Additionally, this paper is also related to the growing number of studies that have examined the relationship between religion and happiness. The results of these investigations have been largely equivocal and range from positive Sander (2017), Lewis and Cruise (2006) to negative Mookerjee and Beron (2005) to null effects Francis et al. (2003), Lewis et al. (2000) of religion on happiness However, whether findings in these studies could be given a causal interpretation remains an open question since endogeneity issues have always been a concern in the religion literature (Argyle (2003), Francis (2010)).

Lastly, our paper relates to the relatively small literature in economics that has examined the effects of fasting during Ramadan in a causal framework. Campante and Yanagizawa-Drott (2015) Campante and Yanagizawa-Drott (2015) use the variation in the length of daily fasting to identify the negative effects of fasting on economic growth and positive effects on subjective wellbeing in Muslim countries. Almond and Mazumder (2011) Almond and Mazumder (2011) use the variation of the timing of Ramadan over the years to identify negative long-term health effects on people who were prenatally exposed to Ramadan fasting whereas Majid (2013) Majid (2015) using the same approach found negative labor market effects.

For our study, it's essential to focus the discussion more precisely on adherence to religious practices during Ramadan, particularly within the context of Bangladesh. This study is not so much an exploration of religiosity in the abstract, but rather an empirical investigation into the concrete effects of specific religious observances—namely, the practices undertaken during Ramadan. By concentrating on these practices, the study aims to understand how adherence to the prescribed rituals and disciplines of this holy month influences various socio-economic and health outcomes.

The emphasis here is on the behaviors and actions associated with Ramadan observance, rather than on religiosity as a broader concept. This distinction is critical, as the paper seeks to untangle the effects of active participation in Ramadan from the underlying, perhaps more static, measure of personal faith or belief. By examining variables such as dietary changes, prayer frequency, and other Ramadan-specific practices, the study sheds light on how these deliberate acts of adherence impact the daily lives of individuals in Bangladesh. This approach allows for a nuanced understanding of how religious observance, as distinct from religiosity itself, plays a role in shaping a range of outcomes, from health to economic activities.

The rest of the paper is organized as follows: section 2 gives some background on Ramadan, Section 3 describes data and outcomes used in this study, Section 4 presents trends in daily prayers and consumption levels, Section 5 discusses the identification strategy and specifications, Section 6 shows baseline balance between households interviewed in/out of Ramadan, Section 7 discusses results, and Section 8 concludes.

2 Background

Ramadan is the ninth month of the Islamic calendar and is considered very sacred. This is because of the belief that Prophet Muhammad (PBUH) received his first revelations in this month. Fasting during Ramadan is one of the five pillars of Islam – obligations for Muslim believers that serve as the foundation of Muslim everyday life. Fasting in this month includes abstaining from food, drinks, smoking, and sexual activities from dawn to sunset. The timing of Ramadan follows the Islamic calendar, which is lunar, as a result, the Islamic year is 11 days shorter than a typical year in a Gregorian calendar. This has implications for the timing of Ramadan each year, which occurs 11 days earlier than the previous year.

During the holy month of Ramadan, Muslims engage in various religious and cultural practices that are emblematic of the fasting period. Each day before sunrise, they partake in a pre-dawn meal known as 'Sehri' or 'Suhoor'. This is followed by the Fajr prayer, the first of the five daily prayers. During daylight hours, from dawn to sunset, they observe a strict fast ('Roza') abstaining from eating, drinking, and other physical needs, as a time of purification and increased devotion. This practice is an act of 'Sawm', one of the Five Pillars of Islam. Upon sunset, they break their fast with 'Iftar', a meal that often begins with dates and water, followed by a variety of traditional dishes. Muslims also engage in increased prayer and recitation of the Quran, with special prayers known as 'Taraweeh' performed after the evening 'Isha' prayer. Charitable acts and giving, known as 'Zakat', are also emphasized during this month. The end of Ramadan is marked by a significant festival known as 'Eid-ul-Fitr', a joyous celebration involving feasts, gift-giving, and special prayers. The rituals and practices undertaken during Ramadan not only strengthen their sense of spirituality but also reinforce community ties and a sense of shared identity.

Fasting from dawn to sunset has obvious physiological consequences which can include weight loss Fernando et al. (2019) , significant metabolic changes Osman et al. (2020), unwillingness to work Afifi (1997), and reduced concentration ability Karaagaoglu and Yucecan (2000), among others. All these changes have implications for productivity at work and much larger implications for economic growth. Indeed, Campante and Yanagizawa-Drott (2015), find longer fasting hours to have a significant negative effect on output growth in Muslim countries.

Considering the distinctive practices undertaken during Ramadan, it is plausible to hypothesize that conformity to these practices could influence individual conduct, subsequently impacting the physical and mental well-being of other household members. Of course, the degree to which individuals engage with each Ramadan practice is likely to exhibit considerable variation across individuals and districts in our study sample, making it a challenging factor to quantify accurately. However, we circumnavigate this issue by utilizing two proxy indicators in our data collection instrument, both of which are highly correlated with Ramadan observance. In particular, we employ the frequency of daily prayers offered and the level of cleanliness maintained in the household as surrogate markers for Ramadan adherence. Our hypothesis posits that a high frequency of daily prayers and elevated hygiene standards during Ramadan are indicative of a high degree of religious commitment or observance of Ramadan in the household.

3 Empirical Framework

3.1 Data

The dataset used in this paper comes from a large-scale anti-poverty experiment that was implemented in Bangladesh. Through a participatory rural exercise and a census that happened before baseline, households were categorized into one of the three wealth classes namely, rich, middle and ultra-poor. A random sample was then selected for the anti-poverty experiment which resulted in a sample population with 56% ultra-poor households, followed by 34% households belonging to the middle class and finally 10% that belonged to the rich class. A detailed household questionnaire was developed and carried out on the randomly selected households that spread across 1,341 villages resulting in a total sample of about 18,000 Muslim households. For more details about the selection process and the original ultra-poor graduation experiment, see Bandiera et al. (2017).

Table 1 shows the total number of households interviewed each year. In the original anti-poverty experiment, these households were first interviewed at baseline (2007), then at midline (2009), and finally again at endline (2011). For the purpose of this study, we only focus on the first two rounds of data because the variable date wasn't recorded properly in the year 2011. Our main source of exogenous variation comes from the day (i.e. date) on which households were interviewed and with that variable being compromised in the 2011 data collection, we had to limit analysis to the first two rounds. As shown in Table 1, we have a balanced panel of about 18,000 households each year.

Table 1: Study Sample

Ramadan	0	1	Total
2007	18,787	0	18,787
2009	14,505	4,282	18,787
Total	33,292	4,282	37,574

In constructing our study sample, we implemented a systematic exclusion criterion, specifically omitting households that participated in interviews during Ramadan in 2007. This methodological approach enables the establishment of a consistent analytical cohort, comprised exclusively of households that were not part of the Ramadan 2007 survey but were subsequently interviewed during Ramadan in 2009. This selection process effectively simulates the conditions of a randomized controlled trial (RCT), ensuring a degree of experimental rigor in tracking and comparing household dynamics across the two distinct time periods. As we show later, households interviewed during Ramadan are very similar to those interviewed outside of Ramadan. This supports our claim about the random nature of the day of the interview. Additionally, our setting gives us a unique opportunity to pool data from both years and introduce household level and year-fixed effects in our regression specification which then teases out the true causal effect of Ramadan on outcomes of interest.

3.2 Study Outcomes

We now explain our outcomes and how they were constructed. All variables used in the analysis come from the household questionnaire. To assess the effect of Ramadan on religiosity, we use number of prayers offered which is taken from the answer to the question: how frequently do you say your prayers: "five times a day, 3-4 times a day, 1-2 times a day, occasionally". We treat this variable as continuous and recorded it to have higher values for more prayers being offered. Similarly, we construct a measure of hygiene that takes the value from 1 to 5 with higher values meaning better hygiene practices in the household. We ask households where they dispose of five types of domestic waste which include kitchen, children, poultry, livestock, and domestic waste. We later recode each of these variables to take the value of 1 if the household has a specific place to dispose of the waste and 0 otherwise. Finally, we sum up the five types of domestic waste variables resulting in a continuous variable that ranges from 1 to 5.

The household survey also had a detailed health module which we use to construct physiological health outcomes of interest. Data on body weight and height comes from the health module in the survey. These were measured on the spot during the interview by enumerators using a weighing scale and a tape measure (flexible ruler). With height and weight, we constructed the body mass index (BMI) for each respondent as well as an indicator variable for malnourishment equal to 1 if BMI was less than WHO's malnourishment BMI threshold of 18.5.

Food consumption comes from the food consumption module in the survey with a recall period of the last three days. Respondents for 12 food items answer the amount in grams consumed for each food item. We add consumption for each food item to calculate total consumption. With the help of a qualified nutritionist, we also calculate the total number of calories for each food item consumed. These variables together with the household size were then used to compute consumption and calorie intake per capita for each household. We also measure anthropometric outcomes for children under 5 years of age in the household. Finally, subjective well-being, is based on the question: How do you consider your life: "unhappy, happy, very happy and don't know"? We replace don't know with missing values and treat the variable as continuous with higher values meaning more happiness in life.

Our survey data also include multiple dimensions of wealth with different recall periods. To make sure our choice of wealth variable remains consistent with other variables, we first create a total wealth variable (using 2007 data) that is a composite of the monetary value of all business assets, non-business assets, land holdings, and savings by the household at the time of the interview. We then construct an indicator variable (Rich) equal to 1 if household wealth is equal to or greater than the median wealth of the sample and 0 if household wealth is less than the median wealth of the sample.

The selection of outcomes in this study was meticulously aligned with the unique characteristics of Ramadan, particularly its duration of 30 days. This temporal aspect was a pivotal consideration in our methodological framework. Specifically, the choice of outcomes with shorter recall periods was imperative to capture the immediate and direct effects of Ramadan observance, rather than prolonged reporting effects that may arise from outcomes measured over longer durations like 6 or 12 months. This approach ensures that the observed changes are more likely to be attributed to the practices and alterations in lifestyle during Ramadan, rather than being diluted by long-term behavioral patterns or seasonal variations unrelated to the holy month.

For instance, the use of the number of prayers offered and hygiene practices as outcomes is particularly relevant due to their daily observance and immediate reflection of changes in religious and personal conduct during Ramadan. The recording of food consumption and calorie intake on a three-day recall basis is another strategic choice. It provides a precise snapshot of dietary habits during Ramadan, capturing any deviations from regular eating patterns induced by fasting. Similarly, the assessment of physiological health outcomes like BMI and malnourishment indicators immediately post-Ramadan offers valuable insights into the physical impacts of this period. These outcomes, with their short recall periods, are crucial in painting an accurate and timely picture of the multifaceted influence of Ramadan on various aspects of life, ranging from spiritual and physical health to dietary habits and general well-being.

3.3 Trends in Daily Prayers and Consumption

In Figure 1, we plot the average daily prayers (min 1, max 5) calculated for each interview day for Muslim households in our study sample. The two dotted lines in the graph refer to the first and last days of Ramadan. As can be seen, average daily prayers during the Ramadan period is higher than both pre and post-Ramadan periods suggesting households become more religious during Ramadan. Interestingly, the increased religiosity effect of Ramadan does not fade immediately after Ramadan,

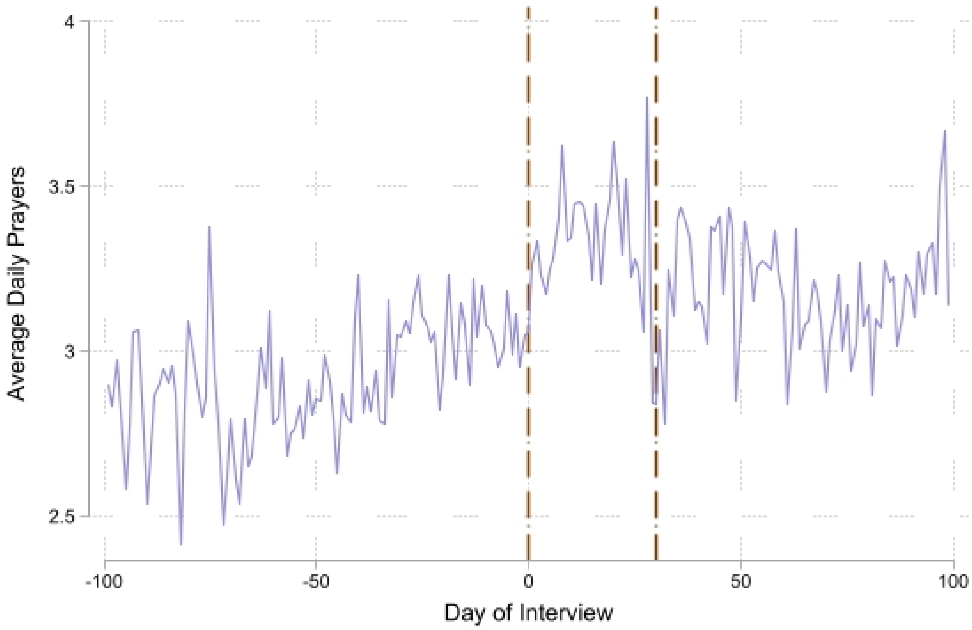


Figure 1: Average Number of Prayers

rather households maintain higher daily prayer levels relative to pre-Ramadan daily prayer levels even a month after Ramadan. This indicates how habits formed during Ramadan may have a spillover effect that goes far beyond the Ramadan period.

Similarly, in Figure 2, we plot the average daily consumption calculated with a 3-day recall period. Once again, the two dotted lines refer to the start and end of Ramadan. As can be seen, the average daily consumption for households interviewed during Ramadan is smaller relative to those interviewed both pre and post-Ramadan. We see an abrupt jump in average consumption levels just after the end of Ramadan which remains high for at most 3-4 days. We take this as proof of Muslims celebrating the festival of breaking the fast (Eid-al-Fitr). This festival is celebrated by Muslims all over the world for 3-4 days just after Ramadan and marks the end of the fasting period. These celebrations include social gatherings, festive meals, charity, and gift-giving among other things. The government in Bangladesh typically announces 3 days of national holiday each year for Eid-al-Fitr. What this means is, the average consumption levels of households interviewed just after Ramadan actually refer to their consumption during Eid-al-Fitr.

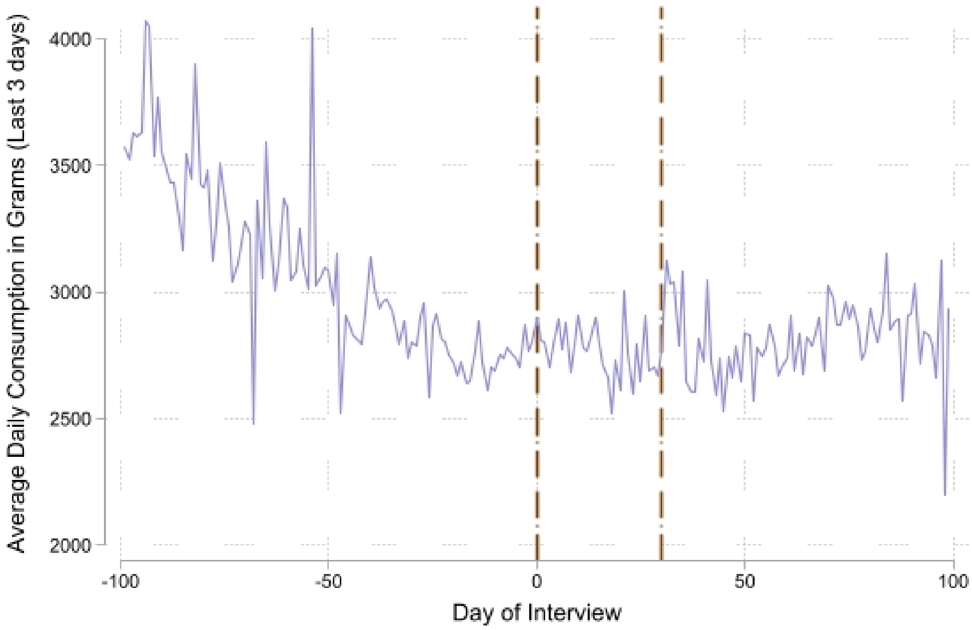


Figure 2: Average Consumption Per Capita (last 3 days)

3.4 Identification Strategy

Our approach to pinpointing cause and effect relies on a key feature of our data collection process—that households were not systematically interviewed over the years, meaning the interview dates were varied and not uniform across all households. This scattered schedule of household interviews is not a drawback; rather, it provides us with a unique method to discern patterns and effects.

Figure 3 visualizes the day-to-day variation of interviews that forms the bedrock of our analysis in this study. On the graph, each day is marked by the number of households interviewed, with the day zero corresponding to the onset of Ramadan. This graphical representation vividly illustrates the considerable variation in the interview schedule across households. The two vertical lines demarcate the households interviewed during the period of Ramadan. What we want to highlight here is that despite the distinctive timing of their interviews, the characteristics of these Ramadan-interviewed households are notably similar to those interviewed outside of the Ramadan period.

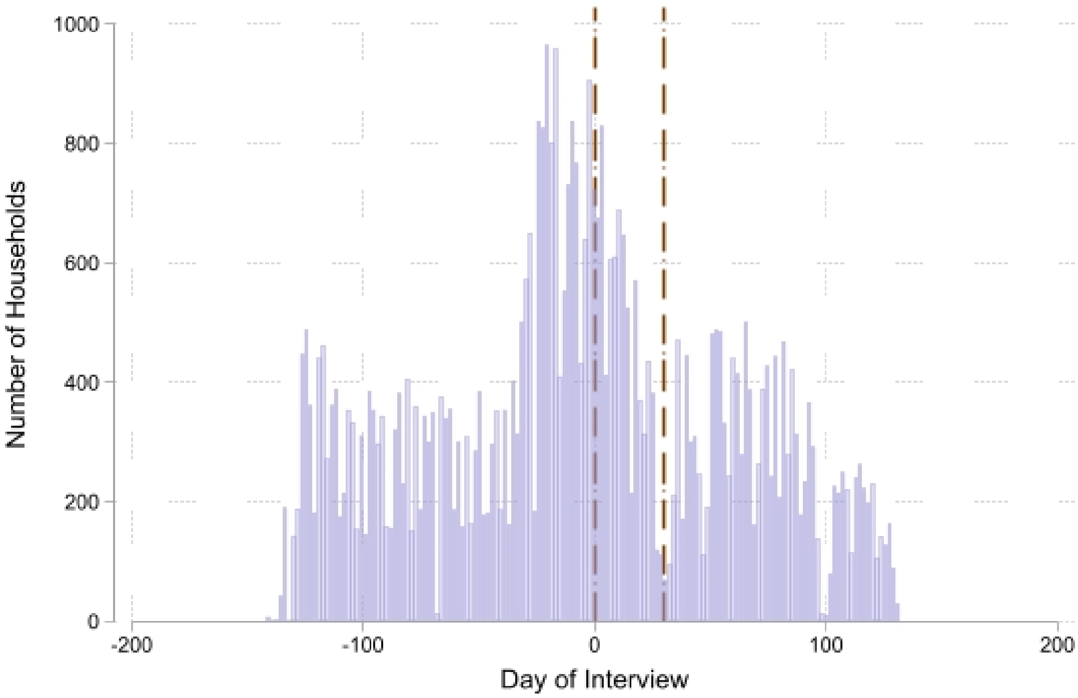


Figure 3: Distribution of Household Interviews

3.5 Empirical Specification

As mentioned earlier, we have two Ramadan periods, one for each year with very few overlapping households providing evidence in favor of the random nature of the household survey. Specifically, there were only 324 households that were interviewed during Ramadan in both periods. This setup gives us a unique opportunity to look at households that were interviewed in Ramadan in one period and out of Ramadan in the other period. We thus, pool data from both years and introduce household and year-fixed effects. This results in a very demanding regression specification with over 21,000 Muslim households fixed effects. Any significant results then can be attributed to the true causal effect of Ramadan. Given our identification strategy, we estimate the following equation:

$$Y_{it} = \alpha + \beta_1 Ramadan_{it} + \rho_{it} + \delta_{it} + \epsilon_{it} \qquad (1)$$

Here, Y_{it} is an outcome (e.g. number of prayers, happiness) for household i in year

t, Ramadan is an indicator variable that equals 1 if the household was interviewed in Ramadan. ρ_{it} and δ_{it} measure household and year-fixed effects respectively. The household fixed effects control all time-invariant differences across households, such as the location of the house or village culture and norms that do not change over time. The year-fixed effects on the other hand control for factors that vary across time but are constant across households such as weather in Bangladesh. We do not control for household-level characteristics because these may be endogenous to Ramadan and thus may do more harm than good. We, however, do acknowledge that not all household-level characteristics will be correlated with Ramadan, and adding those may reduce residual variation, leading to a more precise estimate. In any case, adding household-level controls doesn't change our results.

To further investigate how the effect of Ramadan varies with the wealth of households, we also estimate an interaction specification over the entire sample of Muslim households:

$$Y_{it} = \alpha + \beta_1 Ramadan_{it} + \beta_2 Rich_{it} + \beta_3 Ramadan_{it} * Rich_{it} + \rho_{it} + \delta_{it} + \epsilon_{it} \quad (2)$$

Where $Rich_{it}$ is an indicator variable that equals 1 if the logged wealth of the household is greater than or equal to the median of logged wealth for the entire sample. If the effect of Ramadan is different for the rich and the poor (Rich = 0), then we should expect the coefficient on the interaction term of Ramadan and Rich (β_3) to be statistically different from 0. We estimate equations 1 and 2 on our study sample. While we do provide evidence of households becoming more religious during Ramadan, this does not rule out the possibility of Muslims not complying with formal fasting rules. Our estimates thus should be interpreted as intention-to-treat point estimates of being interviewed in Ramadan. Finally, in all our specifications, we cluster standard errors at the household level to allow for the possibility of error terms being correlated for different observations for a household.

3.6 Comparable Nature of Households

To check if households interviewed during Ramadan are similar to those interviewed outside of Ramadan, we make use of the fact that being interviewed during Ramadan was a completely random instance. Specifically, households interviewed on a specific day in 2007, did not know on which day they would be interviewed in 2009. We, therefore, can perform a balance check for households interviewed in Ramadan in 2009 using 2007 data because for them we have a 2007 baseline round. We, therefore, use the 2009 Ramadan treatment indicator and compare household characteristics in 2007.

In Table 2, we report the results of the baseline balancing tests. For every variable, we report the mean (column 1 and column 2), the difference (column 3), and p-value on a test of equality of means (column 4) for treatment and control households where treatment in our case refers to a household that will be interviewed in Ramadan in 2009. Overall, we see that our sample is well balanced: none of the 18 tests for the equality of means are rejected. We also report standardized differences and p-value for a joint test of orthogonality to see if baseline variables are jointly unrelated to the treatment status. We thus conclude that being interviewed during Ramadan is indeed random and households interviewed outside of Ramadan provide a valid counterfactual for those interviewed in Ramadan.

Table 2: Comparing Households In/Out of Ramadan in 2007

Variable	(1) Non-Ramadan	(2) Ramadan	(3) Difference	(4) P-Values	(5) Normalized-Diff
TUP Treatment Status	0.510	0.528	0.017	(0.597)	0.025
Size of Household	3.851	3.889	0.038	(0.311)	0.015
Years of Schooling (main respondent)	1.591	1.571	-0.020	(0.737)	-0.005
Married (1/0)	0.782	0.790	0.008	(0.328)	0.014
Total Wealth (in TK)	128417.797	135995.891	7,578.093	(0.377)	0.012
Outstanding Loan (1/0)	0.360	0.353	-0.007	(0.611)	-0.010
Value of Outstanding Loan (in TK)	3,624.307	3,323.256	-301.051	(0.319)	-0.013
No of Business Activities	2.436	2.459	0.023	(0.495)	0.018
No of Daily Prayers offered	2.880	2.848	-0.032	(0.473)	-0.015
Hygene	2.580	2.588	0.008	(0.867)	0.004
Body Mass Index (BMI)	19.171	19.149	-0.022	(0.697)	-0.006
Weight (in KGs)	42.809	42.800	-0.010	(0.948)	-0.001
Height (in meters)	1.494	1.494	0.000	(0.683)	0.006
Malnorished (1/0)	0.441	0.454	0.013	(0.228)	0.019
Subjective Wellbeing	1.588	1.581	-0.007	(0.659)	-0.009
Consumption in Calorie Per Capita	7,561.529	7,577.727	16.198	(0.831)	0.004
Consumption in Gram per Capita	3,188.632	3,208.594	19.962	(0.644)	0.009
Food Expenditure Per Capita (in TK)	73.563	73.960	0.397	(0.712)	0.006
Observations	14,505	4,282	18,787		
Joint test of orthogonality (p-value)				0.3167	

Notes: The sample includes respondents from Muslim households who were successfully interviewed in both 2007 and 2009. Column (1) shows the mean of respondents who were not interviewed in the month of Ramadan. Column (2) shows the mean of respondents who were interviewed in the month of Ramadan. Columns (3) and (4) show the difference in means and the associated p-value of that difference whereas Column (5) reports standardized differences between the two groups. *** p < .01 , ** p < .05 , * p < .01

4 Results by Outcome Group

4.1 Religiosity

Table 3 presents the results on the number of daily prayers offered by the main respondent. Column (1) shows a simple regression of the number of daily prayers offered on the Ramadan indicator that equals 1 if the household was interviewed during Ramadan and 0 otherwise. The estimate is positive and statistically significant (p-value < 0.01), suggesting that households in Ramadan on average perform 13.15% more daily prayers relative to households interviewed outside of Ramadan. Column (2) includes year-fixed effects to control for determinants of daily prayers that also correlate with Ramadan. We find a similar positive statistically significant coefficient (p-value < 0.01). Here the positive coefficient estimate implies that in any given year, households in Ramadan perform 6.6% more daily prayers on average. Column (3) then includes household fixed effects to control for factors that affect the number of daily prayers and Ramadan. We see a similar positive coefficient (p-value < 0.01), implying that for a given household, the average number of daily prayers is 7.6% higher during Ramadan.

In Islam, cleanliness and purification are not only requirements for the performance of worship, or when embracing Islam, but are part of a Muslim's very faith. We, therefore, view any improvements in hygiene practices as improvements in adherence to religious practice given our context. We estimate the same three models for our hygene outcome in Columns (4), (5), and (6). In the model without year and household fixed effects, we find households in Ramadan to have 13.33% higher hygene (p-value < 0.01) relative to households interviewed outside of Ramadan. We find similar positive statistically significant (p-value < 0.01) results when we add both year and household-level fixed effects in columns (3) and (4).

Beyond acting as a verification tool (ensuring adherence to the 'treatment', which is the observation of Ramadan), the estimates in Table 3 offer the first causal estimation of improved adherence to religious practices within religious studies. Prior empirical studies often work on the presumption of adherence to religious rituals. However, our study breaks new ground by offering a causal measurement of changes in religious behavior. Bearing these results in mind, it appears highly probable that the households included in our study observe the fast during Ramadan. While we may lack a direct method to confirm this, the results in Table 3, strongly suggest a significant behavioral shift consistent with the religious practices associated with this period.

Table 3: Effect on Daily Prayers & Hygene

	(1)	(2)	(3)	(4)	(5)	(6)
		Prayers			**Hygene**	
Ramadan	0.398***	0.200***	0.232***	0.371***	0.111***	0.103***
	(0.024)	(0.026)	(0.029)	(0.019)	(0.020)	(0.028)
Observations	37,574	37,574	37,574	37,574	37,574	37,574
Adjusted R-squared	0.007	0.019	0.367	0.008	0.035	0.228
Year FE	No	Yes	Yes	No	Yes	Yes
Household FE	No	No	Yes	No	No	Yes
Mean Non Ramadan	3.026	3.026	3.026	2.783	2.783	2.783

Notes: OLS regressions with year and individual fixed effects. Mean Non-Ramadan refers to the mean in the group of respondents who were not interviewed in Ramadam. Robust standard errors in parentheses, clustered at the household level. *** p < .01 , ** p < .05 , * p < .01

4.2 Physical Health

Table 4 presents results on three measures of physiological health namely body weight (in kg), body mass index, and a binary indicator called malnourishment. In columns (1) to (9) we run three specifications for each outcome. We start with a simple equation 1 without year or household fixed effects. We then estimate a second model with year-fixed effects and finally a third model with year and household-fixed effects. In column (1) we show a simple regression of body weight on the Ramadan indicator. We find that households on average lose 0.190 Kgs in Ramadan (p-value < 0.01) relative to households interviewed outside of Ramadan.

In column (2) we add year-fixed effects to control for determinants of body weight that also correlate with Ramadan and results similar to those in column (1) of Table 4. Here the negative coefficient (p-value < 0.01) implies that in any given year, households in Ramadan have on average lower body weight. In column (3) we add household fixed effects to control for factors that are correlated with both body weight and Ramadan. We see a similar negative coefficient (p-value < 0.01), implying that for a given household and in any given year, the average weight is significantly lower in Ramadan most likely due to fasting.

Using the same empirical strategy, we also look at the effect of Ramadan on body mass index and the probability of being malnourished as defined by WHO's guidelines. Reassuringly, we see very similar patterns in body mass index. In columns (5) and (6), we see precisely estimated (p-value < 0.01) negative effects on body mass index indicating that for a given household and in any given year, body mass index is lower in Ramadan. The decrease in body mass index translates into an increased probability of being malnourished as shown in columns (7), (8), and (9). Specifically, respondents interviewed during Ramadan are 2.0 percentage points (column 9) more likely (p-value < 0.01) to be malnourished relative to those interviewed outside of Ramadan. This translates into a 4.8% increase in malnourished households relative to households interviewed outside of Ramadan.

The findings in Table 4 are of considerable significance in light of the backdrop of our investigation. In the dataset we're working with, we encompass households from a spectrum of economic categories including the rich, middle-class, and the extremely impoverished. However, the concentration of households in our sample skews towards the ultra-poor with a 56% share. Middle-class households account for the next major chunk with 34%, leaving wealthy households making up the remaining 10%. It's critical to note that variations in physical metrics such as body weight and body mass index, which subsequently contribute to malnutrition rates, could exhibit substantial disparities across the economic gradient. This differentiation, whether a household is prosperous or impoverished, can bear significant long-term implications on productivity and labor market trajectories.

Table 4: Effects on Body Weight, BMI and Malnorishment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Weight (in KG)			BMI			Malnorished	
Ramadan	-0.190***	-0.112***	-0.102***	-0.163***	-0.056***	-0.033***	-0.003***	0.033***	0.020***
	(0.106)	(0.120)	(0.078)	(0.043)	(0.049)	(0.036)	(0.008)	(0.009)	(0.008)
Observations	37,574	37,574	37,574	37,574	37,574	37,574	37,574	37,574	37,574
Adjusted R-squared	0.000	0.001	0.770	0.000	0.005	0.691	-0.000	0.004	0.510
Year FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Household FE	No	No	Yes	No	No	Yes	No	No	Yes
Mean Non Ramadan	43.04	43.04	43.04	19.34	19.34	19.34	0.416	0.416	0.416

Notes: OLS regressions with year and individual fixed effects. Weight is measured in KGs, Body mass index (BMI) is measured on a continuous scale and Malnorished is a binary variable that takes 1 if BMI is less than 18 and 0 otherwise. Mean Non-Ramadan refers to the mean in the group of respondents who were not interviewed in Ramadam. Robust standard errors in parentheses, clustered at the household level. *** p < .01 , ** p < .05 , * p < .01

4.3 Subjective Wellbeing (Happiness)

Our findings from Table 5 report the impact of Ramadan on self-reported happiness. In column (1), we see a significant positive effect of Ramadan on happiness (p-value < 0.05). However, this effect dissipates when year and household-level fixed effects are controlled for. Consequently, we fail to reject the null hypothesis of no effect on happiness during Ramadan. This observation is especially noteworthy in light of our previous discoveries. We find that while households encounter a detrimental health impact, characterized by a deterioration in physical well-being, this does not extend to affect psychological well-being negatively.

Discussions in Section 1 highlighted the mixed results of studies investigating the association between religion and happiness. Many such studies grapple with identification issues, rendering their findings non-comparable to our results. Except for Campante and Yanagizawa-Drott (2015) who exploited the variation in the timing of Ramadan and observed a significant positive correlation between longer fasting hours and happiness in countries. Their approach stands out for investigating the impact of Ramadan on happiness within a causal framework. However, it's vital to consider that the majority of the Muslim participants they surveyed were interviewed outside of Ramadan, as acknowledged by the authors themselves. Therefore, their findings should not be directly linked to the effect of Ramadan on happiness but rather seen as reflective of Muslims living in countries with longer fasting hours reporting higher levels of happiness post-Ramadan.

In contrast, our approach provides a more precise estimation of the effect of Ramadan on happiness, directly gauging the influence of increased adherence to prescribed religious practices during the holy month. Despite the estimated happiness coefficient in columns (2) and (3) being imprecise, its proximity to zero, coupled with small standard errors, suggests that the impact of Ramadan on happiness hovers around a negligible range (zero). This could likely be the net outcome of two opposing influences during Ramadan, a dip in happiness stemming from poorer physical health and an upswing in happiness due to heightened religious fervor during Ramadan.

Table 5: Effect on Subjective Wellbeing

	(1)	(2)	(3)
		Subjective Wellbeing	
Ramadan	0.069***	0.001	0.008
	(0.009)	(0.010)	(0.012)
Observations	37,574	37,574	37,574
Adjusted R-squared	0.001	0.011	0.255
Year FE	No	Yes	Yes
Household FE	No	No	Yes
Mean Non Ramadan	1.639	1.639	1.639

Notes: OLS regressions with year and individual fixed effects. Subjective wellbeing is a continuous measure that ranges from 1 to 3 with higher values meaning more happiness. Robust standard errors in parentheses, clustered at the household level. *** p < .01 , ** p < .05 , * p < .01

4.4 Consumption & Calories

Our attention now shifts to the impact of Ramadan on total consumption and total calorie intake per capita. Results in Table 6 demonstrate that there's a notable and statistically significant negative effect on consumption (measured in grams per capita) as shown in columns (1), (2), and (3), with a p-value < 0.01. We find consumption per capita (column 3) to reduce by 89.962 grams or 3.0% (p-value $<$ 0.01) for households interviewed in Ramadan relative to those interviewed outside of Ramadan.

Columns (4), (5), and (6) report our findings on the impact of Ramadan on total calorie consumption per capita. These values were derived from the types and quantities of food consumed over a three-day interval. Consistent across all three specifications, we observe a statistically significant reduction (at least pvalue < 0.05) in total calories consumed per capita during Ramadan. These results are in line with the results displayed in Table 5 where we find a statistically significant decrease in weight, body mass index, and likelihood of being malnourished for households in Ramadan relative to households interviewed outside of Ramadan.

Taking these two together, it becomes clear that during Ramadan, for a specific household in a given year, there is a decrease in physical health. This reduction is primarily attributable to less food consumption likely due to fasting, which in turn results in fewer calories consumed. This diminished food and caloric intake during Ramadan has tangible repercussions for households, intensifying the probability of being malnorished.

Table 6: Effects on Consumption and Calories Per Capita

	(1)	(2)	(3)	(4)	(5)	(6)
		Consumption PC			Calories PC	
Ramadan	-331.494***	-60.905***	-89.962***	-503.166***	-52.222**	-10.393**
	(18.090)	(19.207)	(31.082)	(42.541)	(45.760)	(66.333)
Observations	33,751	33,751	30,670	33,751	33,751	30,670
Adjusted R-squared	0.006	0.032	0.259	0.003	0.027	0.246
Year FE	No	Yes	Yes	No	No	Yes
Household FE	No	No	Yes	No	No	Yes
Mean Non Ramadan	2996	2996	2996	7160	7160	7160

Notes: OLS regressions with year and individual fixed effects. Consumption is measured in grams and calories are measured in kcal. The sample in the regression output changes because of missing values in the outcome variables. Specifically, we have 10% missing values in both consumption and calories per capita variables. However, the missing values in these variables aren't correlated with our treatment variable. Mean Non-Ramadan refers to the mean in the group of respondents who were not interviewed in Ramadam. Robust standard errors in parentheses, clustered at the household level. *** $p < .01$, ** $p < .05$, * $p < .01$

4.5 Child Health

The impact of Ramadan on child anthropometric outcomes is studied in depth in the literature. However, pretty much all of this research focuses on the pre-natal exposure to Ramadan on child anthropometric outcomes. The findings of prior research exploring the effects of prenatal exposure to Ramadan include damaging impacts on indicators of child health and development, such as birth weight Almond and Mazumder (2011), under-5 height of male children Karimi and Basu (2018); adolescent height-for-age (Karimi et al. (2021); Kunto and Mandemakers (2019)); and standardized test scores (Almond et al. (2015); Majid (2015)). Our findings diverge from existing literature in two core aspects. Firstly, our unique identification strategy, coupled with the evidence on religiosity, adult weight, and consumption, provides us with confidence that the households included in our study are indeed adhering to religious practices prescribed in the month of Ramadan. Secondly, by directly measuring the parameters of children under five in households during Ramadan, our study provides a more direct and unambiguous depiction of the effects of fasting during Ramadan on the outcomes of interest.

In Table 8, we present the impact of surveying children under five during Ramadan on their anthropometric measurements. These measurements—spanning columns (1) to (4)—are calculated following WHO's recognized benchmarks for assessing malnutrition in children. The coefficients for the Ramadan indicator in Table 8 estimate the average effect of Ramadan on female children under the age of five. With respect to child anthropometric outcomes, the impact of Ramadan is not statistically significant for either gender. This is not entirely surprising, as a month's span may be insufficient to induce observable changes in these anthropometric indicators (as seen in columns (1) to (4)). These results are not surprising as it's not mandatory for children under five to observe fasting in the month of Ramadan.

We also examine the mid-upper-arm circumference (MUAC) and weight of children, as these metrics can exhibit short-term alterations. For both genders, we note a similarly imprecisely estimated coefficient for MUAC, while a slight improvement in weight is observed for male children interviewed during Ramadan. Altogether, these findings suggest that a negative health shock experienced by adult household members during Ramadan does not necessarily translate to an equivalent health shock for children under the age of five within the same households.

Table 8: Effects on Child Anthropometric Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Stunting	Wasting	Underweight	Overweight	MUAC	Weight (Kg)
ramadan	0.001	0.031**	0.007	-0.007	-0.120	-0.059
	(0.022)	(0.016)	(0.021)	(0.021)	(0.595)	(0.141)
treat_cgender	-0.012	-0.003	-0.024	0.002	-0.075	0.234
	(0.027)	(0.020)	(0.025)	(0.025)	(0.729)	(0.188)
Observations	14,748	14,748	14,748	14,748	11,177	13,061
Treatment effect for Males	-0.010	0.027*	-0.016	-0.004	-0.194	0.174
	(0.020)	(0.015)	(0.019)	(0.019)	(0.504)	(0.126)
Control mean, male	0.271	0.128	0.291	0.199	140.869	10.512
Control mean, female	0.254	0.121	0.286	0.199	138.805	10.011

Notes: OLS regressions with year and household fixed effects. Stunting, Wasting, Underweight, and Overweight are dummy variables calculated by following the WHO Malnutrition in Children indicator guidelines. Mid-Upper-Arm Circumference (MUAC) and Weight are measured in centimeters and kilograms respectively. At the bottom of the table, we present the adjusted p-values for the effect for males, which is a linear combination of the other coefficients. "Control mean" refers to the mean in the control group of male/female kids interviewed outside of Ramadan. The sample in the regression output changes because of missing values in the outcome variables. However, the instance of missing isn't correlated with the treatment variable. Robust standard errors in parentheses, clustered at the household level. *** p < .01 , ** p < .05 , * p < .01

4.6 Heterogenous Treatment Effects by Wealth

In Table 9, we present the interaction specification with year and household-level fixed effects. The variable Rich is defined as 1 if the overall wealth of the household is more than the median of the sample and 0 (or Poor) otherwise. The coefficients on the Ramadan indicator in Table 9 show the mean Ramadan effect for poor households.

Table 9 holds two main findings. Firstly, the interaction term in Table 9 is significant for total consumption in grams per capita and total calories per capita (Columns (4) and (5)) suggesting that richer households decrease their consumption and consequently calories by a much larger amount than poor households. One reason that could explain this is richer households on average have higher levels of consumption relative to poor households so they can afford to decrease consumption by a much larger amount without having a significant effect on other measures of health. Moreover, even if decreases in consumption went down by the same proportion for both rich and poor households, in absolute terms, decreases in consumption and calorie levels will be higher for rich households.

Secondly, the interaction term for weight, BMI, and malnourished is not significant. This means that while in Ramadan all three variables deteriorate significantly for the two groups individually, there is no statistically significant difference in the negative effect of Ramadan between the Rich and the Poor. However, in absolute terms, poor households face a much bigger risk of being malnourished because they already have lower consumption levels. As a result, even a small decrease in body weight as a result of fasting in Ramadan brings them closer to the malnourished category. A reflection of this argument can also be seen in column (4). We know from earlier tables that overall gram consumption per capita goes down during Ramadan. Column (4) indicates that the decrease in gram consumption per capita is much higher for rich households relative to poor households. However, that doesn't translate into a bigger probability in absolute terms of being malnourished for richer households relative to poor households.

Table 9: Interaction between Ramadan and Socio-Eocnomic Status

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Weight (in KG)	BMI	Malnorished	Consumption PC	Calories PC
Ramadan	-0.120***	-0.042***	0.020**	-31.100***	196.674**
	(0.101)	(0.048)	(0.012)	(43.675)	(95.699)
Ramadan x Rich	0.034	0.016	-0.001	-235.432***	-362.263***
	(0.135)	(0.063)	(0.015)	(54.360)	(116.192)
Observations	37,574	37,574	37,574	30,670	30,670
Treatment effect for rich	-0.85***	-0.025***	0.019**	-204.33***	-165.589***
	(0.104)	(0.047)	(0.010)	(38.790)	(80.283)
Control mean, rich	44.341	19.794	0.359	3129.44	7430.537
Control mean, poor	41.773	18.887	0.470	2860.163	6885.512

Notes: OLS regressions with year and individual fixed effects. Consumption is measured in grams and calories are measured in kcal. At the bottom of the table, we present the adjusted p-values for the effect for the rich, which is a linear combination of the other coefficients. "Control mean" refers to the mean in the control group of rich/poor households interviewed outside of Ramadan. See the data section for a detailed description of the variables. Robust standard errors in parentheses, clustered at the household level. *** p < .01 , ** p < .05 , * p < .01

5 Robustness Checks

To check the robustness of our results, we use a method similar to Randomization Inference, following the approach outlined by Young (2019). Specifically, we construct a fictitious Ramadan / Treatment period and estimate our main specification to see if we encounter significant results from being interviewed outside of the actual Ramadan period. If we do, that would suggest our results are capturing an effect other than the intended treatment effect of Ramadan. We carry out the following steps for this robustness check:

1. For both years (2007 and 2009), we exclude all households that were interviewed during Ramadan.
2. To maintain our data as a balanced panel, we also exclude households that were interviewed during Ramadan in 2007 but not in 2009 and vice-versa.
3. We create a dummy Ramadan variable using a random number generator, assigning 1 to 16.79% of the overall sample and 0 to the rest, mimicking the proportions of Ramadan and non-Ramadan periods in the original sample.
4. We run our main specification (equation 1) and record the t-statistics from each regression.
5. We repeat steps 1-4 one thousand times for all our outcomes and plot the distribution of t-statistics to see the percentage of times we find a significant effect.

We present the distribution of t-statistics for all results in Section 7.4 of the appendix. Across all outcomes, we identify a significant treatment effect in merely 1.7% to 3% of the models. This outcome suggests a minimal likelihood that the effects we've detected could be ascribed to random fluctuations or chance. Instead, the evidence provides substantial support for our thesis that the observed changes are a direct result of behavioral modifications during the period of Ramadan. Therefore, the alterations in the observed outcomes can be confidently associated with the influences of Ramadan, reinforcing the validity and robustness of our study's main findings.

6 Conclusion

This study distinguishes between the overarching concept of religiosity and the specific, ritualistic observances of Ramadan. The findings herein are not to be interpreted as a broad commentary on the general health effects of religiosity, but rather as an investigation into the tangible impacts of the distinct practices and disciplines during the Islamic fasting month, especially in diverse socio-economic contexts. Our findings are consistent with prior research suggesting that Ramadan fasting has mixed effects on health outcomes, with some negative consequences, particularly for vulnerable populations (Almond and Mazumder (2011); Van Ewijk (2011)). While our results demonstrate a decrease in aggregate consumption levels across all income groups, the negative health shock is larger for households in the bottom 50% of wealth.

Interestingly, the negative health shock for households does not translate into a negative health shock for children under five in the same households. This finding is in line with Almond and Mazumder (2011) Almond and Mazumder (2011)) work, which indicates that the effect of Ramadan observance during pregnancy may not be universally negative, with the impact depending on the stage of pregnancy during which fasting occurs. Our results extend this research by highlighting the potential resilience of young children in the face of adverse conditions associated with Ramadan fasting.

Finally, our study provides evidence of a net zero effect on subjective well-being. This finding resonates with the work of Lim and Putnam (2010) Lim and Putnam (2010), who found that religion can contribute to life satisfaction through social networks and the support they provide. Our results suggest that voluntary adherence to religious practices like Ramadan fasting can change individual behavior in ways that may have negative implications for physiological health but no implications for psychological health, possibly due to the social support networks provided by religious communities.

The nuanced approach of this study sheds light on how different households, based on their wealth status, adapt and respond to the rigors of Ramadan. The emphasis is not on the inherent religious fervor but on the concrete, day-to-day practices prescribed during this period. This distinction is vital in understanding the varied outcomes observed. It's essential for future policy and intervention designs to consider this differentiation, recognizing that the impacts of religious practices like fasting during Ramadan are deeply intertwined with the socio-economic realities of the practitioners. This perspective underscores the need for tailored approaches in addressing the health and well-being concerns arising from such religious observances. Our study has important implications for policymakers, as it highlights the need for targeted interventions that can mitigate the potential negative health effects of religious practices, particularly for vulnerable populations. It also underscores the importance of understanding the complex interplay between religion, health, and well-being in diverse cultural contexts.

Future research could further explore the mechanisms through which fasting during Ramadan affects the health and well-being of individuals and households, as well as potential interventions to address the observed disparities in health outcomes. Additionally, it would be valuable to investigate the long-term effects of religious practices on health and well-being, as well as the potential intergenerational transmission of these effects.

7 Appendix

7.1 Robustness - Fake Ramadan Period

Figure 4: Distribution of T-statistics - Daily Prayers

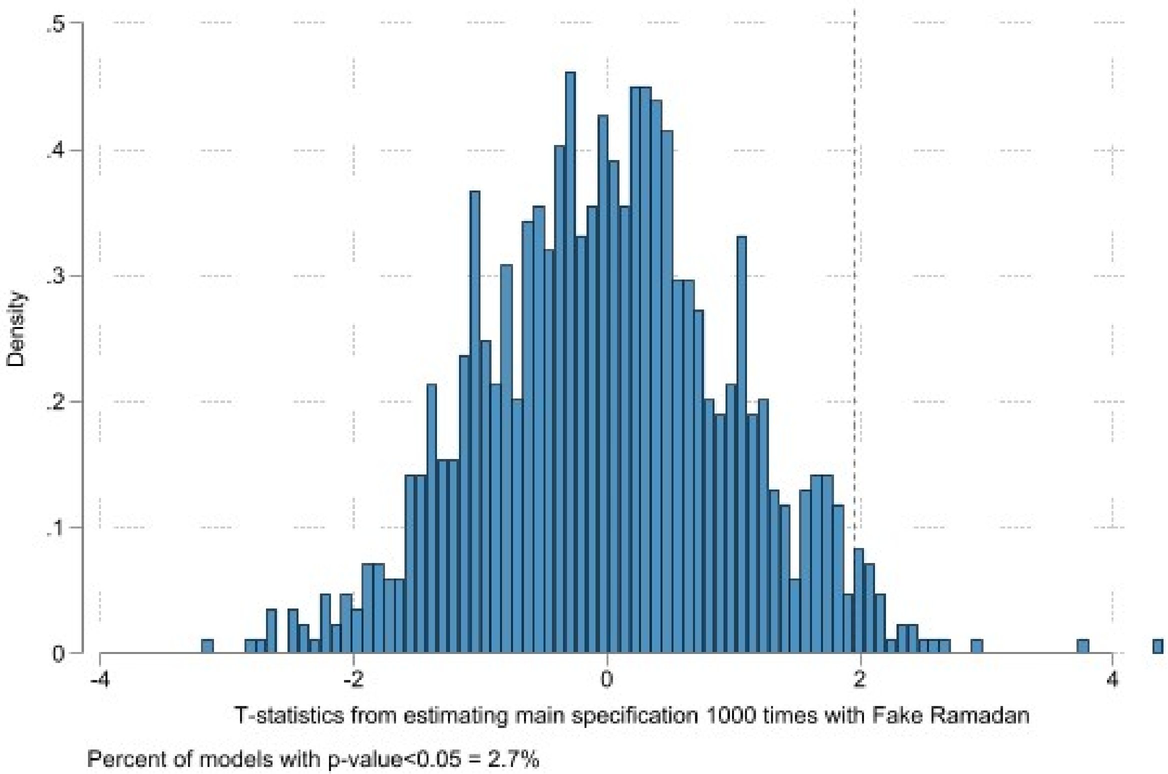


Figure 5: Distribution of T-statistics - Hygene

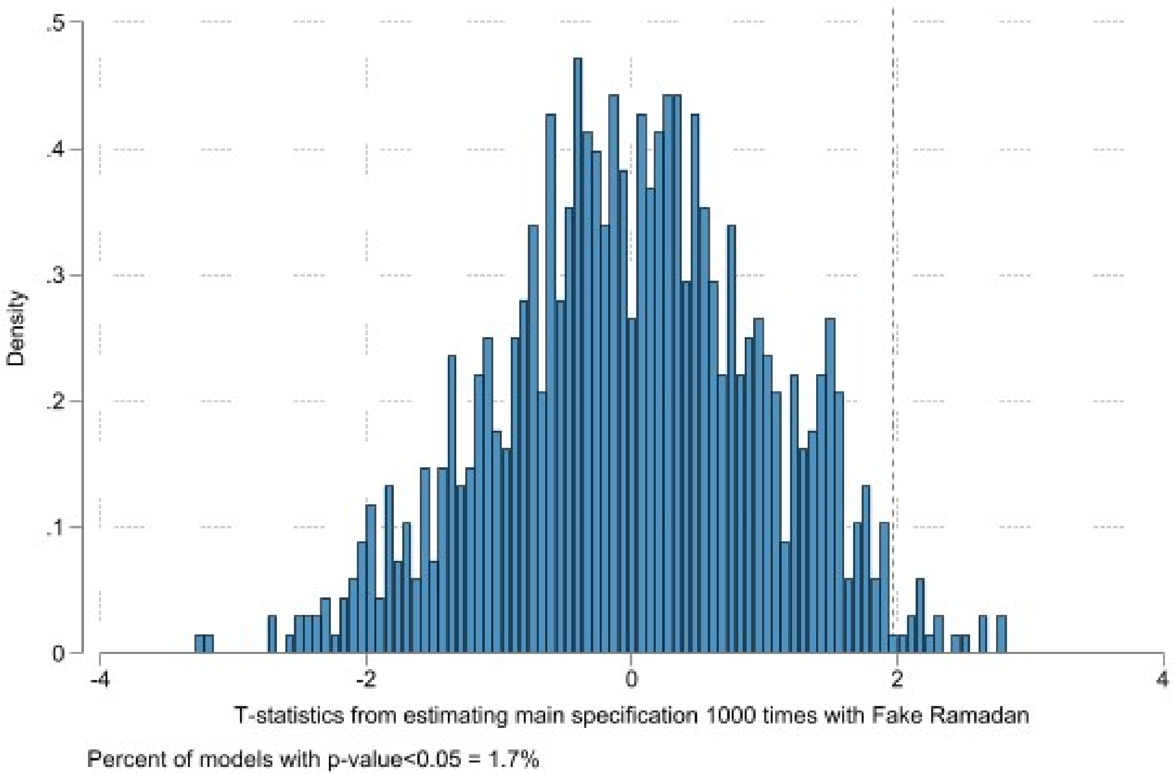


Figure 6: Distribution of T-statistics - Weight (KGs)

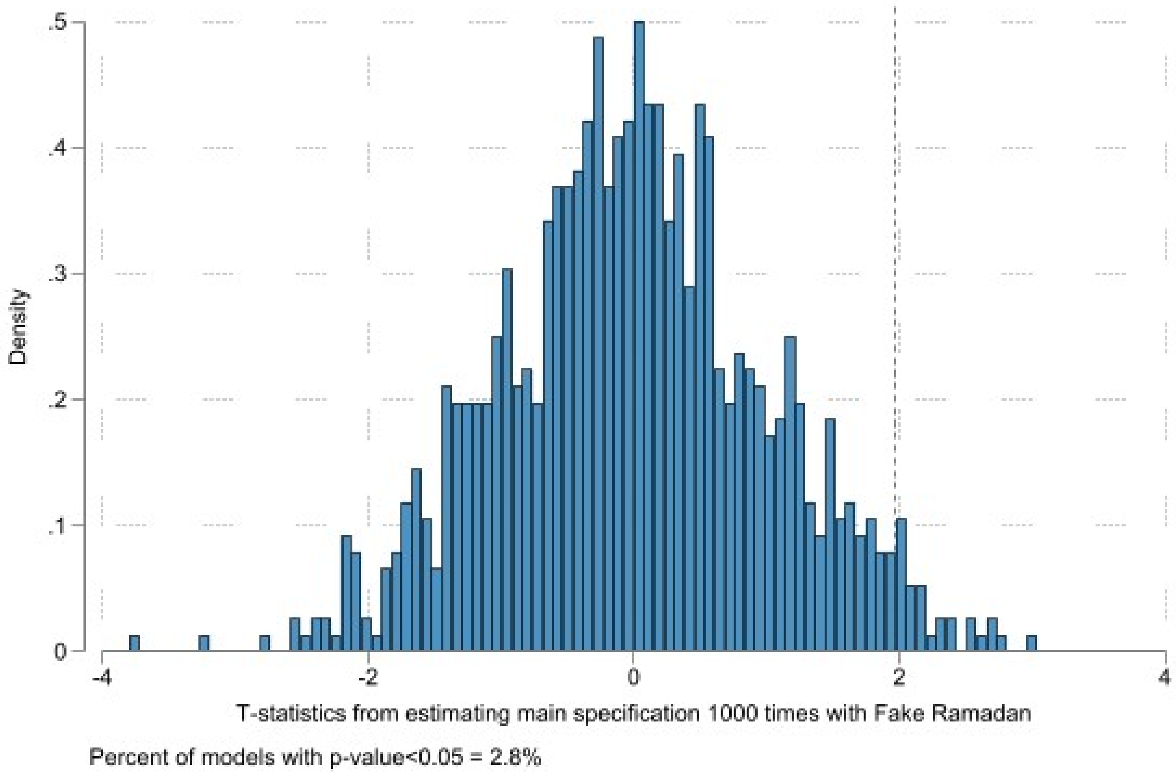


Figure 7: Distribution of T-statistics - Body Mass Index (BMI)

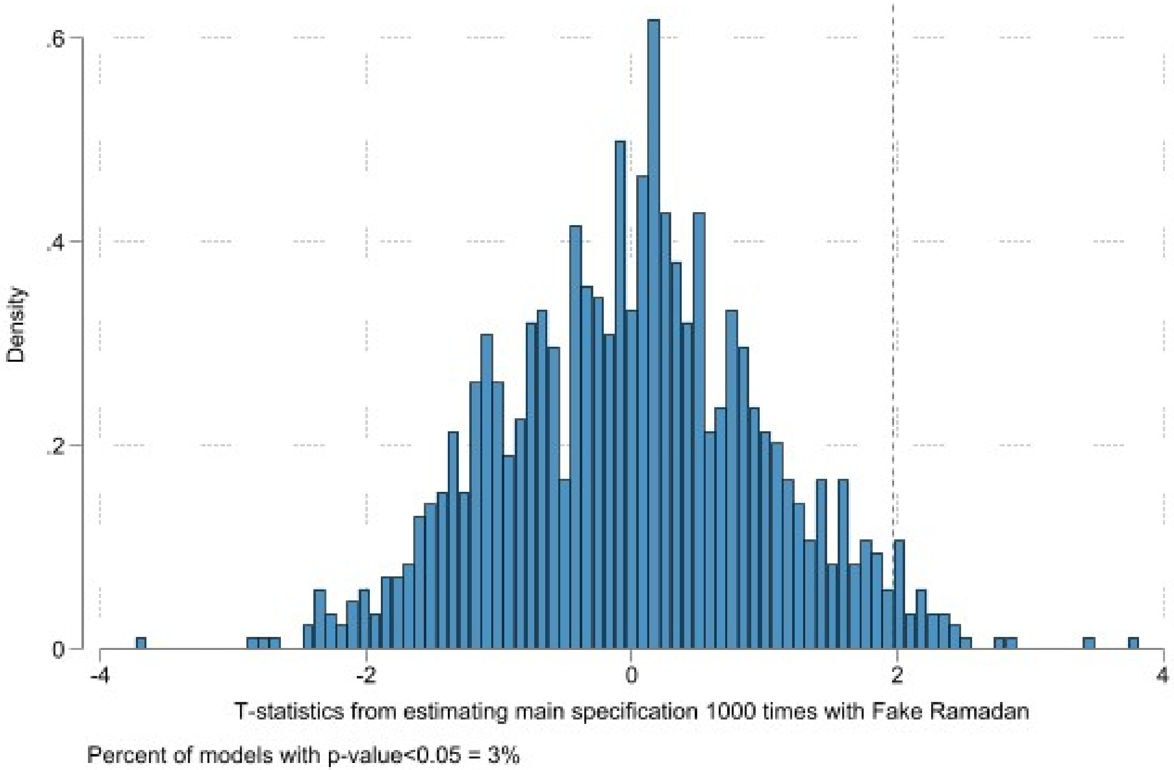


Figure 8: Distribution of T-statistics - Malnorished

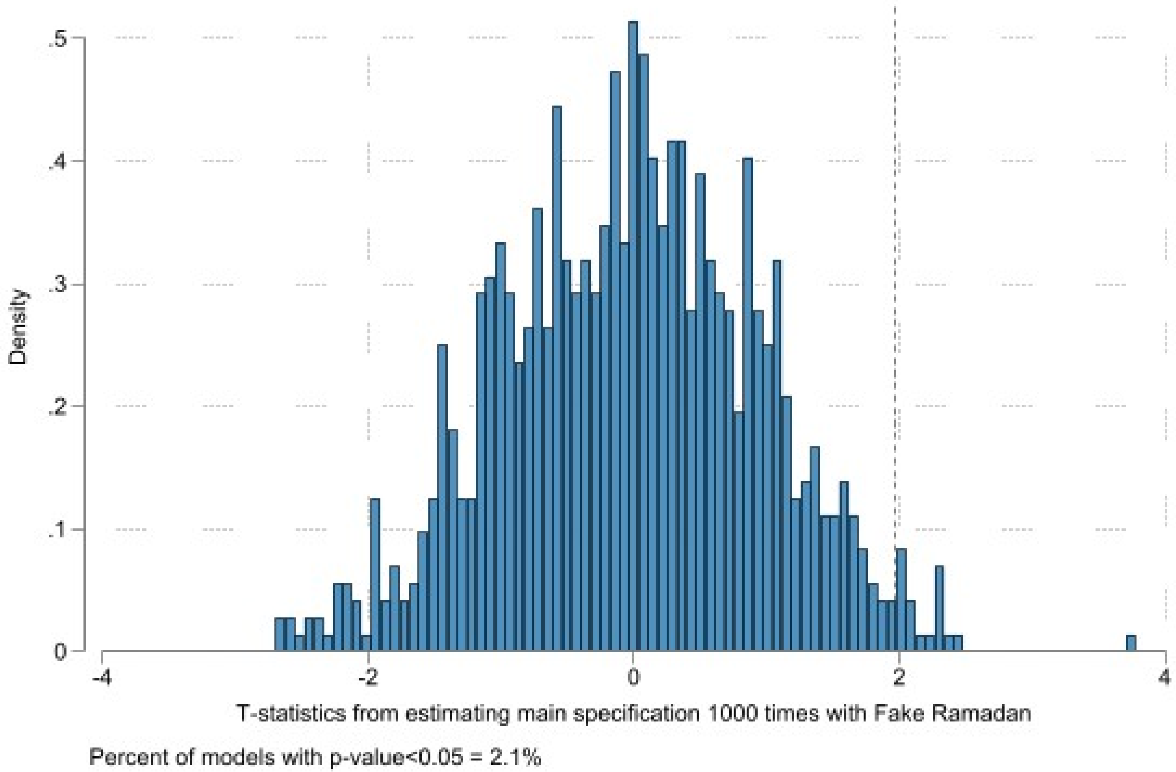
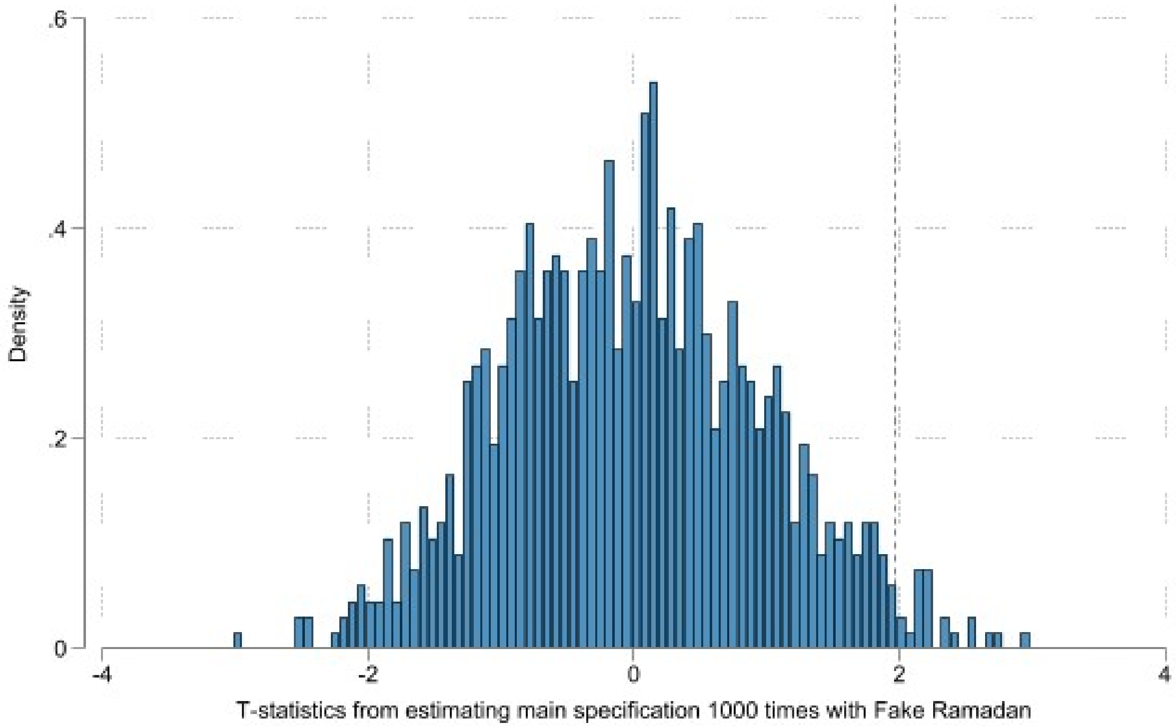
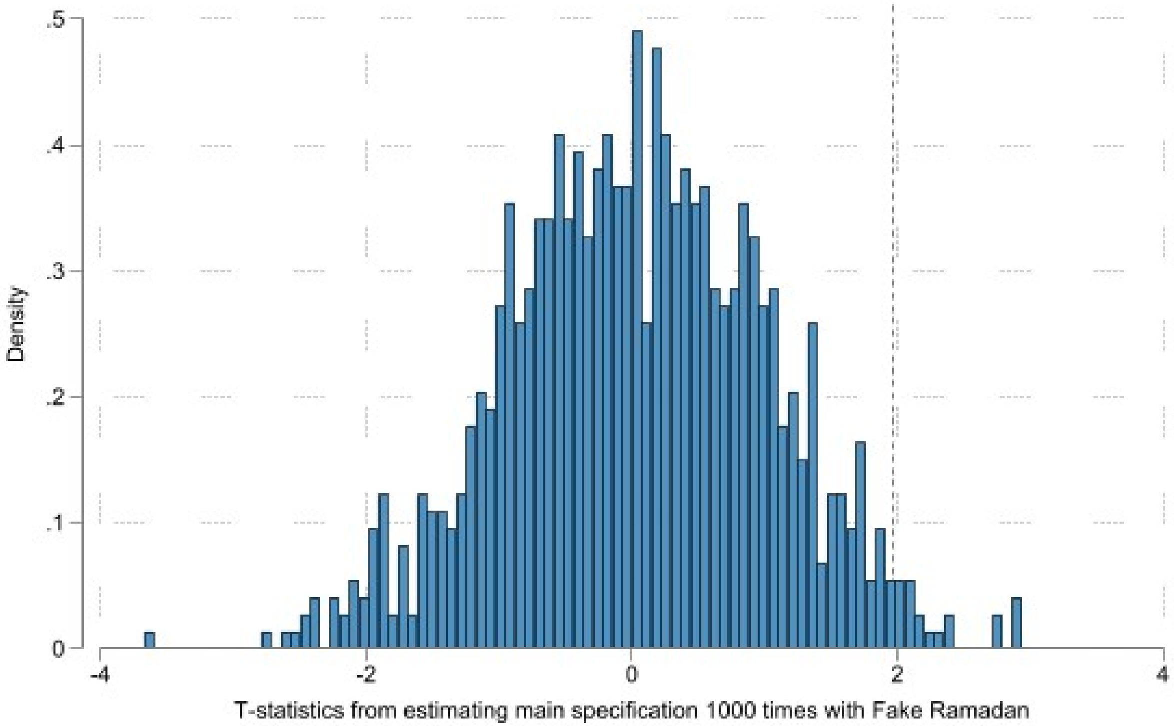


Figure 9: Distribution of T-statistics - Subjective Wellbeing



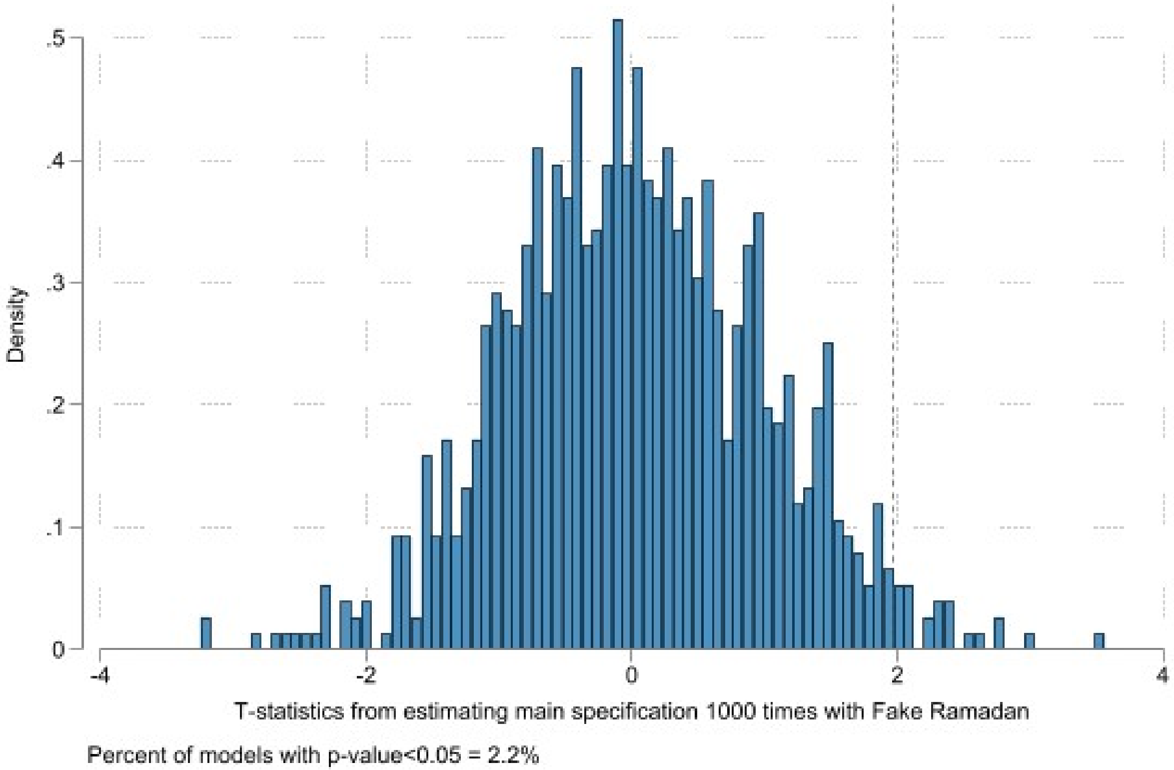
Percent of models with p-value<0.05 = 2.3%

Figure 10: Distribution of T-statistics - Consumption (Gram Per Capita)



Percent of models with p-value<0.05 = 1.9%

Figure 11: Distribution of T-statistics - Calories (Per Capita)



Chapter 3

COVID-19 and Adolescent Girls' Mental Health in Uganda: A Panel Data Analysis

1 Introduction

SARS-CoV-2 is a virus that spreads between humans through coughing, sneezing, and surfaces that are potentially contaminated CDC (2021). On March 11, 2020, the World Health Organization declared SARS-CoV-2 as a pandemic, which by October 1, 2020, had already affected 34 million globally with an estimated death toll of 1 million worldwide WHO (2020). In order to prevent the spread of the virus, strict public health measures were taken, which included social distancing, face masks, travel restrictions, and school closures Wilder-Smith and Freedman (2020). While these preventive measures helped minimize the spread of the virus, they also resulted in negative economic and health consequences, which can serve as triggers for poor mental health conditions Fusar-Poli et al. (2020). For example, analysis conducted during the initial phase of the COVID-19 outbreak in China shows moderate-to-severe psychological impacts in more than half of the study respondents Wang et al. (2020).

A demographic of particular concern in mental health discourse is young people, given that the majority of mental health issues experienced during adulthood begin in adolescence WHO (2021). Adolescence is a life stage rife with heightened psychosocial vulnerability, which, if not managed or treated aptly, can have severe short- and long-term consequences [Carvajal-Velez et al. (2021), Patel et al. (2021), Taylor et al. (2010)]. Moreover, mental health conditions and associated behavioral disorders are the leading causes of years lived with disability and years of life lost due to premature mortality in adolescents [Carvajal-Velez et al. (2021), Lozano et al. (2012)]. Thus, unsurprisingly, mental health disorders among adolescents have increasingly moved to the center stage of global public health and development policy issues in the last few decades, most notably in their inclusion in the Sustainable Development Agenda through Sustainable Development Goal (SDG) target 3.4, which aims to "promote mental health and well-being." Moreover, good mental health is an essential factor in improving women's voice and agency UN (2018), integral mechanisms through which the core goal of SDG 5—"Achieve gender equality and empower all women and girls"—can be attained [UN (2015), Good (2000)].

The unprecedented disruptions to social and community networks, in-person learning, economic and recreational activities, and access to health care due to the COVID-19 pandemic and associated mitigating measures pose unparalleled threats to the mental health of adolescents globally [Samji et al. (2021), UN (2020)]. Given the emotional gravity of COVID-19, many posit that mental health disorders among adolescents will exacerbate, putting millions of young people at risk of mental health deterioration. The anticipated negative effects of COVID-19 on adolescent mental well-being could even be more telling for adolescent girls and young women in low- and middle-income countries (LMICs), who, layered on top of the drastic physical, emotional, and social changes they experience during adolescence, contend with high levels of exposure to poverty, abuse, or violence Fusar-Poli et al. (2020). The pandemic, coupled with the preexisting socioeconomic challenges that most young women in LMICs face, can make adolescent girls extremely vulnerable to mental health problems and their accompanying short- and long-term implications.

This study aims to contribute to a nascent literature on the influence of COVID-19 on the mental health of young women living in low-resource contexts. We use 3 rounds of panel data collected prior to and during the COVID-19 pandemic (2019–2021) on 468, initially 13- to 19-year-old young women residing in urban and peri-urban areas of Kampala, Uganda.1 Using validated measures of mental health, including the Patient Health Questionnaire-8 (PHQ-8) and General Health Questionnaire-12 (GHQ-12), we assess the changes in mental health among these young women before and during the pandemic. We hypothesize that the COVID-19 pandemic led to declines in mental health.

We also explore how young women perceived and actual burden of the COVID-19 pandemic affects their mental health. While there exists a growing literature on the COVID-19 pandemic's role in exacerbating psychological functioning such as suicidal thoughts Bhuiyan et al. (2020) and lower life satisfaction Satici et al. (2021), it is not clear how perceptions about a pandemic (measured in this analysis as an index of perceived impact on the community) can affect young women's overall mental health. Literature relevant in this space focuses on either the impacts of containment policies on older women's mental health Bau et al. (2022) or looks at how fear of COVID-19 among individuals can evolve into a range of adverse mental health outcomes Huarcaya-Victoria et al. (2020). These include psychological distress Alyami et al. (2020), post-traumatic stress symptoms Bo et al. (2020), moderate-to-severe depressive symptoms [Belen (2020), Holmes et al. (2020), Šljivo et al. (2020), Soraci et al. (2020)], and anxiety [Cameron et al. (2020), Roy et al. (2020)]. We also compare this to the actual COVID-19 burden, measured as an index of the self-reported impact of the pandemic on the adolescent girl and her household. Since these questions were asked in the middle of the pandemic and lockdowns, our hypothesis is that higher levels of actual and perceived COVID-19 burden should be associated with worse mental health outcomes.

Our analysis contributes to literature in a number of important ways. First, it adds to a growing literature on COVID-19 and mental health among adolescents and young adults Cowie and Myers (2021), where evidence for LMICs is still limited, particularly among adolescents [UNICEF (2021), Matovu et al. (2021)]. For instance, out of the 116 studies investigating the impacts of the pandemic on mental health of children and youth reviewed by Samji et al. Samji et al. (2021), only 8 used data from an LMIC (3 of which are from African countries). Second, it is one of only a few studies to go beyond cross-sectional analysis, improving our ability to uncover a causal relationship Samji et al. (2021). Third, this study is among the first indicating the importance of perceived and actual burden of COVID-19 as a critical mechanism through which COVID-19 may have affected mental health. Lastly, it is the first article that we are aware of that looks at mental health among young women in Uganda. Matovu et al. (2021) also looks at mental health during the COVID-19 pandemic in Uganda but focuses on the effects of COVID-19 lockdowns on young men's mental health and other socioeconomic outcomes.

2 COVID-19 & Mental Health in Uganda

2.1 Lockdowns, Infections, and Impact on Economy

The first case of COVID-19 infection in Uganda was reported on March 21, 2020, rapidly triggering a robust preventative government response. Among the 33 preventative interventions implemented in response to the pandemic, schools and institutions of higher learning were closed, social gatherings were halted, travel restrictions were instituted, and curfews were instituted in the entire country, including a 3-month-long nationwide home confinement Matovu et al. (2021).

The Government of Uganda declared COVID-19 a national emergency on January 30, 2020, and instituted several institutional arrangements aimed at controlling the spread of the disease. As of December 2, 2021, Uganda had a total of 127,618 confirmed cases of COVID-19 and 3,252 deaths WHO (2021). While pivotal to containing the spread of the virus, the measures adopted in the country (Figure 1) also resulted in severe disruptions to the daily life of the Ugandan population, with unintended consequences. Early evidence found a decline in access to key health services and increase in adverse outcomes, including the prevalence of gender-based violence (GBV) UN (2020). The lockdown also had a severe negative impact on household earnings and access to food, both due to transport restrictions and sudden food price increases. While this was partially mitigated by a food distribution program rolled out by the Government of Uganda early in the pandemic, the strategy had a slow impact, leaving the majority of households vulnerable to food insecurity Nathan and Benon (2020). Uganda's real gross domestic product grew at less than half the rate recorded in 2019, likely as a result of the COVID-19 pandemic and indirect effects of the measures that were undertaken to prevent the spread of the virus WB (2021).

2.2 Mental Health in Uganda

Prior to the pandemic, Uganda ranked among the 6 top countries in Africa with the highest prevalence of depressive disorders WHO (2017), and mental health care

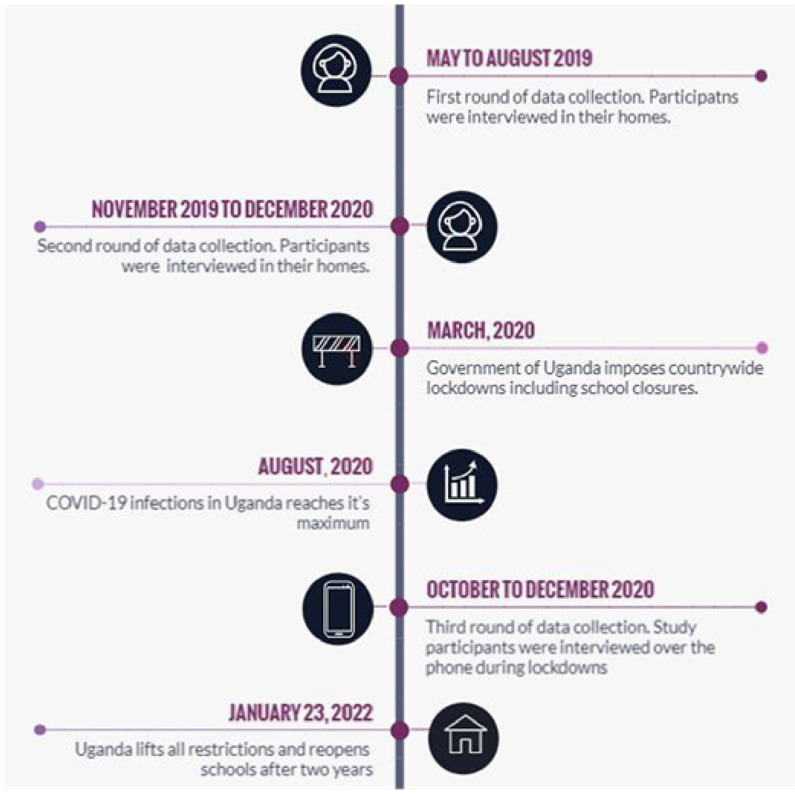


Figure 1: Study Timeline

funding and provision were described as largely inadequate Molodynski et al. (2017). Given the socioeconomic difficulties that the Ugandan population face to meet their daily basic needs, it is likely that the onset of COVID-19 and its associated restrictions have had a particularly severe negative effect in Uganda Kagaari (2021).

This concern is particularly heightened among adolescents. While adolescents are also susceptible to COVID-19 infection, infection is less likely to progress to severe disease than in older adults WHO (2021). Instead, adolescents are more likely to suffer from indirect consequences of COVID-19 WHO (2021). Part of this is due to prolonged school closures, which had a negative effect on the mental health and cognitive development of adolescents globally Kola et al. (2021). In Uganda, the adverse effects of school closures are expected to be disproportionately severe, as closures prevented students from returning to school for almost 2 years [39]. When looking at adolescent girls in particular, COVID-19 has been linked to mental health problems, including disorders, stress, anxiety, and fear in Uganda Plan-International (2021).

Adolescent mental health is vital in the context of Uganda given the social, economic, and political challenges affecting people including adolescent boys and girls Thumann et al. (2016). The country is ranked among the highest African countries in terms of having a population with high levels of mental illness amid inadequate mental health support services and care Miller et al. (2020). During lockdowns, economic pressure, social isolation, fear, and stress have been found to result in increased GBV around the world [43]. With 34% of Ugandan women being married before the age of 18 UNFPA (2019), the COVID-19 home confinements may also have placed young women at heightened risk of GBV in Uganda, with further consequences on their mental health status.

3 Methods

3.1 Data Sources

The present analysis uses longitudinal data from 3 rounds of an ongoing study with adolescent girls aged 13–19 years at baseline (2019), covering 6 urban and 2 peri-urban subdistricts located in the central region of Kampala, Uganda. As outlined in Figure 1, the first round of data was collected in 2019, between May and August, when participants were interviewed in their homes. The same girls were interviewed again for a second round of data collection, which took place between November 2019 and February 2020, ending just before the onset of COVID-19. This was followed by the third round of data collection that took place during the COVID-19 pandemic between October and December 2020. The third round of data collection was conducted virtually to avoid potential risk of COVID-19 infection.

In 2019, all young women between the target age of 13–19 years old living within a 0.5 km radius from BRAC Uganda's "Empowerment and Livelihood for Adolescents" (ELA) clubs, who provided informed assent/consent, were listed and screened for symptoms of depression. These clubs were used as a way to delineate communities and served the basis of an ongoing cluster randomized control trial which is explained in detail by Baird et al. (2020). The selection of participants was based on the 8-item PHQ-8 depression scale: a diagnostic tool to screen for current depression Kroenke et al. (2001). In this study, we restrict our analysis to balanced panel of 468 young women2 who belong to the control group of the original experimental study.3

4 Measures

All 3 rounds of the survey contained detailed information on key demographic characteristics alongside validated measures capturing aspects of mental health. Additionally, COVID-19 specific measures were collected in the third round of data collection. We now describe the precise measures in detail (Table 1).

4.0.1 Dependent Variable: PHQ-8 & GHQ-12

Our primary outcome of interest is the mental health status of the adolescent girl, which we measure in 2 ways, both aimed at capturing symptoms of psychological distress. The first is the total score (from 0 to 24, with higher values indicating worse mental health) on the PHQ-8, which is measured with a set of 8 questions and is a widely used and validated depression instrument that assesses the prevalence and severity of depressive symptoms in clinical and general settings, including in LMICs [46]. In addition, we utilize the GHQ-12 (from 0 to 36, again with higher values indicating worse mental health), which is another widely used—including in LMIC contexts—and reliable 12-item self-assessment screening tool to aid clinical diagnosis of mood disorders such as anxiety and depression Goldberg et al. (1997). We choose to use the continuous score to capture the full distribution of the measure as opposed to specifying a binary cutoff.

Table 1: Variable descriptions and summary statistics (mean and standard deviation, N = 468)

Variable name	**Definition of variable**	**Round 1**	**Round 2**	**Round 3**
PHQ-8	A composite score to measure depression from a set of 8 questions. The index score ranges from 0 to 24 with higher values meaning more depression [46]	13.14	8.05	9.14
		(2.93)	(4.77)	(5.11)
GHQ-12	A composite score to measure anxiety from a set of 12 questions. The index score ranges from 0 to 36 with higher values meaning more anxiety [48]	6.92	4.85	4.79
		(2.92)	(3.17)	(3.17)
Perceived COVID-19 Burden	An aggregate index that was made from a combination of questions relating to perceived impact of COVID-19 and lockdowns on jobs lost, food insecurity, violence, etc. in the community. The score ranges from 1 to 17 with higher values meaning more perceived burden. For details see appendix. For comparison purposes, we use a standardized measure of this score in our regressions.	NA	NA	11.54
				(2.40)
Actual COVID-19 Burden	An aggregate index that was made from a combination of questions relating the impact of COVID-19 and lockdowns on personal level outcomes like getting angrier, arguing more often, being more stressed etc. The score ranges from 2 to 12 with higher values meaning more actual burden. For details see appendix. For comparison purposes we use a standardized measure of this score in our regressions.	NA	NA	8.28
				(1.83)
Age	Age is a continuous variable that ranges from 13 to 19 (at round 1)	16.80	17.09	17.88
		(2.02)	(2.08)	(2.11)
Education	Education is a dummy variable that takes the value of 1 if the respondent has completed at least secondary school level of education or higher and 0 otherwise.	0.23	0.25	0.26
		(0.42)	(0.43)	(0.44)
Never Married	A dummy variable indicating whether the respondent has been married or not (1 – never been married, 0 – otherwise)	0.85	0.85	0.82
		(0.35)	(0.35)	(0.37)

Notes: Means and standard deviations (in brackets) for all variables used in our estimating equation. GHQ-12 = General Health Questionnaire-12; NA = not applicable; PHQ-8 = Patient Health Questionnaire-8

4.0.2 Main Independent Variables: Perceived & Actual COVID-19 Burden

Round 3 data collection involved a COVID-19 experiences section that was adapted from the Evidence-based Measures of Empowerment for Research on Gender Equity COVID-19 module Center on Gender Equity and Health GEH (2020) and Baird et al. (2020). This section assessed community-level awareness of the containment efforts to control the spread of the COVID-19 virus as well as the perceived effect of COVID-19 on the community as a whole by asking "yes" or "no" questions (e.g., due to the COVID-19 pandemic, people are unable to bank or get cash for daily expenses; more people are becoming very anxious or depressed; there is more violence among people in the community, families cannot afford to buy enough food to eat, etc.).

We summed the number of affirmative answers to create an aggregate measure of "Perceived COVID Burden." The COVID-19 experiences survey also assessed the impact COVID-19 may have had in the personal life of the adolescent girl and her household by asking a series of "yes" or "no" questions (e.g., are you getting angry more quickly, arguing more often, etc.) as well as Likert-scale type questions (e.g., "do you agree, partially agree, or disagree with the statement that COVID-19 has increased the stress in your household," etc.). We summed these questions to create an aggregate measure of "Actual COVID Burden." See Appendix (Section 8.1) for the full set of questions used to create both the perceived and actual COVID-19 burden indices.

4.0.3 Covariates

We include the age of the respondent, her educational attainment, and marital status as covariates in our estimating model. These variables are known to be associated with both awareness and state of mental health in Uganda Lemuel et al. (2021). Our models also control for all time-invariant covariates. Table 1 provides the definitions of the variables included in the regression models used in this study along with means across all 3 rounds of data collection. At baseline (Round 1), respondents' average age is 17 years, about 23% of respondents had completed at least secondary school level of education or higher and about 85% of respondents have never been married.

4.1 Data Analysis

All statistical analysis was conducted using Stata 17.0. To analyze how symptoms of psychosocial distress have changed over time among our study population, we combine 3 rounds of data and employ a fixed effects regression approach. The regression equation takes the following form:

$$Y_{itc} = \alpha_i + \beta_1 T_i + X_{itc} + Z_i + \epsilon_{itc} \tag{1}$$

In the equation above, Yi_{tc} is a measure of individual i's PHQ-8 or GHQ-12 scores at time t in cluster c, T_i is a dummy variable that captures time. The coefficient β will measure the change in PHQ-8 and GHQ-12 scores over time as T_i switches from 0 to 1, X_{itc} represents the set of time-variant covariates listed above for individual i at time t in cluster c. Z_i and ϵ_{itc} are individual-level fixed effects and standard errors clustered at the level of ELA club, respectively. The individual fixed effects control for all observable and unobservable time-invariant differences across individuals.

We choose to estimate Equation 1 by first analyzing changes in our main outcomes from Round 1 to Round 2 and then again for examining changes in outcomes from Round 2 to Round 3. We take this approach because we hypothesize that from Round 1 to Round 2 both the PHQ-8 and GHQ-12 scores should substantially decrease due to the design of the study. Specifically, since at baseline we only enroll adolescent girls showing symptoms of moderate-to-severe depression (scoring 10 on the PHQ-8), we anticipate significant remission by Round 2, consistent with other studies GEH (2020). We then treat the data in Round 2 as the steady state, and in the absence of any negative (or positive) shocks hypothesize, controlling for relevant covariates, that rates should remain stable. From Round 2 to Round 3, given the onset of the COVID-19 pandemic, we hypothesize significant declines in mental health in our sample of young women.

To further explore how experiences during COVID-19 pandemic are associated with psychological distress, we investigate how perceived and actual experiences with COVID-19 are associated with symptoms of psychological distress. To this end, we estimate the following equation:

$$Y_{itc} = \alpha_i + \beta_1 CovidBurden_i + X_i + Z_i + \epsilon_{ic} \tag{2}$$

where Y_i is a measure of individual i's PHQ-8 or GHQ-12 scores in Round 3 (or change between Round 2 and Round 3 in an alternative estimation), CovidBurdeni measures the scores on perceived and actual COVID-19 burden for individual i, β measures the association between the outcome Y_i and $CovidBurden_i$, Z_i are ELA club level fixed effects that control for all ELA club level observable and unobservable variables that are fixed over time like subdistrict level norms, geographical location of the subdistrict, and so on, X_i is a rich set of covariates from baseline of data collection which includes individual and household characteristics of the respondent that are associated with depression and psychological distress. These include age (continuous), marital status (indicator for never married), an indicator for qualified secondary school or higher, county of the total number of close friends the respondent has, an index of household's likelihood of falling below the poverty line as measured by the Poverty Probability Index, and an indicator if the respondent has been involved in any paid work activity in the last 12 months. Finally, ϵ_{ic} are standard errors clustered at the ELA club level.

5 Results

5.1 Changes in Mental Health Prior to COVID-19

Table 2 shows results from estimating regression Equation 1 for changes in PHQ-8 and GHQ-12 scores from Round 1 to Round 2. For each outcome, columns correspond to an unadjusted regression (Columns 1 and 4), an adjusted regression that controls for individual-level time-variant covariates (Columns 2 and 5), and finally results for a regression that controls for both time-variant covariates and individual-level fixed effects (Columns 3 and 6).

Table 2: Change in depression and psychological distress from Round 1 (June to August 2019) to Round 2 (November 2019 to February 2020)

VARIABLES	(1) PHQ8	(2) PHQ8	(3) PHQ8	(4) GHQ-12	(5) GHQ-12	(6) GHQ-12
0=Baseline, 1=RR	-5.090***	-5.167***	-5.285***	-2.075***	-2.128***	-2.238***
	(0.374)	(0.374)	(0.382)	(0.279)	(0.284)	(0.298)
Age		0.292***	0.697		0.196***	0.545**
		(0.056)	(0.480)		(0.062)	(0.259)
Never Married		-1.063*	-0.541		-0.444	0.095
		(0.535)	(1.117)		(0.329)	(0.498)
Education		-0.488	-0.245		-0.214	0.485
		(0.313)	(0.793)		(0.253)	(0.751)
Observations	936	936	936	936	936	936
Adjusted R-squared	0.292	0.317	0.351	0.103	0.120	0.254
Controls	No	Yes	Yes	No	Yes	Yes
Individual FE	No	No	Yes	No	No	Yes
Mean in Round 1			13.15			6.925
Mean in Round 2			8.060			4.850

Notes: Column (1) estimates an unadjusted version of Equation 1, Column (2) controls for time-variant covariates, and Column (3) controls for both time-variant covariates and individual-level fixed effects. Robust standard errors clustered at the ELA club level. FE = fixed effects; GHQ-12 = General Health Questionnaire-12; PHQ-8 = Patient Health Questionnaire-8.Stars denote statistical significance: ***P < 0.01, **P < 0.05, *P < 0.10.

Table 2 shows a clear reduction (improvements) in PHQ-8 and GHQ-12 scores across all 3 versions of the model from Round 1 (May to August 2019) to Round 2 (November 2019 to February 2020) which ended just before the start of the COVID-19 pandemic. These improvements in PHQ-8 and GHQ-12 are not only significant at the 1% level but also considerably large in magnitude with an average improvement of 40% for the PHQ-8 and 30% for the GHQ-12, respectively, with consistent effect sizes across specifications. As noted above, we recruited a sample that all exhibited symptoms of moderate-to-severe depression at Round 1 and based on existing literature anticipated levels of remission in this range Baranov et al. (2020). These findings also show a sharp age trend, with older individuals scoring higher on both the PHQ-8 and the GHQ-12.

5.2 Changes in Mental Health During COVID-19

Table 3 follows the same structure as Table 2, but focuses on changes from Round 2 to Round 3. A reminder that data collection in Round 3 was done during COVID-

19 lockdown. In the absence of the pandemic, we hypothesized that these measures should stay stable over time. Our findings suggest increases in symptoms of depression of around 10% from Round 2 to Round 3 for the PHQ-8, with no significant movement on the GHQ-12.

Table 3: Change in depression and psychological distress scores from Round 2 (November 2019 to February 2020) to Round 3 (August 2020 to December 2020))

VARIABLES	(1) PHQ8	(2) PHQ8	(3) PHQ8	(4) GHQ-12	(5) GHQ-12	(6) GHQ-12
0=RR,, 1=Midline	1.083***	0.674**	0.717*	-0.060	-0.279	-0.349
	(0.336)	(0.326)	(0.408)	(0.284)	(0.281)	(0.297)
Age		0.506***	0.465		0.266***	0.354*
		(0.087)	(0.324)		(0.056)	(0.189)
Never Married		-0.580	0.398		-0.415	0.047
		(0.530)	(0.532)		(0.348)	(0.422)
Education		-0.731**	0.659		-0.261	0.696
		(0.344)	(0.904)		(0.238)	(0.532)
Observations	936	936	936	936	936	936
Adjusted R-squared	0.011	0.056	0.343	-0.001	0.031	0.323
Controls	No	Yes	Yes	No	Yes	Yes
Individual FE	No	No	Yes	No	No	Yes
Mean in Round 2			8.060			4.850
Mean in Round 3			9.143			4.791

Notes: Column (1) estimates an unadjusted version of Equation 1, Column (2) controls for time-variant covariates, and Column (3) controls for both time-variant covariates and individual-level fixed effects. Standard errors clustered at the ELA club level. FE = fixed effects; GHQ-12 = General Health Questionnaire-12; PHQ-8 = Patient Health Questionnaire-8. Stars denote statistical significance: ***P < 0.01, **P < 0.05, *P < 0.10.

5.3 Associating Burden of COVID-19 with Mental Health

While the above findings suggest there may have been small declines in mental health as a result of the COVID-19 pandemic, it is not conclusive given different findings for the PHQ-8 and the GHQ-12. But, these average effects may mask important heterogeneity based on exposure to the pandemic. Table 4, Panel A, further explores the association between symptoms of psychological distress with perceived and actual COVID-19 burden. As a reminder, the perceived COVID-19 burden includes the adolescent woman's reported presence of containment efforts in her community to control the spread of the COVID-19 virus, as well as her perceived effect of COVID-19 on the community as a whole.

The actual COVID-19 burden measures the impact of COVID-19 on the participant and her household (see Appendix Section 8.1 for all items included in the construction of perceived and actual COVID-19 burden). Both of these scores are measured on a continuous scale with higher values indicating a greater burden and standardized with a mean of 0 and standard deviation of 1. Column (1) of Table 4, Panel A, shows results from estimating Equation 2 for perceived COVID-19 burden, Column (2) does the same for actual COVID-19 burden and Column (3) estimates Equation 2 with both measures.

Table 4: Burden of COVID & Mental Health

VARIABLES	(1) PHQ8	(2) PHQ8	(3) PHQ8	(4) GHQ-12	(5) GHQ-12	(6) GHQ-12
Panel A: Continuous Measure (PHQ-8 and GHQ-12)						
Perceived COVID Burden	0.920***		0.686***	0.657***		0.673***
	(0.226)		(0.233)	(0.135)		(0.161)
Actual COVID Burden		1.218***	1.131***		0.340	0.253
		(0.262)	(0.258)		(0.232)	(0.198)
Observations	449	449	449	449	449	449
Adjusted R-squared	0.044	0.069	0.087	0.054	0.022	0.105
Panel B: Difference Measures Change in PHQ-8 and GHQ-12 from Round 2 to Round 3						
Perceived COVID Burden	0.096		0.083	0.076		0.184
	(0.254)		(0.272)	(0.168)		(0.210)
Actual COVID Burden		0.502	0.722**		-0.102	-0.055
		(0.318)	(0.270)		(0.228)	(0.180)
Observations	449	449	449	449	449	449
Adjusted R-squared	0.001	0.009	0.043	0.008	0.008	0.072

Notes: Panel A: Column (1) estimates Equation 2 with perceived COVID-19 burden as an independent variable, Column (2) estimates Equation 2 for actual COVID-19 burden as an independent variable, Column (3) estimates Equation 2 with both. All models control for baseline covariates including age, an indicator for qualified secondary school or higher, an indicator for being never married, number of close friends the respondent have, an index of household's likelihood of falling below the poverty line, and whether the respondent has taken up any paid work in the last 12 months. All regressions control for subdistrict level fixed effects with robust clustered standard errors.Panel B: Outcome of interest is the change in PHQ-8 and GHQ-12 scores from Round 2 to Round 3. Column (1) estimates Equation 2 with perceived COVID-19 burden as an independent variable, Column (2) estimates Equation 2 for actual COVID-19 burden as an independent variable, Column (3) estimates Equation 2 with both. All models control for baseline covariates including age, an indicator for qualified secondary school or higher, an indicator for being never married, number of close friends the respondent have, an index of household's likelihood of falling below the poverty line, and whether the respondent has taken up any paid work in the last 12 months. All regressions control for subdistrict-level fixed effects with robust clustered standard errors. CB = Covid burden; GHQ-12 = General Health Questionnaire-12; PHQ-8 = Patient Health Questionnaire-8.Stars denote statistical significance: ***P < 0.01, **P < 0.05, *P < 0.10.

Findings in Table 4 suggest that a 1 standard deviation increase in perceived COVID-19 burden is associated with a 0.920 increase in the PHQ-8 score (Table 4, Column 1). Therefore, going from 1 to 17 on the scale, a 3 standard deviation increase, would lead to an increase of 2.760 on the PHQ-8 score. Similarly, a 1 standard deviation increase in actual COVID-19 burden is associated with 1.218 points increase in the PHQ-8 score (Table 4, Column 2) which is an increase of 1.83 points on a 12-point actual COVID-19 burden scale. We observe a similar pattern for psychological distress measured by GHQ-12. Another interesting aspect of our results is the magnitude of these coefficients. In Column (3), for PHQ-8, both perceived and actual COVID-19 burden are associated with weaker mental health, but the magnitude of the actual COVID-19 burden coefficient suggests that this type of burden may take a much bigger toll on mental health, compared to perceptions about how COVID-19 may have affected the community.

In Panel B of Table 4, we compare changes in symptoms of psychological distress from Round 2 to Round 3 with perceived and actual COVID-19 burden. We find a significant positive association of actual COVID-19 burden with changes in PHQ-8 scores. This suggests that actual COVID-19 burden is associated with larger increases in symptoms of psychological distress. We find no significant association with changes in the GHQ-12.

6 Robustness Checks

We test the sensitivity of our results in Table 3 using alternate specifications of the regression adjustment model. Specifically, we use the p-hack specification check proposed by Brodeur et al. (2020) and use all possible combinations of the baseline controls to determine if varying the choice of controls influences our estimated treatment effects. One of the cardinal advantages of using the p-hack specification check is its capacity to help avoid data dredging or p-hacking. It allows for the effective exploration of the entire specification space, providing insights into how our results might vary across a wide range of analytical choices. Furthermore, it bolsters our research integrity by fostering transparency, as it permits the assessment of how our primary results stand up to potential specification changes.

Figure 3 of the appendix plot the distribution of treatment effects and t-statistics from all specifications for the Patient Health Questionnaire (PHQ-8). We chose this outcome because we find significant impacts for this outcome across all three specifications in Table 3. We use baseline values of age, marital status, education, work history, number of friends, and PHQ-8 scores to run this test. These controls result in 129 permutations of regression specifications. Figure three plots the distribution of all the treatment effects and t-statistics associated with these specifications. We find significant treatment effects for 100% of the specifications for the Patient Health Questionnaire (PHQ-8). Overall, these results suggest that our treatment effect estimates from the primary specification are highly robust.

7 Conclusion & Discussion

The present study adds to the evidence base on how mental health may have been affected during the COVID-19 pandemic. Overall, our results suggest that mental health among adolescent girls in Uganda as measured by the PHQ-8 has worsened during the pandemic, confirming our hypothesis that the pandemic and associated mitigating measures adversely impacted the mental health of young women. Our findings are in line with available evidence that mental health among young people has significantly deteriorated due to the pandemic and control measures [Samji et al. (2021), Baird et al. (2020), Lemuel et al. (2021), Baranov et al. (2020), Alamrawy et al. (2021), Banati et al. (2020), Anbarasu and Bhuvaneswari (2020)]. The current study is one of the few studies to focus on young women in LMICs and complements findings of older women in LMICs [Bau et al. (2022), Sediri et al. (2020)].

That said, when we look at the GHQ-12, we find no significant change in mental health during the COVID-19 pandemic. We speculate that this discrepancy in findings is related to differences in how these 2 measures capture symptoms of psychological distress. The PHQ-8 focuses on how the individual has been feeling over the past 2 weeks, while the GHQ-12 asks how their feelings over the past 2 weeks compare to "usual." Given that the survey took place 6–9 months into the pandemic, it is likely that “usual” was already a world where the COVID-19 pandemic was taking place. Thus, it is perhaps not surprising that we see impacts on the PHQ-8 and not on the GHQ-12, and we believe the findings on the PHQ-8 are a better reflection of the change in mental health as a result of the COVID-19 pandemic. While not a focus of this article, this finding points to the importance of being careful about measurement when looking at mental health, particularly during times of crisis such as a pandemic.

Our findings further unpack the role of the pandemic in increasing symptoms of psychological distress for young women by highlighting the role of the perceived and actual burden of COVID-19. Both of these measures are significantly associated with worse mental health, with the actual burden of COVID-19 also associated with stronger declines in mental health. These findings are similar to Bau et al. (2022), who find worse mental health among women in areas with more COVID-19-related containment measures. In addition, this finding also complements studies that explore the role of mindfulness in mediating the relationship between fear of COVID-19 and mental health Belen (2020). Belen (2020) argues that fear of the pandemic, as measured by the perceived threat of contracting the virus or dying from it, is positively correlated with mental health problems such as anxiety and depression. While our analysis does not explore mitigating measures for improved mental health during the pandemic, our findings on the association between the perceived and actual burden of COVID-19 and mental health align with that from Belen Belen (2020). Future analysis could tease out the fear of disease versus the economic impact to further assess the relative association of each of these on mental health.

This study contributes to the nascent evidence base on the effects of COVID-19 on adolescent girls’ mental health in LMICs. Moreover, it is one of the few studies to date that incorporate panel data, allowing us to go beyond simple cross-sectional correlations [Samji et al. (2021), Bau et al. (2022)]. The use of panel data allows us to control for time-invariant covariates and is better suited to uncovering dynamic relationships Hsiao (2007). That said, the current study has a number of important limitations. First, while our models allow us to control for both observable and unobservable time-invariant characteristics and observable time-variant characteristics, there may be additional unobserved time-varying factors that are not accounted for. Second, since by design we start off with a purposefully selected sample with symptoms of moderate-to-severe depression from urban and peri-urban areas, findings are not necessarily generalizable to the broader population of adolescent girls in Uganda. Third, data collection that took place during the pandemic was done over the phone, as opposed to in person. This change in survey modality could have impacted measurement. Lastly, it needs to be recognized that our measures of perceived COVID-19 burden and actual COVID-19 burden come from self-reported questions and therefore may be subject to response bias, which might affect the generalizability of our findings.

Given the importance of adolescent mental health for future well-being [WHO (2021), Carvajal-Velez et al. (2021), Patel et al. (2021), Taylor et al. (2010)], it is important to understand the potential ramifications of the COVID-19 pandemic. For young women in LMICs, in particular, given broader concerns about school dropout, teenage pregnancy, and increased exposure to GBV, addressing underlying mental health issues is going to be essential as part of gender-equitable post-pandemic recovery. Tailored age- and gender-based policies that both tackle mental health directly but also target associated vulnerabilities will be vital to ensure that progress toward SDG-5 remains on track Banati et al. (2020).

8 Appendix

8.1 Construction of perceived and actual COVID burden

We present the survey module we used to construct our actual and perceived COVID burden in this appendix. The survey module presented here lists all sets of questions that were used to create both perceived and actual COVID burden.

COVID-19 – Perceived & Actual COVID Burden

Note: Q1-2 are adapted from the EMERGE COVID-19 and Gender Survey Questions (Center on Gender Equity & Health, 2020).
Q3-5 are adapted from Baird, S., Malachowska, A. and Jones, N. (2020) Covid-19 phone survey (round 1). Adult female module. London: Gender and Adolescence: Global Evidence.

Perceived COVID Burden

1 In your community, how many households do you think have been affected by infection from Corona (the virus causing COVID19), with someone in the household becoming sick? *Read answer options aloud unless otherwise specified*

- Many, including my own.......... 1
- Many, but not my own.......... 2
- Some.......... 3
- Few.......... 4
- None.......... 5
- *(Do not read aloud)* Refused.......... -97
- *(Do not read aloud)* Don't know.......... -99

2 In your community, which of the following has increased since the start of the Corona pandemic and the social containment efforts to control the spread of the virus (e.g., lockdowns, curfews, etc.)?
[1= Yes, 0= No, -97=Refused, -99=DK]

a. Many people have lost their jobs or their ability to earn wages, and some have lost their business. [____]
b. People are unable to bank or get cash for daily expenses [____]
c. Families cannot afford to buy enough food to eat [____]
d. Many schools have closed, and the children are unable to continue their studies at home [____]
e. There is more violence against children (such as spanking or hitting) in the household [____]
f. There is more violence or other abuse towards women from their husbands or from other family members including in-laws [____]
g. There is more violence or mistreatment from police against people who are out on the streets during social containment [____]
h. People are drinking more and/or using drugs more [____]
i. More people are becoming very anxious or depressed [____]
j. There is more violence among people in the community [ ]
k. There are more young women getting pregnant [ ]
l. More people are unable to get medical care for health needs that are not related to COVID-19 [ ]

Actual COVID Burden

3 Do you agree, partially agree or disagree with the following statement: the Corona situation has increased the stress in my household

- Agree.......... 1
- Partially agree.......... 2
- Disagree.......... 0
- Refused to answer.......... -97
- Don't know.......... -99

4 Did your household lose al, most, some, or none of your income as a result of this public health situation?

- All.......... 1
- Most.......... 2
- Some.......... 3
- None.......... 4
- Refused to answer.......... -97
- Don't know.......... -99

4 Which of the following describes how you are coping and responding to Corona? Are you...?
[1= Yes, 0= No, -97=Refused, -99=DK]

a) Getting angry more quickly [____]
b) Arguing more often [____]
c) Talking more often about problems with your family to find solutions [____]
d) Helping household members more with chores or other tasks [____]
e) Fearing and worrying about your own health and the health of your loved ones [____]

Figure 2: Perceived and Actual COVID-19 Burden

8.2 Attrition

In Round 1 we started off with a sample of 637 adolescent girls, of these 542 were successfully reached for interview in Round 2 and 516 of the overall 637 adolescent girl were interviewed over telephone in Round 3. We run an attrition analysis to look at characteristics of adolescent girls that predict attrition. To do this, we estimate the following equation:

$$Attrition = \alpha_i + \beta_1 X_{ic} + Z_i + \epsilon_{ic} \tag{3}$$

where *Attrition* is a dummy variable that takes the value of 1 if the respondent was not available in a subsequent round and 0 otherwise, X_{ic} is a set of girl-specific characteristics which include PHQ-8 score, GHQ-12 score, age, level of educational attainment, and if the respondent has ever been married, Z_i are subdistrict level fixed effects, and ϵ_{ic} are standard errors clustered at the ELA club level. Column (1) in Table B1 reports estimates from Equation 1 for the attrition that occurred from Round 1 to Round 2 whereas Column 2 does the same for the attrition that occurred from Round 2 to Round 3. For Round 1 to Round 2, we see less educated and older girls were more likely to attrit. For Round 2 to Round 3, girls with less education and higher psychological distress are significantly more likely to attrit.

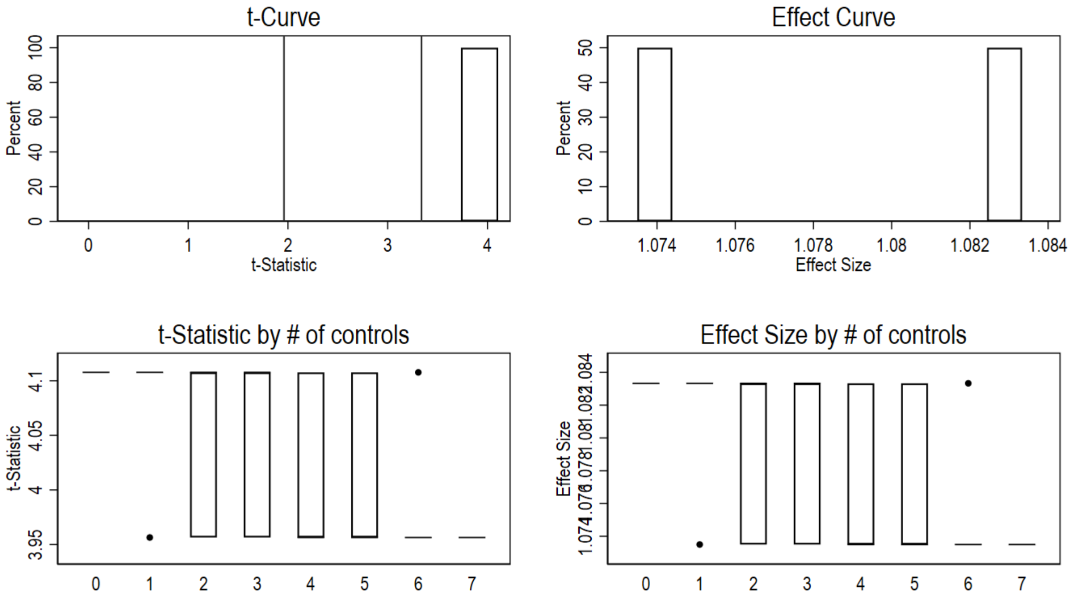
Table 5: Attrition from Round 1 to Round

VARIABLES	(1) Attrition R1-R2	(2) Attrition R1-R3
PHQ-8 Score	0.004	0.001
	(0.004)	(0.004)
GHQ-12 Score	0.005	0.011**
	(0.005)	(0.005)
Age	0.022***	0.005
	(0.008)	(0.009)
Education	-0.083***	-0.073***
	(0.023)	(0.017)
Never Married	0.025	0.048
	(0.044)	(0.037)
Observations	637	542
Adjusted R-squared	0.050	0.062

Notes: Independent variables include PHQ-8 and GHQ-12 score, age, an indicator for qualified secondary school or higher, and an indicator for being never married. All regressions control for subdistrict-level fixed effects with robust standard errors clustered at the ELA club level. GHQ-12 = General Health Questionnaire-12; PHQ-8 = Patient Health Questionnaire-8.Stars denote statistical significance: ***P $<$ 0.01, **P $<$ 0.05, *P $<$ 0.10.

8.3 Robustness: Specification Checks

Figure 3: Robustness Check: Varying Choice of Controls - Patient Health Questionnaire (PHQ-8)



areg phq8_score round3 CR_agebl ms_never_marriedbl ed_highest_qualificationbl pw_anyworkbl sn_nrclosefriendsbl PPI_scorebl religion , always()
Displaying estimates for: round3
Always included:
Total Permutations: 128
Sample Size Mean: 898 S.D.: 0

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