

# Impact of Financial Inclusion on Household Welfare in Liberia: A Gendered Perspective

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# **Impact of Financial Inclusion on Household Welfare in Liberia: A Gendered Perspective**

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# Contents

List of tables

List of figures

List of abbreviations and acronyms

Abstract

1.	Introduction	1
2.	An overview of financial sector in Liberia	3
3.	Literature review	5
4.	Data and methods	8
5.	Results and discussions	14
6.	Conclusion and policy implications	24
	Notes	25
	References	26
	Appendix	32

## List of tables

1.	Definition of variables and measurement	13
2.	Summary statistics of variables	16
3.	IPWRA estimates for correlates of use of mobile money	18
4.	Impact of mobile money on food security for pooled sample	19
5.	Impact of mobile money on food security for male-headed households	20
6.	Impact of mobile money on food security for female-headed households	20
7.	Average treatment effects using propensity score matching (PSM)	21
8.	Heterogeneous treatment effects of all mobile money users	22
9.	Heterogeneous treatment effects of female-headed households who are mobile money users	23
A1.	Inverse probability-weighted regression adjustment estimates for the determinants of food security by mobile money use status	32
A2.	Covariate balancing test for selection bias before and after matching using NNM	33
A3.	Covariate balancing tests, PSM quality indicators before and after matching with NNM and RM, and sensitivity analysis for hidden bias	34

## List of figures

1.	Impact pathways of mobile money on household welfare	9
2.	Use of money sent through mobile money	17
A1.	Key food items consumed in Liberia by mobile money use status	34

# List of abbreviations and acronyms

ATT	Average Treatment Effect on the Treated
COVID-19	Corona Virus Disease 2019
EAs	Enumeration Areas
ECOWAS	Economic Community of West African States
FCS	Food Consumption Score
FHHs	Female-Headed Households
FI	Financial inclusion
FIGG	Financial Inclusion Gender Gap
FPPCs	Fragile and Post-Conflict Countries
FSDA	Financial Sector Deepening Africa
GoL	Government of Liberia
GSM	Global System for Mobile Communications Association
HDDS	Household Dietary Diversity Score
IMF	International Monetary Fund
IPWRA	Inverse Probability-Weighted Regression Adjustment
LHIES	Liberian Household Income and Expenditure Survey
LISGIS	Liberia Institute of Statistics and Geo-Information Services
MAHFP	Months of Adequate Household Food Provision
MHHs	Male-Headed Households
MM	Mobile Money
OECD	Organisation for Economic Co-operation and Development
PSM	Propensity Score Matching
SADC	Southern African Development Community
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
UNCDF	United Nation Capital Development Fund
UNDP	United Nations Development Programme

# Abstract

Financial inclusion is critical to achieving the Sustainable Development Goals (SDGs), particularly zero poverty, gender equality, and reduced inequalities, but there is limited evidence of its impacts on household welfare in fragile and post-conflict countries. This study analyses the impact of financial inclusion on household welfare in Liberia using the Liberian Household Income and Expenditure Survey of 2016–17. For the empirical analysis, we use an inverse probability-weighted regression adjustment model and separate analyses for male-headed households (MHHs) and female-headed households (FHHs) to identify possible gender differences. We find that the use of mobile money significantly increases household food security for MHHs and FHHs. In particular, the welfare impact is greater for MHHs in terms of food availability while in relation to food quality and dietary diversity, the impact is greater for FHHs. These findings show the need to scale up financial inclusion in fragile and post-conflict countries as a catalyst for improving household welfare.

**Key words:** *Financial inclusion; Mobile money; Fragile and post-conflict countries; gender; Impact; Welfare; Liberia.*



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# 1. Introduction

Financial inclusion (FI) is a condition whereby everyone has access to financial services and products provided by formal institutions, and they can affordably utilize one formal account for financial transactions (World Bank, 2017). These formal accounts include a mobile money account, a bank account, and a non-bank account (Demirgüç-Kunt et al., 2018). FI is a means to achieve the 2030 Sustainable Development Goals (SDGs), and it is linked to almost half of the 17 SDGs (World Bank, 2021). In particular, FI contributes to achieving SDG 5 (gender equality), 6 (clean water and sanitation), 7 (affordable and clean energy), and 10 (reduced inequalities) (GSMA, 2021). FI plays an important role in increasing income and reducing poverty (Ahmad et al., 2020; N'dri & Kakinaka, 2020; Omar & Inaba, 2020). In addition, it enables inclusive growth by providing equal opportunities (Demirgüç-Kunt et al., 2017).

Despite these benefits of FI, there are gaps in the access and use of formal financial products and services in sub-Saharan Africa (SSA), especially in the fragile and post-conflict countries (FPCCs). In reference to FSDA and Mercy Corps (2017), financial exclusion in SSA was 66% compared to an average of 90% in FPCCs in the same region. FPCCs such as Liberia have underdeveloped financial sectors and limited financial inclusion (Sile, 2013). For example, the infrastructure and institutional frameworks for accessing formal financial services were destroyed during the 14-year crisis that ended in 2003, in Liberia. Consequently, access to formal financial services is very low in the country (Government of Liberia [GoL], 2020). For example, only 36% of adults in Liberia owned a bank account and four of the 15 counties have no access to commercial banks (International Monetary Fund [IMF], 2016). To ensure financial inclusion in Liberia, the Government of Liberia implemented two strategies; the one of 2009–2013 and the other one during 2014–2018. Some of the key outcomes of these strategies were the creation of sustainable financial institutions such as commercial banks and credit unions and introduction of mobile money services. Mobile money services are the most used option for internal transfer in Liberia, with 26% of the households using it (GoL, 2017). It has the largest access point (93%) and it is followed by point-of-sale terminals (4%), bank branches (1%), and microfinance institutions (0.2%) (GoL, 2020). Liberia recent financial inclusion strategy for 2020 to 2024 is building on a sustainable financial sector that is deeply rooted in digital financial services (GoL, 2020: 3).

Although there are efforts to ensure financial inclusion in Liberia, there is evidence that suggest the persistence of gender gap in accessing financial services (GoL, 2020). Women access to formal financial services such as commercial and mobile banking is

limited, leading to unequal involvement in the financial sector. Women mostly rely on their community's informal financial institutions (UN Women, 2021b). For example, only 12% of Liberian women have a bank account, compared to 21.3% of men (UN Women, 2021a). In addition, only 24.4% of women use their mobile phones for financial transactions, compared to 30% of men (Liberia Institute of Statistics and Geo-Information Services [LISGIS], 2020). There is also a banking disparity between rural and urban women. Rural women have a smaller share of mobile phones (23%) and bank accounts (6%) than urban women, who have 61% and 16%, respectively (GoL, 2020).

This gender gap in access to financial services may also suggest that financial inclusion may have different impacts on welfare of women and men. While there are studies on financial inclusion in SSA (Asuming et al., 2019; Demirgüç-Kunt & Klapper, 2012; N'dri & Kakinaka, 2020; Zins & Weill, 2016), there are few empirical studies on this subject in FPCCs, especially in Liberia. For example, studies have shown that financial inclusion reduced poverty in Burkina Faso (N'dri & Kakinaka, 2020). In Ghana, financially disadvantaged households were associated with poor welfare (Iddrisu & Danquah, 2021). Wieser et al. (2019) found that the use of mobile money improved household food security in Uganda. Financial inclusion has also been reported to reduce income inequality (Omar & Inaba, 2020), increased household income (Sekabira & Qaim, 2016), minimize vulnerability to climatic shocks (Afawubo et al., 2020; Abiona & Koppensteiner, 2022) in some part of SSA. Findings from these studies cannot be used to formulate policies to ensure financial inclusion in Liberia.

In this context, this study aims to address the following research questions: 1) What is the adoption rate of mobile money services among MHHs and FHHs? 2) What are the main uses of money received or transferred through mobile money? 3) What factors influence male (MHHs) and female-headed households' (FHHs) use of mobile money services in Liberia? 4) What are the impacts of mobile money services on welfare outcomes (household food security), and how do the impacts vary according to gender?

By answering these research questions, this study contributes to the literature in the following ways. First, we employ a gendered lens in our analysis to enrich our policy recommendations from the study. Although previous research has explored the issue of gender and financial inclusion in Africa (Adegbite & Macheche, 2020; Aterido et al., 2013; FinScope, 2020; Ghosh & Vinod, 2017), these studies neither contextualize the issue of fragility nor explore the interaction of gender with other socioeconomic characteristics. We contribute towards bridging this gap by focusing on how gender influences financial inclusion in FPCCs. Second, we take advantage of the intersectionality of gender, especially among women, and define outcomes across different women categories as defined by socioeconomic factors.

The rest of this paper is organized as follows. In Section 2, we present the country context, including financial development in Liberia. Section 3 is literature on financial inclusion. Section 4 describes the data and methods, including the conceptual and analytical frameworks illustrating the theory of change. The results are presented in Section 5. Section 6 is the conclusion with policy recommendations.

## 2. An overview of financial sector in Liberia

Liberia's infrastructure and institutional frameworks for accessing financial services were destroyed during the 14-year crisis that ended in 2003. As a result, access to formal financial services was very low. In 2017, about 36% of adults in Liberia had a bank account, and four of the 15 counties do not have access to commercial banks in Liberia. Physical access to commercial banks in Liberia is lower than the average number in sub-Saharan Africa (SSA) and in the Economic Community of West African States (ECOWAS) countries (IMF, 2016). Reasons for the low penetration of financial services include limited access points in the rural areas, lack of required documents to open an account, limited financial capabilities of the population, limited access to electricity and weak credit infrastructure (GoL, 2020).

Despite these challenges, the Government of Liberia has made continuous efforts over the last decade to make financial services accessible to its citizens by developing various strategies. These financial inclusion strategies include the creation of sustainable financial institutions like commercial banks and credit unions that was implemented from 2009 to 2013. Similarly, from 2014 to 2018, mobile money services were implemented and non-banking financial institutions were authorized to provide these services in Liberia. More recently, Liberia has developed a financial inclusion strategy for 2020 to 2024, with a mandate to “build a sustainable financial sector that is deeply rooted in digital financial services to provide access to and enhance the usage of a wide range of affordable financial services” (GoL, 2020: 3). The strategy has led to the introduction of other mobile money services such as Sendwave, TipMe, and the direct transfer of funds from bank accounts to mobile money accounts and vice versa.

The banking institutions that dominate the financial sector in terms of assets are mainly located in the largest urban city (Monrovia), where a quarter of the population lives (IMF, 2016). As outlined in the previous paragraph, banking institutions face constraints which increased the cost of the expansion of digital banking services outside Monrovia and other urban areas (UNDP & UNCDF, 2016). Non-bank financial institutions such as microfinance institutions, credit unions, village saving loan associations and mobile money have helped to bridge the gap for rural households' access to financial services in Liberia.

Mobile money, a new channel for accessing financial services through mobile phones, was launched in Liberia in 2011 by Lone Star Cell MTN Telecommunication. In 2014, the Central Bank of Liberia developed mobile money regulations to allow non-banking financial institutions to provide mobile money services. Lone star MTN was the only telecommunication company offering mobile money services in Liberia at that time. In 2016, Orange, formerly known as Cellcom, launched its Orange Money services from Orange Telecommunication Network. Mobile money enables financial banking institutions and non-financial banking institutions to offer financial services to individuals or businesses that do not have access to formal financial institutions. In addition, mobile money has played a significant role in providing support to vulnerable households in emergency situations. For example, 85,000 vulnerable households in Liberia received direct cash transfers via mobile money from USAID to cope with the aftermath of COVID-19.

The average ownership of the mobile money account in Liberia is higher than that of countries in the ECOWAS region and other FPCCs. In 2017, about 21% of the population has access to a mobile money account (GoL, 2020). Despite the increasing number of mobile money subscribers in Liberia, there is a disparity between women and men in terms of account ownership. About 24% of the male (ages 15 years and above) owned a mobile money account compared to 18% of females (GoL, 2020). Currently, mobile money enables users to transfer money from one user to another, make payments, buy airtime, pay utility bills such as school fees, and facilitates users to withdraw and deposit in their bank account without physical presence at their banks. This has substantially reduced transaction costs in the financial sector such as transportation, and waiting time in sending money (IMF, 2021).

### 3. Literature review

#### Financial inclusion and household welfare

Financial inclusion contributes to economic development (Ahmad et al., 2020; Ifediora et al., 2022). Increasing financial inclusion is also a top priority for governments in their efforts to reduce poverty and decentralize services (Oji, 2015). Access to financial services enables poor people to save and borrow, allowing them to acquire assets, invest in education, and start enterprises, all of which assist them improve their living standards and contribute to poverty reduction (Baidoo et al., 2020; Sakyi et al., 2021).

The literature has established that financial inclusion improves household income and food security in SSA. For example, Sekabira and Qaim (2017) showed that the adoption of mobile money technology contributed 19% and 45% increase in total household income and off-farm income, respectively, in Uganda. Wieser et al. (2019) showed that the use of mobile money improved household food security and reduced the likelihood of missing meals among rural households in Uganda. They explained that mobile money enables people to have extra money from remittances and savings, allowing them to buy more food. Omar and Inaba (2020) used a panel data to show that financial inclusion considerably reduced income gap in emerging countries. Machili (2021) indicated that financial inclusion has a major impact on overall food security in the Southern African Development Community (SADC), and emphasizes the importance of expanding access to and use of financial inclusion services to promote welfare. Arshad (2022) stated that increasing financial inclusion in developing countries will assist poor people in dealing with challenging times and provide them with food security.

Another strand of literature has reported that financial inclusion reduced poverty and increased households' resilience to shocks. For example, Nsiah et al. (2020) indicated that financial inclusion tends to lead to poverty reduction, with money supply being positively related to poverty reduction in SSA. N'dri and Kakinaka (2020) found that financial inclusion had a considerable impact on poverty alleviation in Burkina Faso by reducing nutrition, health care, and education poverty by 0.16–0.20, 0.17–0.24, and 0.24–0.30 points, respectively. Iddrisu and Danquah (2021) found that financially disadvantaged households had lower welfare than their wealthier counterparts in Ghana, showing that financial inclusion has the potential to reduce income disparity. In particular, financial inclusion benefited poor households

significantly more than non-poor households, indicating that it has the ability to alleviate income disparities. Financial inclusion, through mobile money, reduced households' vulnerability to shocks in Togo (Afawubo et al., 2020). Evidence from Omar and Inaba (2020) shows that financial inclusion minimizes households vulnerability to climatic shocks such as floods, droughts, and soil erosion in developing countries. Abiona and Koppensteiner (2022) showed that households that adopted mobile money could maintain smooth consumption throughout periods of rainfall shocks and drought in Tanzania.

Financial inclusion is also considered as a means of achieving women's empowerment and reducing gender inequalities. The impact of financial inclusion on women's empowerment is well documented in the empirical research. For example, Dupas and Robinson (2013) asserted that women's active participation in the financial system improves their risk management and smooths consumption in the face of shocks. Financial inclusion has also been linked to empowering women in households to make decisions in Kenya (Dupas & Robinson, 2013), and lifting female-headed households out of poverty in Kenya (Suri & Jack, 2016), and also in South Africa (Nanziri, 2016).

Financial inclusion can also have impacts on other aspects of welfare, such as health and education, and has been linked to increased access to healthcare and education services. For example, Matekenya et al. (2021) found that financial inclusion improves health outcomes in SSA households, potentially by allowing households to save for medical bills. They also found that financial inclusion may help boost educational achievement and skill development by allowing families to save or borrow to meet educational expenses. Koomson et al. (2021a) observed that increased financial inclusion is associated with increased out-of-pocket health expenditure, particularly among female-headed and urban-located households in Ghana.

In summary, these studies from some parts of SSA have reported positive welfare outcomes of financial inclusion. Therefore, financial inclusion could also improve welfare of households in FPCCs, including Liberia.

## **Gender and financial inclusion**

Gender has been found to have a major impact on financial inclusion (Aterido et al., 2013; Morsy, 2020). Gender gaps in financial inclusion undercut women's critical role in poverty eradication and economic development (Were et al., 2021). In SSA, several studies have also found gender gaps in access to financial services as well as variations across different countries. For example, Were et al. (2021) found that women, particularly married women, were less likely than men to use mobile money and banking services in Tanzania. Adegbite and Machethe (2020) found an increase in the financial inclusion gender gap (FIGG) in Nigeria and showed that the disparity was influenced by socioeconomic, sociocultural institution, legal, and regulatory

factors that affected the demand and supply of formal financial services. Zins and Weill (2016) found that men had better access to financial services in 37 African countries. Aterido et al. (2013) also found that women had lower levels of participation in formal financial services in SSA.

Demirgüç-Kunt et al. (2013) pointed out that the significant gender inequalities in bank account ownership are due to legislative constraints on the ability to work, household headship, receipt of an inheritance, and other manifestations of gender norms. The Global Findex Report of 2014 showed that women worldwide are 20% less likely to have a bank account compared to men (Demirgüç-Kunt et al., 2015). The lower level of financial literacy of women may contribute to the gender gap in most countries, especially in developing countries (Grohmann, 2016). The Organisation for Economic Co-operation and Development (OECD, 2015) also showed that lack of own resources, lack of titles of ownership or other goods that could function as guarantees, lack of business knowledge and financial education, high interest rates, requirement for collateral or periods of indebtedness (short-, medium-, and long-term) are the main obstacles that women face.

Klugman and Yvonne (2018) reported that gender gaps are more pronounced in fragile and conflict affected countries than in other countries. Only 25% of women in fragile contexts had a financial account compared to 33% of men in the same context (Klugman & Yvonne, 2018). The reason is that consumers in fragile contexts have limited financial literacy and are inexperienced in using financial products and services (FSDA & Mercy Corps, 2017). In Liberia, despite increases in overall account ownership, the Liberian National Financial Inclusion Strategy of 2020–2024 reports that a gender disparity exists; in particular, Liberian women being less likely to have an account than men (GoL, 2020).

Previous studies (Nanziri, 2016; Sekabira & Qaim, 2017; Kim, 2021) have examined the issue of gender and financial inclusion in Africa. However, these studies did not contextualize the issue of fragility, nor do they examine the interaction between gender and other socioeconomic characteristics, and the assessment of the impacts of financial inclusion on welfare on the basis of gender. This, therefore, emphasizes the need to intensify research on impact of financial inclusion on welfare in Liberia.



## 4. Data and methods

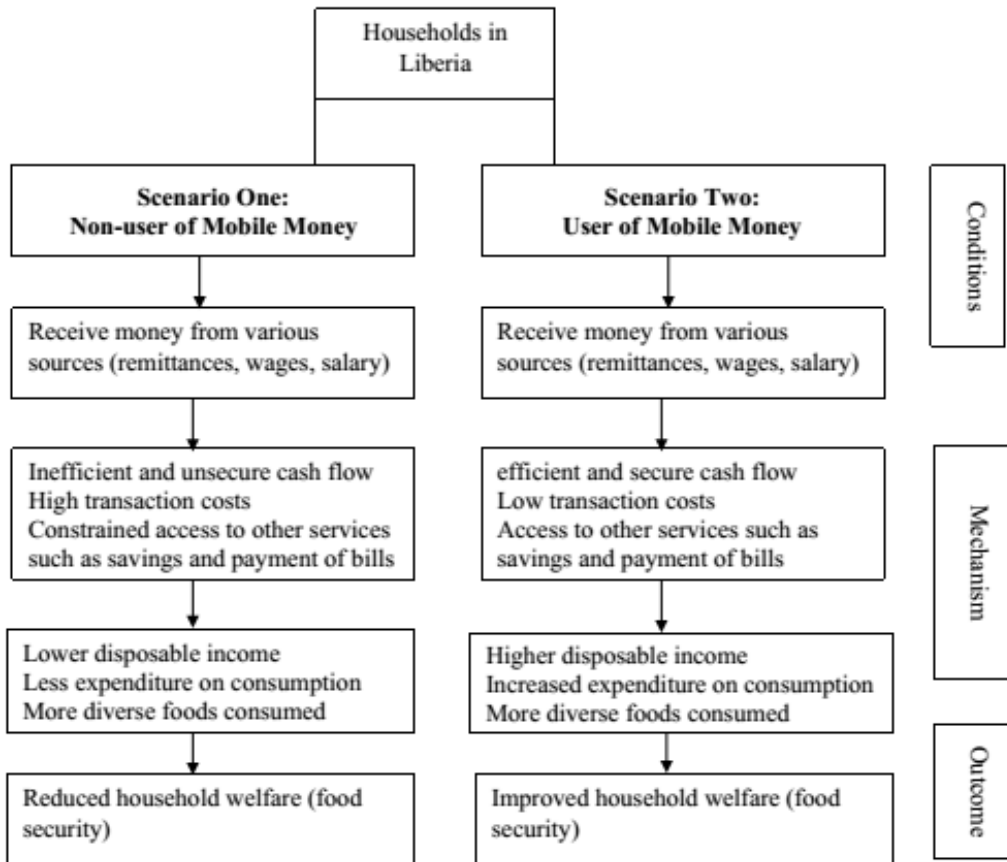
### Conceptual framework

In this paper, we develop a conceptual framework to explain the impact pathway of mobile money usage on welfare of households, as shown in Figure 1. Following previous studies (Munyegera & Matsumoto, 2016; Murendo & Wollni, 2016), our conceptual framework shows that, use of mobile money (MM) can influence household welfare in two scenarios: user and non-user of mobile money (Figure 1). The effects could be more significant for the rural poor who are constrained in accessing formal financial services. In both scenarios, households receive money from various sources using different methods. How one receives the money can influence disposable income (Murendo & Wollni, 2016). In scenario one, where the household is a non-user of MM services, they use a person, bus and taxi to send money to their recipients. This traditional money transfer approach is inefficient and insecure. Further, in some cases, the recipient has to travel to distant locations to receive money. The money may also be sent through banks. However, the financial system in many rural areas in FPCCs is underdeveloped such that banks are not easily accessible (Kikulwe et al., 2014). Moreover, bank transactions are usually associated with hefty fees, especially in cases where the recipient does not have a formal account with the bank. To access the money sent through the highlighted methods, the households are faced with high costs of transport fare and the opportunity cost of time when travelling to receive their remittances because of the dispersed limited bank branches in rural areas. These high transaction costs reduce disposable income, which consequently has a negative effect on household welfare (Kikulwe et al., 2014; Murendo & Wollni, 2016; Sekabira & Qaim, 2017).

In scenario two, where the household is a mobile money service user, access to remittances is likely to be better, faster and more secure through the use of mobile money innovation (Murendo & Wollni, 2016; Sekabira & Qaim, 2017). This is likely to contribute to improving household welfare. One pathway through which MM service can increase household welfare is the likelihood of a household to receive transfers faster and immediately from various sources, hence increasing the liquidity of the household. Secondly, MM can also reduce transaction costs associated with sending and receiving remittances (Jack & Suri, 2014). The lower transaction costs associated

with using MM services can result in more money being available for household consumption expenditure (Murendo & Wollni, 2016). Third, MM services have expanded to include a range of other services like savings. We envisage that households using MM services can manage risk effectively through access to savings (Afawubo et al., 2020).

**Figure 1: Impact pathways of mobile money on household welfare**



In our empirical analysis, we analyse the impact of mobile money on household welfare in terms of months of adequate household food provision (MAHFP), food consumption score (FCS), and household dietary diversity score (HDDS).

### Survey data

We used the Liberian Household Income and Expenditure Survey (LHIES) of 2016–17 implemented by the Liberia Institute of Statistics and Geo-information Services (LISGIS). This is the most recent and the only national data set that captures the seasonality of household consumption patterns and income within 12 months preceding the survey. The survey employed a sampling frame from the 2008 National Housing and Population Census of Liberia. The survey is based on a two-stage stratified sampling design. In the first stage, 835 enumeration areas (EAs) were selected based

on probability proportionate to size. In the second stage, an average of ten households was selected from each EA sample using a systematic random sampling technique. A total of 8,350 men and women were interviewed. The survey collected detailed information on demographic characteristics, poverty, food security, household characteristics, education, health, employment, household non-farm enterprises, crop and livestock production, transfers, shocks, and welfare.

## **Outcome variables**

This paper uses food security as a measure of household welfare. We employ three proxies, namely, the months of adequate household food provision (MAHFP), household dietary diversity score (HDDS) indicator, and the food consumption score (FCS). The MAHFP index is an indicator used to assess the level of the household food access within 12 months before the survey. Respondents were asked to indicate if they experienced any lack of food within any month over a 12-months period. Respondents were also asked, which of the months in the past 12 months did you not have enough food to meet your family's needs? These responses are then summed and subtracted from the total number of months (12), which is referred to as MAHFP. The range of the score is between 0 and 12, where, the higher the score the more food secure the household is.

The HDDS reflects the household's ability to access a variety of foods. This method uses a seven-day recall period to identify the food items that have been eaten in the household. The HDDS was developed as a measure of household food access by the FANTA II Project (Swindale & Bilinsky, 2006). These food items are then categorized into 12 food groups. The dietary diversity score is calculated by summing the number of food groups consumed in a household over the 7-day recall. The HDDS ranges from 0 to 12, with a higher score indicating a higher level of access to diverse foods. In Figure A1 (in the appendix), we present results of the consumption of key food items in Liberia, and find that users of mobile money consumed higher levels of protein related food such as legumes and nuts, meat, fish, and milk, relative to non-users of mobile money.

The FCS is a frequency weighted dietary diversity score generated from eight food groups consumed by the household over a 7-day recall period. The frequency of consumption of a particular food group is recorded and multiplied by its weight. To get the FCS, we take the sum of the product of the frequency and weight of all the 8 food groups for each household. The higher the score, the more food secure the household is.

## **Analytical framework**

As explained in the conceptual framework, male (MHH) and female-headed households (FHH) are faced with different socioeconomic constraints associated with MM services,

and MM services can have different impact on the welfare of these gender groups. For this reason, the empirical analysis takes into consideration these gender groups by running separate models for each gender group.

The use of mobile money services cannot be considered an exogenous variable because a MHH or FHH decision to use mobile money is based on observable characteristics (education, gender, location, availability of mobile money agents, age of the household head) and unobservable characteristics (change in technology preference, entrepreneurial skills, and managerial ability). The household will utilize mobile money services if the expected utility derived from using it is greater than the utility of not using it (Ding & Abdulai, 2020; Tesfaye & Tirivayi, 2016). The utility of the choice made is a latent variable that is only known to the household and observed through the choices (user or non-user) made (Murendo & Wollni, 2016).

With the above scenario, a commonly used method to estimate the impact of the use of mobile money on household welfare would be to include a dummy variable that captures the use of mobile money services in the equation of outcome variables (MAHFP, HDDS, FCS), then apply an ordinary least squares (OLS) regression for each gender group specified as:

$$Y_{ik} = \alpha_k X_{ik} + \beta_k M_{ik} + \varepsilon_{ik}, k = \mathbf{1(MHH)}, \mathbf{0(FHH)} \quad (1)$$

Where:  $Y_i$  is the outcome variables representing welfare indicators (MAHFP, or HDDS, or FCS);  $X_i$  is pre-treatment characteristics (like marital status, gender, age, and location);  $M_i$  is the dummy variable capturing use of mobile money services;  $\alpha$  and  $\beta$  are the parameters to be estimated, and  $\varepsilon_i$  is the random error term.  $k$  denotes the gender group. The estimate of  $\beta$  measures the impact of mobile money use on the outcome variables. However, this method may likely give a biased estimate since it assumes that use of mobile money services is exogenously determined. However, use of mobile money services among MHH and FHH is random process but the household makes this self-decision, which introduces self-selection bias problem. This self-selection bias renders the coefficient ( $\beta_k$ ) of the use of mobile money services inaccurate.

Following previous studies (Blekking et al., 2021; Manda et al., 2018; Wossen et al., 2017; Zheng & Ma, 2021), we adopted the inverse probability-weighted regression adjustment (IPWRA) to address the potential selection bias problem in estimating the impact of the use of mobile money on household welfare for the gender groups. The IPWRA provides efficient estimates by modelling both the treatment and outcome equations to control for endogeneity in using mobile money services. It is a potential solution for the misspecification of biased estimates (Blekking et al., 2021). The IPWRA is a combination of the Inverse Probability-Weight (IPW) and the Regression Adjustment (RA). This makes the IPWRA a double robust estimator since it combines the IPW estimator and RA estimator, and it only needs the correct specification of treatment equation (IPW equation) or the outcome equation (RA equation) to provide unbiased estimates of the impact of the use of mobile money services on household food security indicators (Wooldridge, 2010).

In this study, we use IPWRA to estimate the impact of using mobile money services on food security for each of the gender group. IPWRA is an improvement over both propensity score based matching method and the Regression Adjustment (RA) method. In the RA adjustment method, regressions on treated and control units are estimated separately to estimate the Potential Outcome Means for treated and control, and the difference is considered as an estimate of Impact. However, if there are pre-treatment differences across the two groups, then the estimate of impact will be biased. To account for the pre-treatment differences across the groups, inverse of the propensity scores are used as regression weights in the IPWRA method.

The IPWRA involves three steps in estimating the average treatment effect on the treated (ATT) of the use of mobile money on food security indicators (Imbens & Wooldridge, 2009; Tambo & Mockshell, 2018). The first step requires calculating the IPW by weighting the observation based on the inverse probability of using mobile money services. The probability, which is the propensity score of using mobile money services is calculated as:

$$p(X_k) = \Pr (M_{ik} = 1) = F \{h (X_k)\} = E(M_{ik}|X_k) \quad (2)$$

Where:  $p(X_k)$  is the probabilities of using mobile money services.  $X_k$  is the vector of observed household characteristics (education, marital status, age, and gender);  $M_{ik}$  is the dummy variable capturing the use of mobile money services among MHH and FHH;  $F\{\cdot\}$  is the cumulative distribution function;  $h(X_k)$  measures the regression specification indicating the determinants of using mobile money services. A probit model was used to estimate Equation 2. Adopting from Manda et al. (2018) and Zheng & Ma (2021), the inverse weights of 1 for use of mobile money services and  $\frac{\hat{p}(X_k)}{1-\hat{p}(X_k)}$  for not using mobile money services can be denoted as:

$$W_{ik} = M_{ik} + (1 - M_{ik}) \frac{\hat{p}(X_k)}{1-\hat{p}(X_k)} \quad (3)$$

Where:  $\hat{p}$  is the propensity score.

In the second step, separate linear regression models are estimated for use of mobile money services and non-use of mobile money services for each gender group. We then subsequently average the predicted outcome for use of mobile money services and non-use to mobile money services to estimate the ATT for the RA estimator as defined below:

$$ATT_k^{RA} = n_A^{-1} \sum_{i=1}^n T_{ik} [r_A (X_k, \delta_A) - r_N (X_k, \delta_n)] \quad (4)$$

$ATT_k^{RA}$  is a weighted average of the difference between potential outcomes for treated and control for those individuals who are in the treated group. We consider only the treated group for estimation and hence  $\frac{1}{n_A}$  term is there in the beginning. The next term in the expression,  $r_A (X, \delta_A)$  represents the Potential Outcome for  $i$ th unit estimated based on the given values of  $X_k$ , based on the regression  $r_A$ . The  $\delta_A$  is a

set of regression coefficients estimated based on  $r_A$ . Similarly, the second expression ( $r_N(X_k, \delta_n)$ ) indicates potential outcome control for the same unit.  $n_A$  indicates the number of persons using mobile money services;  $r_A(\cdot)$  and  $r_N(\cdot)$  show the regression models for users and non-users of mobile money services, respectively.

The last step involves combining Equation 3, (i.e., IPW) with Equation 4, (i.e., RA) to yield consistent and unbiased estimates. Hence, the  $ATT_k$  of the IPWRA is estimated as follows:

$$ATT_K^{IPWRA} = n_A^{-1} \sum_{i=1}^n T_{ik} [r_A^*(X_k, \delta_A^*) - r_N^*(X_k, \delta_N^*)] \quad (5)$$

When you compare with Equation 4, the only change in Equation 5 is the regression coefficients, i.e.,  $\delta_A^*$  and  $\delta_N^*$ . These coefficients are the estimated inverse probability-weighted parameters attained from the weighted regression for users and non-users of mobile money services, respectively. The definitions of variables (outcome, treatment, and explanatory variables) are presented in Table 1.

**Table 1: Definition of variables and measurement**

Variables	Variable Description	Unit of Measurement
<b>Outcome variables</b>		
Food security	Months of adequate household food provision (MAHFP)	Continuous
Dietary diversity score	Household dietary diversity score (HDDS)	Continuous
Food consumption score	Household food consumption score (FCS)	Continuous
<b>Treatment variable</b>		
Mobile money account ownership (% Yes)	Did the household receive/send money through mobile money	Dummy
<b>Household characteristics</b>		
Age	Age of the household head in years	Continuous
Duration of stay	Number of years the household head has stayed in that village	Continuous
Spouse outside the household	Number of spouses living outside the household	Continuous
Education	Years of formal schooling	Continuous
Gender (% MHHs)	Gender of the head of household	Dummy
Location (% urban)	Location of the head of household	Dummy
Off-farm activities (% Yes)	Does the household participate in off-farm activities	Dummy
Own production (% Yes)	Did the household have its own food production	Dummy
Marital status (% married)	Marital status of the household head	Dummy
Access to electricity (% Yes)	Did the household have access to electricity	Dummy
Group membership (% Yes)	Anyone in the household is a member of any group	Dummy

## 5. Results and discussions

### Descriptive results

Table 2 presents the socioeconomic characteristics of households in Liberia disaggregated by their status of mobile money use and gender of the household head. In columns (3) and (4) of Table 2, we show socioeconomic characteristics of the households by their mobile money service use status. On average, mobile money users were more food secure than non-mobile money users. Households that used mobile money had higher scores in terms of MAHFP, HDDS, and FCS (Table 2). This is likely due to lower transaction costs associated with mobile money transfer that translates into an increase in disposable income that can be used on food, health, education, and also an investment into other income-generating activities (Jack & Suri, 2014). MHHs and FHHs had similar MAHFP and FCS, but they exhibit significant differences with HDDS. On average, FHHs reported a higher diversity score than MHHs. This may be due to the fact that income earned by women are more likely to be spent on increasing and diversifying a household's food supply to enhance the nutrition status of children (Gitungwa et al., 2021).

In columns (6) and (7) of Table 2, we show socioeconomic characteristics of households by gender of the household head. There were more FHHs who used mobile money services compared to MHH. The consultations that we had with women groups revealed that women use mobile money to get support from their spouses, especially when their spouses work away from home. Households who used mobile money services were significantly younger than households who did not utilize the services. We find that mobile money users were more educated than non-users (Table 2). Male-headed households were also more educated than their female counterparts. More than half of the households that used mobile money services were from urban areas. This is likely due to mobile money being mostly introduced in urban areas where telecommunication networks are fully functional and agents are available compared to rural areas that sometimes suffer from network problems. There were more users who engaged in off-farm activities compared to non-users. A more detailed interrogation of the use of remittances received through mobile money revealed that some households used the money either for business or investment purposes, which are examples of off-farm activities (Figure 2). Surprisingly, we find more FHHs to be involved in off-farm activities as compared to their male counterparts. Similarly, most

of non-users of mobile money were involved in own food production. These results validate our earlier observation that links use of mobile money and investment in off-farm activities. More MHHs were involved in own food production compared to FHHs. These results confirm the gendered nature of access to land that is biased towards males (Johnson et al., 2016). A significant proportion of households who are non-users of mobile money were married compared to users of mobile money. In addition, more MHHs were married compared to FHHs. A higher portion of the households that used mobile money services had access to electricity compared to non-users of mobile money. The proportion of mobile money users who belonged to a group was higher than that of non-users (Table 2). Group membership allows households to get information about the importance of mobile money, such as the ease of transactions (Gichuki & Mulu-Mutuku, 2018).

The descriptive results cannot be used to make conclusions on the causal impacts of mobile money services on MHHs and FHHs welfare. We therefore applied more rigorous impact analysis technique to evaluate the impacts of mobile money service use on household welfare for each gender group.



Table 2: Summary statistics of variables

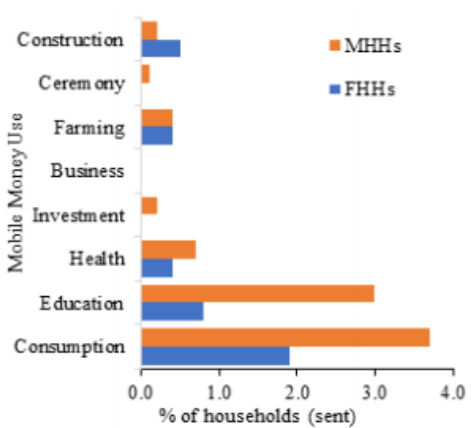
Variable	Pooled Sample		Mobile Money Account Status		Gender of Household Head			
	(1) Mean (n = 8347)	(2) Std. Dev.	(3) Non-users (n = 7365)	(4) Users (n = 982)	(5) Mean differences (3 - 4)	(6) FHHs (n=2121)	(7) MHHs (n= 6226)	(8) Mean difference (6 - 7)
<b>Outcome variables</b>								
Food security	11.30	1.23	11.28	11.42	-0.13***	11.27	11.31	-0.04
Dietary diversity score	8.15	2.18	8.101	8.491	-0.39***	8.317	8.09	0.23***
Food consumption score	47.17	17.46	46.99	48.54	-1.55***	47.18	47.17	0.01
<b>Treatment variable</b>								
Mobile money account ownership (% Yes)	12.00					14.00	11.00	3***
<b>Household characteristics</b>								
Age	42.10	13.81	42.27	40.81	1.47***	42.58	41.94	0.64*
Duration of stay	46.33	43.36	47.95	34.19	13.76***	46.24	46.36	-0.12
Spouse outside the household	1.92	0.28	1.922	1.868	0.05***	1.897	1.92	-0.02***
Education	2.12	4.08	1.988	3.121	-1.13***	1.340	2.39	-1.05***
Gender (% MHHs)	75.00		75.00	70.00	0.05***			
Location (% urban)	33.00		30.00	58.00	-0.28***	42.00	30.00	0.12***
Off-farm activities (% Yes)	50.00		50.00	56.00	-0.06***	54.00	49.00	0.04***
Own production (% Yes)	47.00		49.00	28.00	0.22***	36.00	50.00	-0.14***
Marital status (% married)	72.00		73.00	68.00	0.05***	26.00	88.00	-0.62***
Access to electricity (% Yes)	9.00		8.00	17.00	-0.10***	9.00	8.00	0.01
Group membership (% Yes)	26.00		25.00	36.00	-0.11***	26.00	26.00	0.00

Notes: \*\*\*, \*\*, \* denote significant values at 1%, 5%, and 10%; MHHs denote male headed households; FHHs denote female headed households; mean differences denote differences in averages between the two groups in comparison.

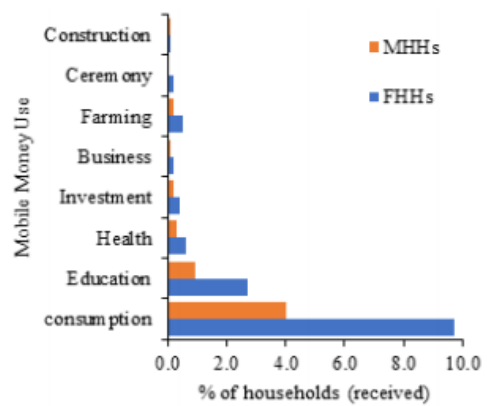
## Uses of mobile money

Figures 2 and 3 show a summary of how households spent the money sent or received through mobile money. We find that majority of the households used the money for household consumption, education, and health purposes. These patterns are consistent with recent evidence that indicate mobile money transfer is mainly used for consumption smoothing (Meneses et al., 2019; Morsy, 2020). We find a clear gender pattern in the use of money from mobile money services. Most FHHs spent a large part of the remittances received via mobile money on household consumption, while MHHs sent money via mobile money services for consumption, education, and health purposes (Figures 2 & 3).

**Figure 2: Use of money sent through mobile money**



**Figure 3: Use of money received through mobile money**



## Factors influencing the use of mobile money among MHHs and FHHs

Table 3 shows the correlates of use of mobile money in Liberia. We do not discuss the estimates of the outcome equations of the IPWRA, but present the results in Table A1 (in the appendix). Contrary to our expectation, we find that male-headed households (MHHs) are less likely to use mobile money than female headed household (FHHs). A plausible explanation is that, men may prefer mobile money less because they have access to more formal financial services. Women, on the other hand, still encounter many barriers in accessing formal financial services and, therefore, prefer to use mobile money. Kim (2020) showed that mobile money increased women's access to financial channels which they were previously excluded from, leading to higher levels of financial inclusion. As a result, more women may prefer this option than men. In Liberia, only 12% of women have a formal bank account compared to 21.3% of men (UN Women, 2021b). In addition, compared with MHHs, the adoption of mobile money increases the chances of FHHs receiving support and overcoming shocks (Afawubo et al., 2020; Koomson et al., 2021b).

**Table 3: IPWRA estimates for correlates of use of mobile money**

Variables	Pooled		MHHs		FHHs	
	Coeff.	Robust SE	Coeff	Robust SE	Coeff	Robust SE
Gender (MHHs)	-0.10*	(0.05)				
Age	-0.00	(0.00)	0.00*	(0.00)	-0.01***	(0.00)
Duration of stay	-0.00***	(0.00)	-0.00***	(0.00)	-0.00**	(0.00)
Spouse outside the household	-0.27***	(0.06)	-0.29***	(0.07)	-0.16	(0.13)
Off-farm activities	0.05	(0.04)	0.06	(0.04)	0.05	(0.07)
Own farm production	-0.37***	(0.04)	-0.37***	(0.05)	-0.37***	(0.08)
Education	0.02***	(0.00)	0.02***	(0.00)	0.01	(0.01)
Married	-0.04	(0.05)	-0.03	(0.07)	-0.06	(0.10)
Central region	-0.00	(0.06)	0.03	(0.07)	-0.10	(0.11)
Southern region	-0.22***	(0.07)	-0.27***	(0.08)	-0.10	(0.12)
Western region	0.19***	(0.04)	0.23***	(0.05)	0.09	(0.08)
Constant	-0.41	(0.15)	-0.65	(0.18)	-0.23	(0.30)

Notes: Robust standard errors in parentheses; \*\*\*, \*\*, \* denote significant values at 1%, 5%, and 10%; SE denotes standard errors; MHHs denote male headed households; FHHs denote female headed households.

The longer a person has lived in an area, the less likely they are to use mobile money in Liberia (Table 3). A possible explanation could be that households that have lived in a particular village for a longer time have better social networks (in terms of friends and relatives) and are more likely to receive forms of support other than mobile money transfers from these contacts. In contrast, households who have stayed in the village for a shorter period rely heavily on remittances from friends or relatives who are located far away, hence the need to use mobile money.

The number of spouses outside the household has a significant negative influence on use of mobile money. This result can be supported by our descriptive results in Table 2 that show that MHHs are more likely to have spouses outside the household and consequently have a lower preference for using of mobile money relative to other banking products.

Own farm production reduced the probability of using mobile money in Liberia. One reason for this is that money sent through mobile money is usually used for immediate consumption (mostly for food purchases and health expenses) (Aker et al., 2016; Ahmed & Cowan, 2021). However, households with own production are less likely to need money for food purchase; hence, this may reduce the likelihood for mobile money use. Furthermore, households engaged in off-farm activities are more likely to use mobile money services. Most off-farm earning activities are undertaken outside of the village, and mobile money is used as one of the methods for remitting money to household members in the village (Murendo et al., 2018).

Education is positively correlated with use of mobile money in Liberia. Highly educated household heads may be well informed about the convenience of using

mobile money and the various products and services offered through mobile money platforms than household heads with a lower level of education. Similar findings were reported by previous studies in Kenya (Kikulwe et al., 2014) and Senegal (Fall et al., 2020).

Our results indicate that households in the southern region are less likely to use mobile money than households in the northern region (Table 3). A probable reason for this observation may be that the northern region has a large population and telecommunication companies preferred areas that are populated for business interventions. The preference of telecommunication companies supports the use of mobile phones, which improve the use of mobile money services. In addition, households in the western region are more likely to use mobile money compared to those in the northern region. The main reason is that the western region is more urbanized and the capital city Monrovia is located in this region. More educated households and youth reside in this region. Counties in this region, that are mostly closer to Monrovia, experience a spill over effect of activities from Monrovia.

We also compared correlates by gender of the household head. Our results show that factors such as age, duration of stay, and own farm production had an effect on both MHHs and FHHs; but number of spouses outside the household, level of education, and location variables were only significant for MHHs. In particular, MHHs that did not participate in own production and were highly educated were more likely to use mobile money. These results imply that, there are gender specific correlates that are relevant for use of mobile money services among households in Liberia.

#### {B}Impacts of mobile money on food security

Results on the impact of use of mobile money on the three outcome variables (months of adequate household food provision, household dietary diversity score, and food consumption score) are presented in tables 4, 5, and 6. The ATT estimates from the IPWRA estimator show that households that used mobile money services are better off than non-users on all outcome variables (Table 4).

**Table 4: Impact of mobile money on food security for pooled sample**

Outcome Variables	Mobile Money Use Status			
	Users	Non-users	ATT	Change (%)
MAHFP	11.41	11.31	0.10 (0.04) ***	0.8
HDDS	8.49	8.02	0.47 (0.08) ***	6
FCS	48.54	46.16	2.38 (0.63) ***	4.9

Notes: \*\*\* and \*\* denote 1% and 5% level of significance, respectively; standard errors in parentheses; ATT=average treatment effect on the treated; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score.

Use of mobile money services shows a positive and significant impact on MAHFP, HDDS, and FCS. In particular, use of mobile money increases the MAHFP, HDDS, and FCS by 0.8%, 6%, and 4.9%, respectively. These findings support the findings of Murendo and Wollni (2016) and Wieser et al. (2019) in Uganda, and Aker et al. (2016)

in Niger. A plausible explanation for these findings could be that, the use of mobile money increases the liquidity of cash within the household, which can be used for consumption purposes (Murendo & Wollni, 2016). Further, the use of mobile money reduces transaction costs incurred by a household in accessing financial services and goods (Suri & Jack, 2016). In many developing countries, mobile money is relatively cheaper, more accessible and convenient for delivering financial services (Aker et al., 2016; Kikulwe et al., 2014). The decrease in transaction costs associated with sending money through mobile money translates to increased disposable income in the household, which can be spent on consumption expenditures such as food. Further, we perform a disaggregation analysis to examine the gendered-differential effects of the use of mobile money on food security (tables 5 and 6). We show that, relative to households that did not use mobile money, households that used mobile money services were more food secure among both MHHs and FHHs. We, however, see that use of mobile money had a greater impact on FHHs who were users, relative to their male counterparts.

**Table 5: Impact of mobile money on food security for male-headed households**

Outcome Variables	Mobile Money Use Status			
	Users	Non-users	ATT	Change (%)
MAHFP	11.44	11.32	0.12 (0.04) ***	1.06
HDDS	8.29	7.93	0.36 (0.10) ***	4.5
FCS	48.24	46	2.24 (0.77) ***	4.9

Notes: \*\*\* and \*\* denote 1% and 5% level of significance, respectively; standard errors in parentheses; ATT=average treatment effect on the treated; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score.

**Table 6: Impact of mobile money on food security for female-headed households**

Outcome Variables	Mobile Money Use Status			
	Users	Non-users	ATT	Change (%)
MAHFP	11.35	11.28	0.07 (0.07)	0.06
HDDS	8.96	8.29	0.67 (0.12) ***	8.08
FCS	49.23	46.90	2.33 (1.05) **	5.0

Notes: \*\*\* and \*\* denote 1% and 5% level of significance, respectively; standard errors in parentheses; ATT=average treatment effect on the treated; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score.

## Robustness check

Imbens and Wooldridge (2009) shows that there are multiple approaches in estimating treatment effects; therefore, they recommend several approaches to estimate the treatment effect to check for the robustness of the results. Following previous studies (Blekkings et al., 2021; Ma et al., 2021; Manda et al., 2018; Tambo & Mockshell, 2018), we estimated the treatment effect of the use of mobile money services on food security indicators using propensity score matching (PSM) model for robustness check. Since

the validity of the PSM result requires matching the treated and control to check for significant differences between the two groups, we employed the three matching algorithms: nearest neighbour, kernel, and calliper to check for systematic differences within the covariates. We also look at the percentage reduction in the absolute bias to compare with the one proposed by Rosenbaum (2002).

The PSM and IPWRA are based on observable characteristics. The two methods do not account for selection bias based on the unobservable factors. Since the use of mobile money services is not random, there may be unobservable factors that influence a household decision. Using the Rosenbaum bounds test (rbounds) proposed by Rosenbaum (2002), we assessed how unobservable factors may have influenced the selection process thus yielding a biased ATT.

We compare the results obtained from the IPWRA estimator (Table 4) with estimates from propensity score matching (Table 7). We first check the quality of matching covariates. Results in Table A2 and Table A3 (in the appendix) show that the matching is of good quality. This is because, after matching, all the mean differences in all the variables are insignificant, indicating a good counterfactual. The mean bias and the pseudo R2 are significantly reduced. The PSM estimates using NN, radius, and kernel matching algorithms provide very similar results as those in Table 3. Table 7 shows that the use of mobile money services significantly increased MAHFP, HDDS, and FCS, by 0.8-0.9%, 5-5.6%, and 4.4-4.8%.

**Table 7: Average treatment effects using propensity score matching (PSM)**

Matching Algorithm	Outcome Means				
	Outcome Variables	Mobile Money Users	Non-users	ATT	Change (%)
NNM	MAHFP	11.42	11.32	0.10 ** (0.04)	0.8
	HDDS	8.49	8.08	0.41 *** (0.09)	5
	FCS	48.54	46.50	2.04 ** (0.71)	4.4
Radius	MAHFP	11.42	11.31	0.11 *** (0.04)	0.9
	HDDS	8.49	8.04	0.45 *** (0.08)	5.6
	FCS	48.54	46.33	2.21 *** (0.64)	4.8
Kernel	MAHFP	11.42	11.31	0.11 *** (0.04)	0.9
	HDDS	8.49	8.05	0.44 *** (0.08)	5
	FCS	48.54	46.39	2.14 *** (0.64)	4.6

Notes: \*\*\* and \*\* denote 1% and 5% level of significance, respectively; standard errors in parentheses; ATT=average treatment effect on the treated; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score.

We also check if the PSM results are sensitive to hidden bias as a result of unobservable factors. We conduct sensitivity analysis as proposed by Rosenbaum (2002). The result from the rbound test shows that the PSM estimates are not sensitive to hidden bias (Table A3 in the appendix). The results show that the critical level of gamma ( $\gamma$ ) for the impact of use of mobile money services on MAHFP, HDDS, and FCS is 1.5-1.9, 1.6-2, and 1.2-1.4, respectively. Thus, indicating that the estimates are not sensitive to hidden bias and the results are robust.

{B}Heterogeneous impacts of mobile money use over household characteristics

Previous studies in SSA (Meneses et al., 2019; Ndlovu & Toerien, 2020) have shown that financial inclusion can have heterogeneous impacts on various welfare outcomes among households. In this study, we focus on the heterogeneity effects of gender, and we extend our analysis by doing a comparison between both MHHs and FHHs, and among FHHs. First, we seek to understand the effects of gender on the ATT of all households that used mobile money services (Table 8). Second, we interrogate the effect of marital status and other socioeconomic characteristics on the ATT of FHHs who are users of mobile money (Table 9). Following previous studies (Shumeta & D'Haese, 2016; Wossen et al., 2017), we use the ATT of households in the treated group as our dependent variable in an OLS regression to estimate the heterogeneous effect.

**Table 8: Heterogeneous treatment effects of all mobile money users**

Variables	ATT (MAHFP)		ATT (HDDS)		ATT (FCS)	
	Coeff	Robust SE	Coeff	Robust SE	Coeff	Robust SE
Gender (MHHs)	0.05***	(0.01)	-0.36***	(0.01)	-1.69***	(0.08)
Age	0.00***	(0.00)	-0.01***	(0.00)	0.02***	(0.00)
Off-farm activities	-0.02***	(0.00)	-0.11***	(0.01)	-0.82***	(0.05)
Education	-0.00***	(0.00)	-0.01***	(0.00)	-0.00	(0.01)
Married	-0.02***	(0.01)	0.11***	(0.01)	2.36***	(0.07)
Central region	-0.07***	(0.01)	-0.64***	(0.01)	-5.22***	(0.09)
Southern region	-0.31***	(0.01)	0.37***	(0.01)	0.65***	(0.10)
Western region	-0.05***	(0.00)	0.10***	(0.01)	-0.32***	(0.06)
Constant	-0.02	(0.01)	1.06	(0.01)	2.34	(0.10)
Observations	982		982		982	

Notes: \*\*\* and \*\* denote 1% and 5% level of significance, respectively; ATT=average treatment effect on the treated; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score.

Table 8 shows that the impact of mobile money use on MAHFP, HDDS, and FCS is significantly influenced by gender and other household characteristics. For example, we found that the positive impacts of use of mobile money on MAHFP are stronger for MHHs, whereas impacts for HDDS and FCS are stronger for FHHs. The finding can be explained by the fact that MAHFP captures food availability, whereas HDDS and FCS refer to both the availability and quality of food used by the household. In addition, we find statistically significant and negative results for households with off-farm activities and those from the central region.

Table 9 shows that the impact of mobile money use on the food security status of FHHs is significantly influenced by some household characteristics. The main reason for focussing on FHHs is that literature has shown that women are greatly constrained with regards to FI as opposed to men. In particular, we find that the positive impact of mobile money use on household food security is stronger for FHHs who are married and are from the northern region relative to FHHs who are unmarried and reside in the central region, respectively.

**Table 9: Heterogeneous treatment effects of female-headed households who are mobile money users**

Variables	ATT (MAHFP)		ATT (HDDS)		ATT (FCS)	
	Coeff	Robust SE	Coeff	Robust SE	Coeff	Robust SE
Age	0.00***	(0.00)	-0.01***	(0.00)	0.02***	(0.00)
Off-farm activities	-0.01	(0.01)	-0.08***	(0.01)	-0.61***	(0.09)
Education	-0.00***	(0.00)	-0.01***	(0.00)	-0.00	(0.01)
Married	0.01	(0.01)	0.15***	(0.02)	2.71***	(0.14)
Central region	-0.07***	(0.01)	-0.65***	(0.02)	-5.26***	(0.18)
Southern region	-0.32***	(0.01)	0.35***	(0.02)	0.45***	(0.16)
Western region	-0.05***	(0.01)	0.09***	(0.01)	-0.41***	(0.09)
Constant	-0.03	(0.01)	1.04	(0.02)	2.20	(0.15)
Observations	296		296		296	

Notes: \*\*\* and \*\* denote 1% and 5% level of significance, respectively; ATT=average treatment effect on the treated; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score.



## 6. Conclusion and policy implications

Previous research has documented the spread of mobile money services and suggested positive welfare effects, especially for the rural poor who are often neglected by the formal financial system. Yet, evidence on the role of mobile money services in the context of a fragile and post-conflict country is lacking. In this paper, we have contributed to literature by analysing the impact of mobile money use on food security in Liberia. Furthermore, we have disaggregated our analysis to examine the gendered-differential effects of mobile money use on the level of household food security.

Our results show that the use of mobile money services has a positive impact on household food security. When we disaggregate our results by gender, we find that the use of mobile money services had positive welfare effects for both FHHs and MHHs. However, the impact of use of mobile money services on the level of food security among FHHs was higher than that of their male counterparts. Further, results on heterogeneity effects of the pooled sample (all users of mobile money) confirm that gender significantly influences the level of food security. In particular, in the case of months of adequate household food provision, the effect is stronger for MHHs, while, in the case of household dietary diversity score and food consumption score, the effect is stronger for FHHs. Consequently, heterogeneity effects among FHHs who are users of mobile money show that, married FHHs have a higher food security status in comparison to unmarried FHHs. Factors such as gender, education, location, and own farm food production significantly influenced a household decision to use mobile money.

The findings of this study show that patterns observed in majority of non-fragile countries on the impacts of mobile money services may also hold for fragile countries, particularly Liberia. Therefore, policy makers should intensify incentives that advocate for the adoption and use of mobile money services in fragile countries. This can be done through incentives to the private sector that are meant to catalyse expansion of mobile money agent services. However, the results of heterogeneity effects demonstrate the importance of going beyond the average effects. It is necessary to recognize the important role that gender plays in the effectiveness of the use of mobile money services. Our results have also shown the complementarity of the use of financial services between men and women; whereby, men greatly use bank accounts whereas women use mobile money accounts. From these results, we can imply that women can also be incentivized to have or open bank accounts if financial service providers are able to tap into this complementary role and build their capacity through education on the linkages between mobile money and bank accounts.

## Notes

1. <https://microdata.worldbank.org/index.php/catalog/2986>
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# Appendix

Table A1: Inverse probability-weighted regression adjustment estimates for the determinants of food security by mobile money use status

VARIABLES	MAHFP				HDDS				FCS			
	Non-Users		Users		Non-Users		Users		Non-Users		Users	
	Coeff	Robust SE	Coeff	Robust SE	Coeff	Robust SE	Coeff	Robust SE	Coeff	Robust SE	Coeff	Robust SE
Gender	0.06	(0.05)	0.14*	(0.08)	-1.29***	(0.12)	-1.60***	(0.24)	-7.59***	(0.86)	-8.82***	(1.69)
Age	-0.00***	(0.00)	-0.00	(0.00)	0.00	(0.00)	-0.00	(0.01)	0.14***	(0.02)	0.15***	(0.05)
Duration of stay	0.00	(0.00)	0.00*	(0.00)	-0.00***	(0.00)	-0.00	(0.00)	-0.01***	(0.01)	-0.00	(0.01)
Spouse outside the household	-0.07	(0.06)	-0.18**	(0.09)	1.22***	(0.16)	0.97***	(0.28)	6.66***	(1.13)	4.53**	(2.19)
Off farm activities	-0.02	(0.03)	-0.03	(0.07)	0.56***	(0.07)	0.48***	(0.16)	3.28***	(0.56)	2.70**	(1.22)
Own farm production	-0.03	(0.04)	-0.04	(0.08)	0.26***	(0.06)	0.26*	(0.14)	1.90***	(0.48)	2.10*	(1.22)
Level of education	0.01***	(0.00)	0.01	(0.01)	-0.00	(0.01)	-0.01	(0.02)	-0.12	(0.07)	-0.13	(0.13)
Married	-0.01	(0.05)	-0.07	(0.08)	1.70***	(0.12)	1.72***	(0.26)	11.66***	(0.86)	13.30***	(1.80)
Central region	-0.21***	(0.05)	-0.27**	(0.12)	-0.11	(0.11)	-0.73***	(0.27)	-1.63*	(0.84)	-6.75***	(1.90)
Southern region	-0.36***	(0.06)	-0.67***	(0.15)	-0.02	(0.12)	0.36	(0.33)	-2.28***	(0.86)	-1.59	(2.55)
Western region	-0.21***	(0.04)	-0.26***	(0.07)	-0.32***	(0.08)	-0.21	(0.16)	-2.45***	(0.62)	-2.76**	(1.26)
Constant	11.67	(0.14)	11.85	(0.22)	5.18	(0.35)	6.68	(0.63)	25.37	(2.54)	31.65	(4.86)
Observations	8,347		8,347		8,347		8,347		8,347		8,347	

Notes: Robust standard errors in parentheses; \*\*\*, \*\*, \* denote significant values at 1%, 5%, and 10%, respectively; SE=standard errors; MAHFP=months of adequate household food provision; HDDS=household dietary diversity score; FCS=food consumption score; overidentification test for covariate balance  $\chi^2(12) = 17.71$ ;  $p > \chi^2 = 0.12$

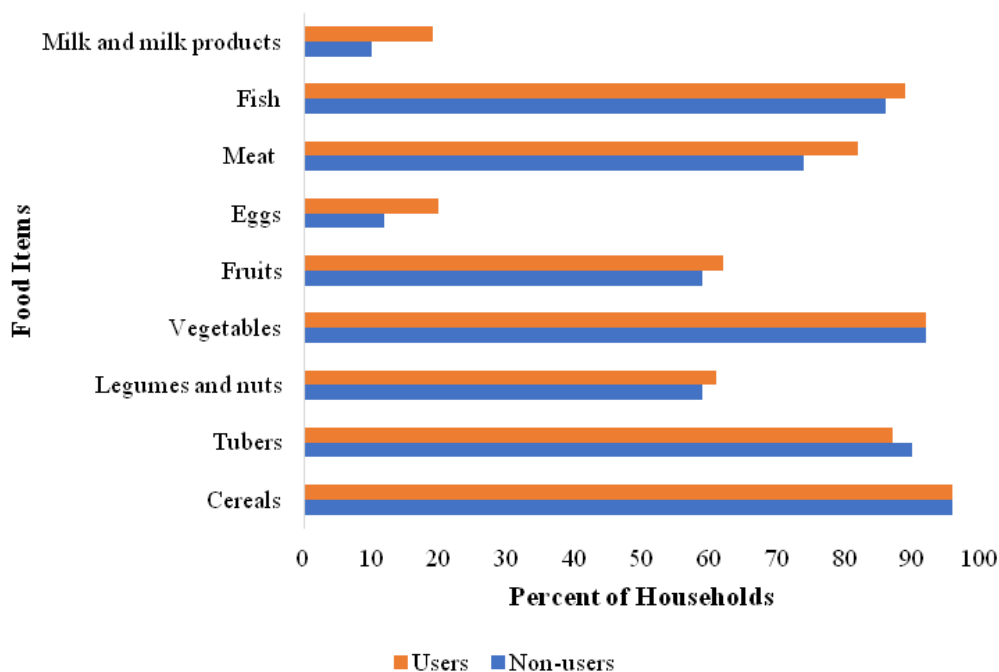
**Table A2: Covariate balancing test for selection bias before and after matching using NNM**

<b>Independent Variables</b>	<b>Sample</b>	<b>Mean Treated</b>	<b>Control</b>	<b>Significance P-value</b>
Gender	Before matching	0.70	0.75	0.00
	After matching	0.70	0.68	0.49
Age	Before matching	40.81	42.27	0.00
	After matching	40.81	40.71	0.88
Duration of stay	Before matching	34.19	47.95	0.00
	After matching	34.19	34.90	0.70
Spouse outside the household	Before matching	1.87	1.92	0.00
	After matching	1.87	1.87	0.82
Off-farm	Before matching	0.56	0.50	0.00
	After matching	0.56	0.57	0.60
Own farm production	Before matching	0.28	0.49	0.00
	After matching	0.28	0.27	0.83
Level of education	Before matching	3.12	1.99	0.00
	After matching	3.12	3.02	0.64
Married	Before matching	0.68	0.73	0.00
	After matching	0.68	0.68	0.98
Central region	Before matching	0.12	0.13	0.45
	After matching	0.12	0.12	0.91
Southern region	Before matching	0.08	0.13	0.00
	After matching	0.08	0.07	0.88
Western region	Before matching	0.44	0.37	0.00
	After matching	0.44	0.44	0.87

**Table A3: Covariate balancing tests, PSM quality indicators before and after matching with NNM and RM, and sensitivity analysis for hidden bias**

Matching Algorithm	Pseudo R <sup>2</sup> Before Matching	Pseudo R <sup>2</sup> After Matching	Mean bias Before Matching	Mean Bias After Matching	Outcome Variable	%  Bias  Reduction	Critical Level of Hidden Bias ( $\gamma$ )
Nearest Neighbour	0.05	0.00	18.4	1.3	MAHFP	102	1.5-1.6
					HDDS		1.6-1.7
					FCS		1.2-1.3
Radius	0.05	0.00	18.4	3.2	MAHFP	100	1.7-1.8
					HDDS		1.9-2
					FCS		1.3-1.4
Kernel	0.05	0.00	18.4	4.5	MAHFP	100	1.8-1.9
					HDDS		1.8-1.9
					FCS		1.3-1.4

**Figure A1: Key food items consumed in Liberia by mobile money use status**





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