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Investigating the Effects of Mobile Money Usage and Gender of the Household Head on Food Insecurity and Children's Nutritional Health in Tanzania

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Abstract: Mobile money is an invaluable financial service that has improved welfare for many people in developing countries and mitigated household shocks through low-cost and simple money transfers. In this paper, we explore the effects of mobile money usage on household food insecurity and children's nutritional health in Tanzania, incorporating a gender perspective by evaluating whether the gender of the household head affects the outcomes of mobile money usage. To achieve this, we utilise data from a national panel survey in Tanzania. We find some evidence indicating that mobile money usage has a significant effect on reducing food insecurity and further find that having a female household head can strengthen these effects. However, the evidence regarding improvements in children's nutritional health is inconclusive. Our findings contribute to existing literature by highlighting the importance of gender dynamics and financial inclusion in decreasing food insecurity and improving the welfare of households that lack access to traditional financial systems.

Keywords: Mobile Money, Food Insecurity, Child Health, Financial Inclusion, Nutrition, Household Gender Dynamics, Tanzania

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1. Introduction

Financial inclusion plays a crucial role in alleviating rural poverty by enabling individuals to save, borrow, and manage their finances more effectively. It enables economically disadvantaged individuals to maintain stable consumption and safeguard themselves from various vulnerabilities (Demirgüç-Kunt, Klapper, 2012). In recent years, mobile money services have become an essential tool for financial inclusion in Tanzania. By 2021, mobile money account ownership had surged to 45%, up from 32% in 2014. In contrast, approximately 23% of the population aged 15 years and above held accounts with traditional financial institutions, marking a modest increase from 19% in 2014 (World Bank, 2021). Approximately 38% of rural residents utilised mobile money services by 2017 (World Bank, 2018). This substantial increase in mobile money usage highlights its accessibility and user-friendliness compared to traditional banking methods, particularly benefiting unbanked and economically marginalised populations.

Building on this momentum, evidence shows that mobile money services have significantly reduced costs and increased the speed and reliability of remittance transfers, a crucial income source for many households. Remittances support daily expenses, education, healthcare, and investments. By making remittances more affordable and accessible, mobile money platforms enable households to utilise these funds more efficiently, enhancing income stability and allowing for strategic financial planning and investment, thereby strengthening economic resilience (Aron, (2018).

Despite advancements in financial inclusion, Tanzania continues to face significant challenges in food security. In 2022, the country recorded a high level of food insecurity, scoring 49.1 out of 100 on the Global Food Security Index, placing it 90th out of 113 countries. Critical areas such as food affordability, food quality and safety, and natural resource management and resilience exhibited particularly poor outcomes (The Economist, 2022), highlighting the weight of this issue in Tanzania.

A recent study by Ajefu et al. (2024), titled "Exploring How Mobile Money Adoption Affects Nutrition and Household Food Security," utilising panel data from the Tanzania National Panel Survey, provides empirical evidence that mobile money usage positively impacts household food security. Building on their research, this study focuses on the effect of mobile money usage on children's food security and nutritional outcomes in Tanzania, delving deeper into gender mechanisms and addressing a critical gap in the existing literature.

The remainder of this paper is organised as follows: Section 2 provides a background on the current state of mobile money, food insecurity, and child nutrition in Tanzania. Section 3 reviews the existing literature on the topic. Section 4 details the data sources and characteristics, followed by Section 5, which outlines the research methodology. Section 6 presents the results of the study, while Section 7 offers a discussion of the findings. Finally, Section 8 concludes the paper, lastly, a reference list and an appendix are provided at the end.

2. Background

2.1 Mobile Money

Underdeveloped banking systems result in limited access to financial services, leaving over 1.4 billion adults globally without formal bank accounts (World Bank, 2021). This lack of accessible financial infrastructure restricts individuals' ability to perform transactions, consequently, many people are unable to participate fully in the formal economy. The absence of inclusive and accessible economic infrastructure increases social inequalities, preventing marginalised groups from accessing the financial resources necessary to improve their livelihoods and contribute to broader economic growth (Barajas, Beck, Belhaj, and B. Naceur, 2020).

Mobile money services have emerged as an accessible alternative to traditional banking systems, partly overcoming these systemic barriers. Mobile money enables the delivery of financial services through mobile phones, enabling users to transfer funds, make payments, save money, and access microloans. These services enable users to perform financial transactions without the need for internet access, relying solely on mobile network connectivity. To use mobile money services, individuals need a basic mobile phone, a registered SIM card, and an active network subscription. The growth in mobile money usage in Tanzania has happened at the same time as there has been a widespread adoption of mobile phones and the rapid expansion of mobile money network operators, particularly in sub-Saharan Africa. These developments have significantly advanced financial inclusion, especially for the unbanked poor, by offering an affordable and accessible alternative to traditional banking services (Aron, 2018). This system provides a simple, secure, and accessible alternative to traditional banking, promoting financial inclusion even in areas lacking internet infrastructure (Venkatesen, 2013).

Since 2007, mobile money services have rapidly expanded across emerging and developing economies. Kenya pioneered the concept of mobile money with Safaricom's introduction of M-Pesa. The service rapidly gained momentum across Africa and shortly after its introduction Tanzania embraced mobile money service (MNS Consulting, 2017). Mobile money's success can be attributed to its affordability, often costing significantly less than traditional cash transfer options. For example, Kenya's M-Pesa is up to 50% cheaper than alternatives, allowing users to retain more of their money (World Bank, 2012).

Individuals in low-income communities often rely on informal financial methods, such as local lending circles or barter systems (Zambrano et al., 2023). Additionally, they frequently depend on physical assets like livestock or gold, which are difficult to sell and risky to transfer (World Bank, 2017). Tanzania's mobile money sector has experienced significant growth, driven by widespread mobile phone usage and the urgent need for accessible financial services. According to the Tanzania Communications Regulatory Authority, the number of mobile money accounts surged from 25.8 million in 2019 to 55.8 million in 2023, marking a 116.2% increase over five years (Tanner, 2024).

2.2 Food Insecurity and Its Impact on Children in Tanzania

Food insecurity is a critical inequality issue in Tanzania, hindering economic and social development by limiting reliable access to sufficient, affordable, and nutritious food. Despite steady economic growth in recent years, 27 percent of the population still live below the poverty line, and an additional

8 percent reside in extreme poverty. Consequently, a large portion of the population remains malnourished, exhibiting high rates of stunting alongside increasing incidences of overweight, obesity, and vitamin and mineral deficiencies. Furthermore, an estimated 59 percent of families cannot afford a nutritious diet, exacerbating existing inequalities and posing substantial barriers to the country's overall development (WFP, 2024).

Food insecurity in Tanzania is driven by climate challenges such as erratic rainfall and prolonged droughts, which severely impact crop and livestock production and leave rural households vulnerable (IPC Acute Food Insecurity Analysis Report, 2021–2022). Additionally, rising food prices and declining livestock values reduce the purchasing power of impoverished populations, while agricultural issues like crop pests and significant post-harvest losses further increase food shortages. The Integrated Food Security Phase Classification (IPC) categorises food insecurity into five phases, ranging from minimal (Phase 1) to famine (Phase 5). According to the IPC (2024), between November 2023 and April 2024, approximately 900,000 people, 13% of the 7.1 million population across 21 district councils in mainland Tanzania, are experiencing acute food insecurity. These districts are classified as Phase 2 (Stressed) or Phase 3 (Crisis), highlighting the severity of the situation and the urgent need for targeted interventions.

This acute food insecurity has implications for public health, particularly in relation to malnutrition. Malnutrition remains a significant public health concern in Tanzania, particularly among children under five years of age (Unicef, n.d). Malnutrition is commonly assessed through three key anthropometric measures. Stunting (height-for-age/height-to-age) indicates chronic undernutrition and is a measure of a child's failure to grow adequately due to prolonged nutritional deprivation. Wasting (weight-for-height/weight-to-height) measures acute malnutrition, highlighting a sudden and severe lack of food or illness that results in rapid weight loss. Underweight (weight-for-age/weight-to-age) is a composite measure that combines elements of both stunting and wasting, providing an overall indication of a child's malnourished state, whether due to chronic or acute causes (WHO, n.d). As of 2021, approximately 31.8% of Tanzanian children under five years of age were affected by chronic malnutrition or stunting (Cowling, 2024).

The high prevalence of malnutrition in Tanzania has profound implications for children's development. Malnutrition significantly increases child mortality rates, as undernourished children are more vulnerable to infections and diseases. Chronic undernutrition also leads to long-term cognitive impairments, which can negatively impact educational outcomes and reduce future economic productivity (Khamis, Mwanri, Kreppel, Kwesigabo, 2020). Food insecurity in Tanzania is not just a health crisis but a fundamental barrier to economic development and social equity. Chronic malnutrition and acute food shortages disproportionately affect vulnerable populations, particularly children, perpetuating cycles of poverty and limiting the country's human capital potential. Without sufficient nutritious food, individuals struggle to work, learn, and contribute effectively to society. The Tanzania National Nutrition Survey underscores the need for multi-sectoral interventions to address the root causes of malnutrition and improve health and development outcomes in Tanzania (TNNS, 2018).

2.3 Research Aim and Question

This study aims to examine the impact of mobile money usage on household food security and nutritional outcomes of children in Tanzania. Utilising panel data from the Tanzania National Panel Survey, this research specifically focuses on children aged eleven years or younger to assess whether

mobile money services can reduce food insecurity and improve access to adequate and nutritious food. The study also investigates how the gender of the household head influences the effectiveness of mobile money in achieving these outcomes, providing valuable insights into the role of financial leadership within households.

The study hypotheses that:

(1) Mobile money usage has a positive effect on food insecurity.

(2) Mobile money usage positively impacts children's food security, which in turn improves their anthropometric measures, indicating better nutritional health.

(3) Female-headed households are more effective than male-headed households in leveraging mobile money to enhance food security and improve children's nutritional health.

The core research question driving this study is: "What is the impact of mobile money usage on children's food security and nutritional outcomes in Tanzania, considering the gender of the household head?" Addressing this question will deepen the understanding of how financial technologies can reduce food insecurity and promote better nutritional outcomes for children.

This research is important as it explores the intersection of financial inclusion, child welfare, and gender dynamics. In contexts where financial and food resources are constrained, the study aims to create insights that can inform policies targeting financial inclusion, poverty alleviation, and the enhancement of child health and nutrition. By emphasising the role of the household head's gender, the study highlights how gender dynamics influence the effectiveness of mobile money interventions in improving child-specific outcomes.

3. Literature Review

3.1 Theoretical Background

Mobile money has achieved substantial adoption in several countries, and a growing amount of research highlights its diverse impacts across multiple areas. The relationship between mobile money usage and food insecurity has gained increasing attention, particularly as mobile financial services rapidly increase in developing economies. This study builds on three interconnected research strands to explore how mobile money influences children's food security and nutritional outcomes in Tanzania.

This literature review first explores how mobile financial services enhance financial inclusion by overcoming traditional banking barriers. Secondly, the broader socioeconomic effects of mobile money, including poverty reduction and increased household consumption, while also considering household gender dynamics. Lastly, the study assesses the contribution of mobile money to food security, with a specific focus on children's health and well-being.

3.1.1 Previous Research on the Effects of Mobile Money on Financial Inclusion

Mobile money has been widely recognised as a transformative tool for promoting financial inclusion, particularly in regions with underdeveloped banking systems. Demirgüç-Kunt et al. (2018) emphasise that mobile money is a key driver of global financial inclusion, with Sub-Saharan Africa leading adoption rates. Countries like Tanzania have demonstrated significant growth, as mobile money accounts enable millions to engage with formal financial systems, reducing the unbanked population.

The GSMA's State of the Industry Report on Mobile Money (2024) similarly underscores the transformative impact of mobile money in developing economies. Over the past two decades, mobile money services have grown exponentially, driving financial inclusion for billions and creating opportunities for entrepreneurs and small businesses. By 2024, mobile money services supported 1.75 billion registered accounts globally, processing transactions worth $1.4 trillion annually. Sub-Saharan Africa remains a major contributor, hosting half of the world's accounts and exemplifying mobile money's success in fostering financial access (GSMA, 2024).

Mbiti and Weil (2011) further illustrate the benefits of mobile money through the example of M-Pesa in Kenya. By providing a cheaper and more accessible alternative to traditional money transfer methods, such as bus companies and Western Union, M-Pesa reduced transaction costs and created competitive pressure on other financial services. These changes directly benefited users while broadening access to financial systems, reinforcing financial inclusion among underserved populations.

Simione and Muehlschlegel (2023) provide additional insights into how mobile money influences financial behaviors. Using nationally representative data from Uganda, they find that mobile money users perceive cash as riskier and avoid carrying large amounts. Mobile money adoption also increases engagement in financial activities such as remittances, savings, and borrowing, while boosting the amounts saved and borrowed. However, the study highlights persistent challenges, including infrastructure limitations and the lack of interoperability between platforms. Addressing

these barriers is essential for fully realising mobile money's potential to enhance financial inclusion, reduce cash reliance, and expand access to financial services.

Despite the widely recognised benefits of mobile money, the literature identifies significant challenges. Data privacy remains a critical concern. For example, Kenya's lack of comprehensive data protection laws has exposed users to risks, with Safaricom, the operator of M-Pesa, facing legal action in 2019 for allegedly breaching the privacy of 11.5 million subscribers. Reports of user data appearing on the black market underline the urgent need for robust data protection measures to safeguard users' trust and security (The Nairobi Law Monthly, 2022).

Fraud and system vulnerabilities also pose substantial challenges. As highlighted by Wambugu (2024), mobile money systems are at risk of impersonation, insider collusion, cyberattacks, and agent-related schemes. These issues are intensified by the rapid evolution of mobile money platforms, which often outpace the development of effective fraud prevention measures. Low levels of customer literacy further increase vulnerability to fraud, while inconsistent regulatory frameworks and limited law enforcement capacity hinder comprehensive management of these risks. Addressing these challenges is critical for sustaining mobile money's role as a transformative tool for financial inclusion.

In summary, the existing literature illustrates mobile money's potential to drive financial inclusion and improve livelihoods, particularly in underserved regions. However, realising its full potential requires an effort to align regulations and infrastructure with technological advancements.

3.1.2 Previous Research on the Effect of Mobile Money on Household Welfare

Jack and Suri (2014, 2016) provide evidence of the transformative impact of mobile money on household welfare and financial resilience in Kenya. Their 2014 study highlights mobile money's role in improving risk-sharing by reducing transaction costs and enhancing access to financial networks. Households using M-Pesa were able to maintain stable consumption levels during income shocks, whereas non-users experienced a 7% decline in consumption. These findings underscore mobile money's critical role in mitigating economic vulnerabilities. Building on this, their 2016 follow-up study demonstrates the long-term socioeconomic benefits of mobile money, revealing that M-Pesa lifted 2% of Kenyan households out of poverty by facilitating better financial management and resource allocation.

Munyegera and Matsumoto (2014) explore the effects of mobile money on rural household welfare in Uganda, focussing on per capita consumption and remittance patterns. Their findings show that mobile money adoption increases household per capita consumption by 72%, driven primarily by improved access to remittances. Users receive remittances more frequently, securely, and in larger amounts compared to non-users. The study highlights mobile money's pivotal role in enhancing financial inclusion, reducing poverty, and improving rural household welfare.

Similarly, Abiona and Koppensteiner (2020) examine the impact of mobile money adoption on household welfare in Tanzania, with a particular focus on consumption smoothing and poverty reduction. Using panel data from 2010 to 2012 and rainfall shocks as exogenous variables, their study finds that mobile money users are better equipped to smooth consumption and avoid poverty during periods of negative income shocks. Mobile money adoption helps preserve investments in health and

education, mitigates adverse effects on children's schooling, particularly for girls, and reduces the likelihood of households falling into poverty.

A report from the Bill & Melinda Gates Foundation (2021) reinforces these findings, highlighting mobile money's ability to reduce poverty and improve welfare in developing economies. The brief shows that mobile money increases household consumption, particularly during economic shocks, as evidenced in Kenya and Mozambique. By enhancing financial access and resilience, mobile money plays a role in mitigating the effects of economic volatility on vulnerable households.

3.1.3 Previous Research on the Effects of Mobile Money on Food Insecurity

Ajefu et al. (2024) investigates the impact of mobile money on nutrition and household food security in Tanzania, using panel data and an Instrumental Variable (IV) approach. The study finds that mobile money adoption significantly improves food security indicators, including dietary diversity, food expenditure, and food consumption scores. The key mechanism identified is the facilitation of remittances, which enhance household liquidity and enable access to better-quality food. These findings underscore mobile money's potential to reduce food insecurity and promote financial inclusion in developing economies.

Similarly, Murendo and Wollni (2016) examine mobile money usage in rural Uganda and report significant reductions in food insecurity alongside increased food expenditures. Households using mobile money benefit from greater financial stability through faster and more secure remittance flows, reduced transaction costs, and access to additional financial services such as savings and insurance. The study highlights that the frequency of mobile money use and the volume of money transferred are positively associated with food security outcomes. This suggests that promoting mobile money services could serve as an effective policy tool for improving food security and financial inclusion in rural areas.

Aker et al. (2016) provide further evidence of mobile money's positive impact on food security through a randomized experiment in Niger. The study finds that households receiving mobile transfers experienced a 9–16% increase in dietary diversity, and children consumed approximately one-third more meals per day. These improvements are partly attributed to the time savings associated with mobile transfers, as recipients spent less time traveling to and waiting for payments.

Mbiti and Weil (2011) also highlight mobile money's indirect role in enhancing food security through improved consumption and overall welfare. Similarly, Weiser et al. (2019) report that mobile money usage in rural Uganda led to a 45% increase in food security, largely driven by the facilitation of remittances. Together, these studies demonstrate the transformative potential of mobile money in improving food security and household welfare across different contexts.

3.1.4 Previous Research on Gendered Dynamics in Financial Decision-Making

Research consistently demonstrates that the biological gender of a household head significantly influences financial practices and outcomes. Kamath and Dattasharma (2015) studied informal urban workers in India and found that female-headed households tend to prioritise welfare-oriented expenditures. These households allocate a larger share of their income to essentials such as vegetables, milk, and spices, in contrast to male-headed households, which spend more on fuel, entertainment, and personal accessories. This focus on necessities reflects female household heads'

commitment to nutrition and well-being, even under economic constraints. Despite managing both work and caregiving responsibilities, female-headed households demonstrate an effective balancing of finances, ensuring critical needs are met and family welfare is maintained (Kamath and Dattasharma, 2015).

Chant (2009) strengthens this perspective, highlighting how women's income allocation patterns frequently emphasise essential household needs such as healthcare and education, which enhance the overall well-being of family members. Such focused spending strategies maximise the impact of limited resources, particularly in financially constrained environments. Furthermore, Chant suggests that the absence of a male head in certain households can improve economic and social stability, particularly in situations where male contributions are inconsistent or increase financial strain through mismanagement or neglect. These findings challenge traditional assumptions about the economic vulnerability of female-headed households, instead portraying them as resilient and resourceful.

In rural South Africa, Booysen and Guvuriro (2021) examine financial decision-making within households and find that wives with greater decision-making power allocate more resources to education. This trend highlights the potential of female financial empowerment, especially in enhancing investments in human capital. Women in such households also prioritise expenditures on healthcare and family-focused goods, in contrast to male-dominated households, which often allocate more resources to discretionary expenses such as transportation and clothing. These findings align with broader research, emphasising the role of women in promoting welfare-enhancing expenditures and improving rural family well-being.

Existing research also underscores the significant role of gender dynamics and marital status in household financial decision-making. For example, in "The Accumulation of Wealth in Marriage: Over-Time Change and Within-Couple Inequalities," Kapelle and Lersch (2020) utilise data from the German Socio-Economic Panel (SOEP) to demonstrate that married households tend to accumulate wealth more effectively than single households, primarily through investments in housing. However, the study also reveals notable gender disparities, with men accumulating wealth at a faster rate than women due to income gaps and institutional advantages such as tax benefits. These findings suggest that both the marital status and the gender of the household head can influence financial stability and wealth accumulation.

This research highlights the context-dependent nature of gendered financial decision-making, illustrating how the biological gender and marital status of household heads shape financial priorities, resource allocation, and overall family welfare. These findings underscore the importance of considering gender dynamics when analysing household financial behaviours and outcomes.

3.2 Final Remarks

Together, these theoretical perspectives establish the foundation for understanding how mobile money can mitigate child malnutrition and enhance long-term health outcomes in Tanzania. The reviewed studies underscore mobile money's pivotal role in promoting financial inclusion by overcoming traditional banking barriers, improving household welfare, and addressing gender dynamics within households. This comprehensive framework supports the investigation into the specific impact of mobile money usage on children's food security and nutritional outcomes, additionally emphasising the role of the household head's gender.

While existing research highlights mobile money's ability to enhance household food security and nutrition through mechanisms such as facilitating remittances, smoothing consumption, and improving financial resilience, much of this literature remains focused on the household level. Studies like Aker et al. (2016) and Ajefu (2024) demonstrate that mobile money can improve dietary diversity, meal frequency, and food consumption scores, but they often infer benefits to children without directly measuring child-specific nutritional or developmental outcomes. This gap in targeted analysis limits our understanding of the specific pathways through which mobile money influences children's food security and long-term well-being.

Moreover, existing evidence highlights the pivotal role of gender dynamics in financial decision-making. While prior research has separately examined gender dynamics and mobile money, the specific interplay between mobile money usage, gender relations within households, and child-specific nutritional outcomes remains, as per our knowledge, underexplored. This thesis seeks to address this gap by investigating how mobile money usage affects child-specific food security and nutritional outcomes in Tanzania, with a particular focus on the gender of the household head. By employing a gender-sensitive approach, this study explores the mechanisms linking mobile money to child nutrition, providing a comprehensive understanding of its impact and offering insights into the intersection of financial technology and gendered financial decision-making.

4. Data

4.1 Data Description

This study employs data from the Tanzania National Panel Surveys (TNPS), specifically utilising the waves conducted in 2010/11, 2012/13, and 2014/15. (National Bureau of Statistics, 2020). The dataset also includes data from 2008/2009, however this wave was not incorporated into the analysis due to the absence of data on mobile money service usage among households. The TNPS is Tanzania's nationally representative longitudinal survey series designed to collect comprehensive information on the living standards of the population. It encompasses data on consumption expenditure, farm and non-farm income-generating activities, and various socio-economic characteristics.

The National Panel Survey is conducted by the Tanzania National Bureau of Statistics (NBS) in collaboration with the World Bank's Living Standards Measurement Study (LSMS) team, with financial support from the European Union, the Bill and Melinda Gates Foundation, and the Foreign, Commonwealth and Development Office. The sample design examines four analytical strata across Tanzania: Dar Es Salaam, Other Urban Areas in Mainland Tanzania, Rural Areas in Mainland Tanzania, and Zanzibar.

The TNPS collects data at both the Unique Person Identifier (UPI) level, pertaining to individuals, and the Unique Household Identifier (UPHI) level, pertaining to households. This study focuses on a selected subset of these variables, including detailed information on demographics, economic status, mobile money usage, and various indicators of household welfare. By concentrating on the waves that include comprehensive data on mobile money usage, this study ensures a robust foundation for analysing the impact of mobile financial services on household food security and welfare in Tanzania.

By utilising these specific waves, the study ensures the inclusion of relevant and complete data on mobile money usage, thereby enabling a thorough analysis of its impact on household food security and welfare in Tanzania.

4.2 Variables Used

The variables from the TNPS utilised in our dataset are presented in the table below.

Table 1: Explanations of All Variables Used in the Analysis

Variable	Description
MM Usage	Mobile Money Usage, (Yes = 1, No = 0)
Female HH Head	Gender of household head, 1 = Female, 0 = Male
Marital Status HH Head	Marital Status of household head
# Of Fridge/Freezer	Number of refridgerators and/or freezers in household
# Of Livestock	Number of livestock household owns
Fields/Land	Amount of land household owns (Undefined size)
HH Bank Account	If any member of the household has a bank account, (Yes = 1, No = 0)
Mobile Phone	Number of mobile phones in household
Vehicle	Number of vehicles in household
Drought/Flood	If the household has experienced a drought of flood in the last two years
Food Shortage 12 M	Has experienced food shortage in the last 12 months, (Yes = 1, No = 0)
Less Preferred Food	Have had to eat less preferred foods, # of days last week
Limited Variety	Have had to limit the variety of food, # of days last week
Smaller Portions	Have had to eat smaller portions foods, # of days last week
Fewer Meals	Have had to eat a fewer amount of meals, # of days last week
Less Food For Adults	Have had to decrease the food for adults in favour of children, # of days last week
Borrowed Food	Have had to borrow food or get help from a friends, # of days last week
No Food In HH	Have had no food in the household, # of days last week
No Meals For A Day	Have had to go 24 hours without eating, # of days last week
WtoH Female	Weight to height - Female
WtoH Male	Weight to height - Male
WtoA Female	Weight to age - Female
WtoA Male	Weight to age - Male
HtoA Female	Height to age - Female
HtoA Male	Height to age - Male

Data Source: *Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 1 describes the definitions of all variables utilised in the analysis*

4.3 Data Cleaning

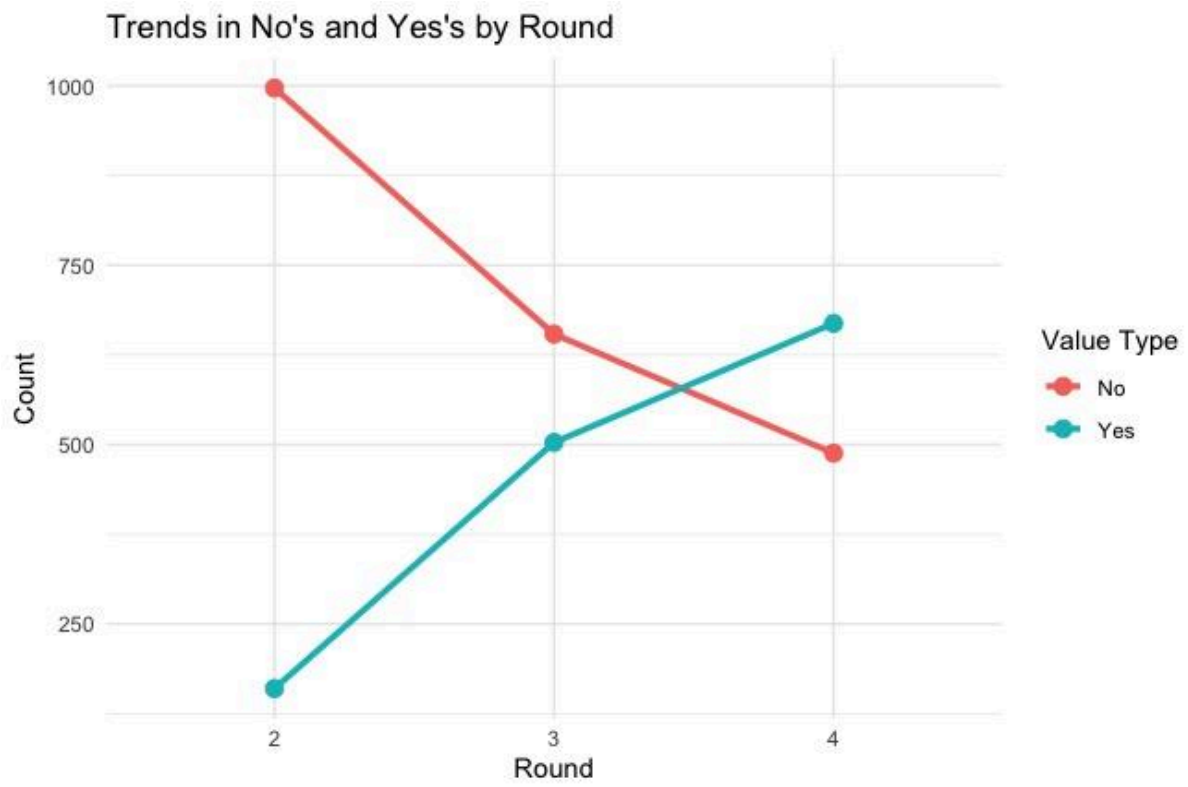
To prepare the data for analysis, a comprehensive cleaning and merging process was undertaken. The TNPS encompasses a wide range of variables, from which this study focuses on a selected subset. These variables are recorded either at the UPI level or the UPHI level, as described above. Utilising both UPI and UPHI data, necessitates their integration into a single unified dataset for effective analysis. Since mobile money information and food insecurity was specifically collected at the UPHI level, we chose to merge all data at this level to maintain consistency and incorporate comprehensive mobile money and food insecurity data. Merging the data at the UPI level would have resulted in duplicate responses, compromising the dataset's integrity. Therefore, we restructured the UPI

variables including household head gender, marital status, number of children and anthropometric measures to align with the UPHI framework. This approach ensured that our unified panel dataset accurately links observations across different survey rounds without duplication, enhancing the reliability and depth of our subsequent analyses. The merging methodology for the various variables is detailed in the following section.

4.3.1 Construction of Mobile Money Variable

The Mobile Money Usage variable (MM Usage) was collected in the survey at the UPHI level, where respondents were asked which mobile money services they used, including M-Pesa, EzyPesa, Airtel Money, Tigo Pesa, Z-Pesa, and Zap. To effectively utilise this data in our analysis, we converted it into a binary variable by merging the responses from these six services. The survey inquired whether households used any of these services, thereby indirectly capturing mobile money usage. These responses were consolidated into a single variable, coded as 1 if the household utilised any of the services and 0 if none were used. Households that marked "not applicable" (N/A) for all mobile money services were assigned N/A. This consolidation allows for a comprehensive assessment of mobile money usage across various platforms, ensuring that the analysis accurately captures the overall impact of mobile financial services on the dependent variables. In figure 1 the adoption trend of mobile money in the dataset is visualised.

Figure 1: Graph of Adoption Trends of Mobile Money Over Rounds.



***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
***Note**: Figure 1 depicts the adoption trends of mobile money in our dataset over the 3 rounds. The first round was in 2010/2011, the second in 2012/2013 and the third in 2014/2015.*

4.3.2 Construction of Children's Anthropometric Variables

To prepare the anthropometric data for analysis, we converted individual-level measurements from the UPI to the UPHI level. Beginning by selecting only children under twelve years of age and creating health indicators such as weight-to-height, weight-for-age, and height-for-age ratios, further dividing these by gender into six distinct variables. Given that households often contain multiple children, we utilised the household ID (r_hhid (Round Household Identifier)), present in both UPI and UPHI datasets to link individuals to their respective households. However, some individuals share the same r_hhid and round combination. Thus, to prevent duplicate entries and ensure a representative UPHI dataset, we averaged children in households that had multiple children of the same gender under the age of twelve, to one averaged observation per round. This process resulted in each household having potentially one female and one male observation per round, thereby maintaining data consistency and minimising data loss. By filtering and averaging the data in this manner, we successfully merged the individual-level anthropometric data with household-level information, enabling a comprehensive and accurate analysis of children's nutritional health within the unified panel dataset. Further, this ensured that the same households could be used for evaluating the effects of mobile money on food insecurity, as well as children's anthropometric data. Albeit the final dataset concerning children's anthropometric measures being smaller, it is a subset of the dataset testing the effects of mobile money on food insecurity and not a unique dataset of households.

4.3.3 Construction of Other Control Variables

The variables gender of household head (Female HH) and marital status of household head (Marital Status HH Head) were also collected at the individual level, UPI. However, these variables lacked a direct UPHI key, making conventional merging with the UPHI key impossible. To address this issue, the r_hhid was used as it was present in both the household-level and individual-level datasets. Since each household only has one household head, the dataset was filtered to identify the household head by selecting individuals with a family position indicator of 1 (household head) and excluding those with another position indicator of non-household head. This filtering process ensured that only one observation per household per round was retained. The gender and marital status of the identified household head were then used to construct the Female HH and Marital Status HH Head variables, respectively, while eliminating any duplicates. This approach ensured that these control variables were accurately merged with the household-level data using the r_hhid identifier. By maintaining data integrity, this method allows for analysis of the impact of mobile money on children's nutritional outcomes.

Other variables, such as control variables used in the analysis were surveyed at the UPHI level and did not require additional processing or transformations.

4.4 Limitations

Despite the robustness of the TNPS data and the analytical methods employed, this study has limitations that may influence the interpretation of the findings.

Firstly, selection bias remains a potential concern as households with incomplete responses for critical variables, particularly those marked as "missing" or "N/A," were excluded from the analysis. This exclusion could lead to an underrepresentation of households experiencing severe food insecurity or

limited access to mobile money services, potentially underestimating the true effects of mobile money usage.

Secondly, attrition is an inherent limitation of panel datasets like the TNPS. If households drop out across survey waves non-randomly, especially those experiencing higher levels of food insecurity or economic hardship, the resulting sample may no longer accurately represent the population. To mitigate this, the study retained only households with complete responses across all survey rounds. However, if the reasons for missing data are related to the studied variables, this approach could still introduce bias.

Thirdly, the age of the data poses a limitation. The TNPS dataset spans from 2008 to 2015, and mobile money adoption and access to nutritional resources in Tanzania have likely evolved since then. This temporal gap may limit the applicability of the findings to current policy discussions and the present mobile money landscape.

Additionally, endogeneity remains a concern despite using fixed-effects models. Unobserved variables that simultaneously influence mobile money adoption and food security outcomes could confound the results. For instance, household preferences or community-level factors affecting access to mobile money may not be fully accounted for, leading to bias.

A further limitation is related to data consolidation. Variables initially collected at the UPI level, such as gender and marital status of the household head, and children's anthropometric measures, had to be aggregated to the UPHI level to create a unified dataset. This process involved averaging anthropometric data for households with multiple children, which may introduce measurement inaccuracies and obscure individual variations, potentially leading to unreliable outputs.

4.5 Final Dataset

In total, the final dataset comprises 3,468 to 3,471 observations with food security measures as dependent variables and 1490 to 1768 observations with children’s anthropometric measure variables. The reason behind the varying number of observations is due to differing response rates across the dependent variables. The TNPS dataset consists of longitudinal household observations, allowing the study to leverage within-household variations over time. This panel structure offers the advantage of controlling for unobserved household-specific characteristics that remain constant over time, thereby reducing the risk of omitted variable bias. Tables 2, 3 and 4 are summary tables of the dependent and independent variables utilised in our analysis.

Table 2: Descriptive Data of Children's Anthropometric Measurements.

Descriptive Statistics of Dependent Variables - Children

Statistic	Mean	St. Dev.	Median	N
Weight-to-Height Female	17.86	32.33	15.59	1,768
Weight-to-Height Male	18.29	38.04	15.93	1,738
Height-to-Age Female	28.33	17.14	22.45	1,490
Height-to-Age Male	28.51	17.04	22.25	1,471
Weight-to-Age Female	4.34	2.51	3.60	1,490
Weight-to-Age Male	4.39	2.12	3.67	1,471

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 2 is a table of descriptive statistics of dependent variables for measures of children's anthropometric data.*

Table 3: Descriptive Data of Food Insecurity Measurements.

Descriptive Statistics of Dependent Variables - Food Insecurity

Statistic	Mean	St. Dev.	N
Food Shortage 12M	0.29	0.45	3,468
Less Preferred Food	0.94	1.86	3,471
Limited Variety	0.54	1.52	3,471
Smaller Portions	0.41	1.24	3,471
Fewer Meals	0.71	1.76	3,471
Less Food for Adults	0.17	0.82	3,471
Borrowed Food	0.23	0.91	3,471
No Food in HH	0.11	0.65	3,471
No Meals for a Day	0.05	0.38	3,470

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 3 is a table of descriptive statistics of dependent variables measuring food insecurity.*

Table 4: Descriptive Data of Independent Variables.

Descriptive Statistics of Independent Variables

Statistic	Mean	St. Dev.	N
MM Usage	0.38	0.49	3,471
Female HH Head	0.22	0.42	3,471
Marital Status HH Head	0.74	0.44	3,458
Fridge	0.05	0.23	3,470
Livestock	1.48	7.38	3,471
Fields of Land	0.90	1.34	3,471
HH Bank Account	1.78	0.41	3,471
Mobile	0.47	1.10	3,471
Vehicle	0.01	0.14	3,471

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 4 is a table of descriptive statistics of independent and control variables.*

5. Methodology

5.1 Research Design

This study adopts a quantitative framework to examine the impact of mobile money usage on food security and children's anthropometric outcomes, serving as proxies for their nutritional status, in Tanzania. Utilising panel data from the TNPS, as described in the previous section, the analysis employs Ordinary Least Squares (OLS) and Fixed Effects (FE) regression models. The OLS models serve as baseline estimators, while the FE models account for unobserved, time-invariant household characteristics, providing a robust method for estimating within-household variations in the effects of mobile money usage over time.

The analysis encompasses 60 regression models, comprising 30 OLS and 30 FE models. Of these, 9 OLS and 9 FE models explore various dimensions of food insecurity using different dependent variables. Additionally, 6 OLS and 6 FE models incorporate anthropometric measures to assess the nutritional status of children, conducting separate analyses for males and females.

Lastly, the same OLS and FE models are utilised, of which 18 of each for food insecurity and 12 of each for anthropometric measures. These models employ the same foundational regression but include an interaction term between household head gender and mobile money usage to capture any differences based on the gender of the household head. This comprehensive modelling approach allows for an in-depth analysis of the impact of mobile money usage on both food security and children's anthropometric outcomes, thereby indicating their nutritional status, while also taking into account the role of household head gender.

5.2 Variable Definition and Models

All the OLS and FE regression models are constructed consistently, employing the same set of control variables across all specifications. The distinction between the models lies in their respective dependent variables.

$$Ye_{it} = \alpha + \beta_1 MobileMoney_{it} + \beta_2 Gender_{it} + \beta_3 MaritalStatus_{it} + \beta_4 Fridge_{it} + \beta_5 Livestock_{it}$$

$$+ \beta_6 FieldsLand_{it} + \beta_7 BankAccount_{it} + \beta_8 Mobile_{it} + \beta_9 Vehicle_{it} eDrought/Flood_{it} + \varepsilon_{it}$$

The primary independent variable ($\beta_1 MobileMoney$), is a binary indicator representing whether a household reported using mobile financial services during the survey period, explained in more detail in Section 4.

Control variables are incorporated into both the OLS and FE models to account for various factors that may influence the relationship between mobile money usage and the dependent variables of food security and children's anthropometric outcomes.

Table 5: Descriptive Table of Independent and Control Variables Used.

Variable	Description
MM Usage	Mobile Money Usage, (Yes = 1, No = 0)
Female HH Head	Gender of household head, 1 = Female, 0 = Male
Marital Status HH Head	Marital Status of household head
# Of Fridge/Freezer	Number of refridgerators and/or freezers in household
# Of Livestock	Number of livestock household owns
Fields/Land	Amount of land household owns (Undefined size)
HH Bank Account	If any member of the household has a bank account, (Yes = 1, No = 0)
Mobile Phone	Number of mobile phones in household
Vehicle	Number of vehicles in household
Drought/Flood	If the household has experienced a drought of flood in the last two years

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 5 showing independent and control variables used.*

Demographic controls include the gender of the household head and marital status. The gender of the household head is included as previous studies have demonstrated that female-headed households often prioritise essential expenditures differently, positively affecting financial welfare (see Section 3 for supporting evidence), indicating that it may have an influence on the relationship. Marital status is categorised as married, encompassing monogamous and polygamous relationships as well as having a spouse (versus being single, such as being widowed or unmarried for other reasons). This distinction is important because married households may benefit from additional adult members and support, potentially enhancing financial stability and resilience.

Household controls encompass ownership of a fridge and/or freezer, livestock, land, and a bank account. Possessing a fridge or freezer allows households to store food for longer periods, promoting consistent food consumption and reducing spoilage, while also indicating the household's capacity to manage food resources effectively. Ownership of livestock and land contributes to self-reliance in food production, thereby potentially decreasing food insecurity. A household bank account provides a secure means of storing and transferring money, enhancing financial resilience by facilitating savings and efficient financial transactions.

Shocks such as exposure to droughts and floods are included to account for external factors that can significantly impact food security and household economic stability. These variables help control for sudden and adverse events that may affect a household's ability to secure sufficient and nutritious food. Mobile phone ownership is also included as, even without the usage of mobile money, a mobile phone can help to reduce food insecurity with the ability to communicate and receive information more efficiently. Owning a mobile phone can mitigate the effects of sudden shocks and improve the ability to facilitate help more efficiently. This supports household financial stability and ensures that households can effectively utilise mobile money services.

By including these control variables, the study ensures a comprehensive analysis that isolates the impact of mobile money usage on food security and children's nutritional outcomes, while accounting

for demographic characteristics, household wealth, and external shocks that could otherwise confound the results.

In the FE models, the gender of the household head and their marital status were evaluated and found not to be fixed effects, as these variables could change over time within households during the study period. For instance, a change in household head could alter the gender variable, while events such as divorce or a spouse moving out could result in a change in marital status. These time-varying characteristics were therefore treated as time-varying variables in the analysis.

5.2.1 OLS and FE models with Dependent Variables on Food Insecurity

The nine OLS models and nine FE models addressing food insecurity include variables as can be seen in the table below.

Table 6: Definitions of Food Insecurity Dependent Variables

Variable	Description
Food Shortage 12 M	Has experienced food shortage in the last 12 months, (Yes = 1, No = 0)
Less Preferred Food	Have had to eat less preferred foods, # of days last week
Limited Variety	Have had to limit the variety of food, # of days last week
Smaller Portions	Have had to eat smaller portions foods, # of days last week
Fewer Meals	Have had to eat a fewer amount of meals, # of days last week
Less Food For Adults	Have had to decrease the food for adults in favour of children, # of days last week
Borrowed Food	Have had to borrow food or get help from a friend, # of days last week
No Food In HH	Have had no food in the household, # of days last week
No Meals For A Day	Have had to go 24 hours without eating, # of days last week

***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
***Note**: Table 6 describes the definitions of the dependent food insecurity variables.*

The dependent variables related to food insecurity were collected through household-level survey questions (UPHI). The first dependent variable answers the question;

In the last 12 months, have you been faced with a situation when you did not have enough food to feed the household?"

Which is a binary question answered with "Yes" or "No".

The following eight dependent variables are measured in days and treated as continuous variables, enabling a detailed analysis of the frequency and severity of food insecurity within households. These variables are based on responses to the questions;

In the past seven days, how many days have you or someone in your household had to…

1. *… Rely on less preferred foods?*
2. *… Limit the variety of foods eaten?*
3. *… Limit portion size at meal-times?*
4. *… Reduce number of meals eaten in a day?*

5. *... Restrict consumption by adults for small children to eat?*
6. *... Borrow food, or rely on help from a friend or*
7. *... Have no food of any kind in your household?*
8. *... Go a whole day and night without eating anything?*

Together, these measures capture the household's reliance on food and provide a comprehensive understanding of food insecurity in Tanzania. As the questions progress down the list, they can be interpreted as indicators of more severe food insecurity, allowing for a nuanced assessment of the household's food situation.

5.2.2 OLS and FE Models with Dependent Variables on Children's Anthropometric Measures

The following twelve OLS and FE models utilise anthropometric measures as dependent variables, calculated separately for male and female children aged eleven years or younger. The dependent variables for anthropometric outcomes are assessed using ratios that serve as proxies for children's nutritional status. These measures provide insights into different aspects of children's anthropometric health, as described in Section 2.

Table 7: Descriptive Table of Dependent Variables Measuring Children's Nutritional Health.

Variable	Description
WtoH Female	Weight to height - Female (Kg/Meter)
WtoH Male	Weight to height - Male (Kg/Meter)
WtoA Female	Weight to age - Female (Kg/Age)
WtoA Male	Weight to age - Male (Kg/Age)
HtoA Female	Height to age - Female (Meter/Age)
HtoA Male	Height to age - Male (Meter/Age)

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 7 displays the anthropometric measures used as dependent variables to evaluate the effects of mobile money on children's nutritional health.*

By examining these anthropometric measures separately for male and female children, the study can identify any gender-specific impacts of mobile money usage on children's anthropometric outcomes.

5.2.3 The Models with Gender Interaction Term

The final 15 OLS and 15 FE models maintain the same structure as the previously described models, with nine of each focusing on food insecurity and six of each on anthropometric measures, using the same dependent and control variables. However, these models also incorporate an interaction term between the gender of the household head and mobile money usage.

$$Ye_{it} = \alpha + \beta_1 MobileMoney_{it} + \beta_2 Gender_{it} + \beta_3 MaritalStatus_{it} + \beta_4 Fridge_{it} + \beta_5 Livestock_{it}$$

$$+ \beta_6 FieldsLand_{it} + \beta_7 BankAccount_{it} + \beta_8 Mobile_{it} + \beta_9 Vehicle_{it} + \beta_{10} Drought/Flood_{it} +$$

$$\beta_{11}(MobileMoney_{it} * Gender_{it}) + \varepsilon_{it}$$

This interaction term is included to assess whether the impact of mobile money on food security and children's nutritional outcomes varies depending on the gender of the household head. By adding this interaction term, the study aims to uncover any differential effects that mobile money services may have in female-headed versus male-headed households. This is particularly important because gender dynamics can influence financial decision-making, resource allocation, and the prioritisation of expenditures within households, as can be seen in Section 3. While the initial models assessed the main effects of mobile money (i.e., the direct impact of mobile money usage on food insecurity) and gender (i.e., the difference in food insecurity between female-headed and male-headed households), these models assumed that the effect of mobile money is uniform across both genders. However, socio-economic factors and gender-specific challenges may lead to differing impacts of financial interventions like mobile money. By introducing the interaction term, *MobileMoney* × *Gender,* the models can capture these potential variations, providing a more nuanced understanding of how mobile money influences food insecurity within different household structures. Understanding these effects allows for a more comprehensive analysis. Consequently, these interaction models provide deeper insights into the gender-specific pathways through which mobile money usage affects food security and nutritional outcomes in Tanzanian households.

This modelling strategy facilitates an in-depth analysis of the impact of mobile money usage on both food security and children's anthropometric outcomes, while also considering the role of household head gender. Understanding these gender-specific pathways improves the study's ability to provide insights into the effectiveness of mobile financial services in improving household welfare and child nutrition in Tanzania.

5.3 Analytical Framework

To try to establish a causal link between mobile money usage and children's food security and anthropometric outcomes, this study employs panel data. The primary methodological challenge lies in addressing and mitigating heterogeneity and potential endogeneity. To mitigate these issues, both OLS and FE regression models are applied with clustered standard errors. By focusing on within-household changes over time, the FE models effectively isolate the effects of mobile money.

Clustered standard errors are employed at the UPHI (household) level, aligning with the survey's hierarchical structure, to ensure inference. Robustness checks are undertaken to confirm the reliability of the findings. More specifically, Wooldridge tests for autocorrelation, Variance Inflation Factors (VIF) for multicollinearity, and Breusch-Pagan tests for heteroscedasticity are undertaken.

The VIF test concludes that there is no multicollinearity present in the regression models. The results from the VIF test are presented in Table 8. Further, A Wooldridge test for autocorrelation suggests that there is no autocorrelation present. Breusch-Pagan tests conclude the presence of heteroskedasticity. This is, as mentioned, addressed by clustering the standard errors.

Table 8: Variance Inflation Factor Results

VIF								
MM Usage	Female HH Head	Marital Status HH Head	Fridge/Freezer	Livestock	Fields/Land	HH Bank Account	Mobile Phone	Vehicle
1.259	3.232	3.240	1.458	1.331	1.290	1.441	1.810	1.064

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 8 shows the results of a VIF test on the independent variables. The results show that there is low to no multicollinearity present between the variables. Female HH Head (3.232) and Marital Status HH Head (3.240) exhibit the most multicollinearity.*

6. Results

In this section, we present the results of our analysis as outlined in our methodology section.

6.1 OLS Models with Dependent Variables on Food Insecurity

Table 9: OLS Regression Models on Food Insecurity

	Food Shortage 12M	Less Preferred Food	Limited Variety	Smaller Portions	Fewer Meals	Less Food for Adults	Borrowed Food	No Food in HH	No Meals for a Day
(Intercept)	0.265***	0.960***	0.441***	0.361***	0.782***	0.018	0.265***	0.121*	0.072***
	(0.031)	(0.136)	(0.090)	(0.085)	(0.143)	(0.041)	(0.060)	(0.049)	(0.018)
MM Usage	0.048**	−0.090	0.019	−0.009	−0.202**	0.037	−0.085*	−0.083***	−0.003
	(0.018)	(0.071)	(0.057)	(0.047)	(0.064)	(0.029)	(0.036)	(0.025)	(0.014)
Female HH Head	0.025	0.209	0.146	0.219**	0.238+	0.101*	0.111+	0.125*	0.005
	(0.030)	(0.133)	(0.090)	(0.084)	(0.137)	(0.051)	(0.058)	(0.056)	(0.017)
Marital Status	−0.005	−0.170	0.058	−0.035	−0.089	0.080+	−0.011	0.054	−0.010
	(0.029)	(0.128)	(0.083)	(0.078)	(0.133)	(0.042)	(0.054)	(0.049)	(0.017)
# of Fridge/Freezer	−0.117***	−0.082	−0.304***	−0.221**	−0.302***	−0.294***	0.095	−0.073*	−0.050+
	(0.028)	(0.140)	(0.076)	(0.073)	(0.088)	(0.068)	(0.105)	(0.032)	(0.026)
# Of Livestock	−0.006***	−0.015***	−0.005	−0.006**	−0.013***	−0.004***	−0.004***	−0.003***	−0.001***
	(0.001)	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)
Fields/Land	0.000	0.051*	−0.012	0.017	−0.004	−0.021*	−0.021*	−0.024**	−0.011*
	(0.006)	(0.024)	(0.019)	(0.017)	(0.022)	(0.009)	(0.011)	(0.008)	(0.005)
HH Bank Account	−0.123***	−0.427***	−0.329***	−0.235***	−0.369***	−0.027	−0.027	−0.066**	−0.055***
	(0.018)	(0.068)	(0.049)	(0.042)	(0.058)	(0.037)	(0.040)	(0.021)	(0.012)
Mobile Phone	−0.008	−0.013	0.072**	0.035	0.024	0.096***	−0.019	−0.002	0.010
	(0.009)	(0.033)	(0.023)	(0.023)	(0.028)	(0.021)	(0.013)	(0.010)	(0.009)
Drought/Flood	0.247***	0.817***	0.399***	0.303***	0.603***	0.255***	0.073*	0.013	0.043*
	(0.020)	(0.088)	(0.071)	(0.059)	(0.088)	(0.049)	(0.036)	(0.026)	(0.018)
Num.Obs.	3454	3457	3457	3457	3457	3457	3457	3457	3456
R2	0.083	0.061	0.023	0.029	0.046	0.028	0.009	0.013	0.008
R2 Adj.	0.081	0.058	0.021	0.026	0.044	0.025	0.006	0.011	0.005
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
***Note**: Table 9 shows 9 OLS regression models. The regressions measure the different effects of mobile money usage and control variables on food insecurity. N = 3454 for Food Shortage 12 M, and N = 3456 or 3457 for the rest of the models. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%. The coefficients are reported in number of days.*

The findings in Table 9 reveal significant relationships in some key areas. First, mobile money usage appears to reduce food insecurity in specific contexts. Households using mobile money experienced fewer days in the last week where they, on average, had to eat fewer meals (-0.202**, days), borrow food (-0.085*, days), or have no food in the household (-0.083***, days). However, mobile money

usage is also, on average, associated with a higher likelihood of experiencing a food shortage in the last 12 months (0.048**, days). Other food insecurity outcomes do not show significant effects.

Among the control variables, having a female household head is significantly associated with higher levels of food insecurity in several dimensions. Specifically, households led by females are, on average, more likely to experience smaller portions (0.219**, days), less food for adults (0.101*, days), and have no food in the household (0.125*, days). Marital status had no significant effect at the 5% level across all dependent variables. Asset ownership provides important insights into food security. For example, owning a fridge or freezer and/or livestock significantly reduces the on average number of days households experience food insecurity across multiple measures. Owning fields or land also shows some positive effects on decreasing food insecurity, although the reductions are less consistently significant. Having a bank account is associated with a decrease in food insecurity, with significant negative effects across multiple dimensions. Environmental factors play a significant role, where households affected by droughts or floods report significantly higher levels of food insecurity across nearly all measures, with notable increases on average number of days experiencing food insecurity.

The R-squared values for the models range from 0.008 to 0.083, indicating varying explanatory power depending on the food insecurity outcome. The explanatory value overall decreases as the dependent variable represents more severe levels of food insecurity, such as having no meals for a day. This suggests that as food insecurity becomes more extreme, unobservable or external factors, such as sudden shocks, deeper structural issues, or coping mechanisms not captured in the model, play a larger role in influencing outcomes, making them harder to explain with the included variables.

6.2 FE Models with Dependent Variables on Food Insecurity

In this section, we re-estimate the effects of mobile money usage on food insecurity using FE models to address potential unobserved heterogeneity.

Table 10: Fixed Effects Regression Models on Food Insecurity

	Food Shortage 12M	Less Preferred Food	Limited Variety	Smaller Portions	Fewer Meals	Less Food for Adults	Borrowed Food	No Food in HH	No Meals for a Day
MM Usage	0.003	0.237**	0.236**	0.148*	0.068	0.128**	−0.113*	−0.045	0.002
	(0.024)	(0.090)	(0.085)	(0.064)	(0.095)	(0.047)	(0.053)	(0.032)	(0.020)
Female HH Head	0.098+	−0.321	0.298+	0.163	0.529*	0.089	−0.018	0.027	−0.020
	(0.052)	(0.220)	(0.176)	(0.124)	(0.215)	(0.103)	(0.147)	(0.076)	(0.041)
Marital Status	0.068	−0.490*	0.133	0.023	0.305*	−0.021	−0.029	0.076	0.000
	(0.042)	(0.192)	(0.133)	(0.101)	(0.155)	(0.050)	(0.114)	(0.065)	(0.026)
# of Fridge/Freezer	−0.079*	0.129	−0.265*	−0.144	−0.302*	−0.290***	0.211*	−0.024	0.000
	(0.037)	(0.137)	(0.106)	(0.093)	(0.118)	(0.072)	(0.105)	(0.052)	(0.035)
# Of Livestock	−0.004***	−0.009*	0.000	−0.007*	−0.011***	−0.004**	−0.003+	−0.004*	−0.001
	(0.001)	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)	(0.001)
Fields/Land	0.005	0.034	−0.017	0.063**	0.015	−0.040**	−0.012	−0.012	−0.004
	(0.008)	(0.033)	(0.028)	(0.023)	(0.028)	(0.015)	(0.015)	(0.011)	(0.006)
HH Bank Account	−0.070*	−0.199	−0.252**	−0.323***	−0.292**	0.026	0.048	−0.060+	−0.089**
	(0.031)	(0.121)	(0.083)	(0.096)	(0.112)	(0.074)	(0.079)	(0.033)	(0.030)
Mobile Phone	0.068***	−0.044	0.064+	0.047+	0.064+	0.071***	−0.046*	−0.048*	−0.005
	(0.011)	(0.043)	(0.034)	(0.028)	(0.038)	(0.021)	(0.022)	(0.020)	(0.011)
Drought/Flood	0.219***	0.789***	0.277**	0.219**	0.558***	0.274***	0.022	−0.034	0.058**
	(0.026)	(0.111)	(0.094)	(0.077)	(0.100)	(0.057)	(0.053)	(0.039)	(0.020)
Num.Obs.	3454	3457	3457	3457	3457	3457	3457	3457	3456
R2	0.470	0.457	0.381	0.406	0.444	0.396	0.398	0.386	0.404
R2 Adj.	0.199	0.180	0.065	0.104	0.161	0.088	0.091	0.073	0.099
R2 Within	0.056	0.036	0.012	0.016	0.024	0.028	0.006	0.011	0.008
R2 Within Adj.	0.053	0.032	0.008	0.012	0.021	0.025	0.002	0.007	0.005
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI
FE: UPHI	X	X	X	X	X	X	X	X	X
FE: round	X	X	X	X	X	X	X	X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 10 shows 9 fixed effects regression models. The regressions measure the different effects of mobile money usage and control variables on food insecurity. N = 3454 for Food Shortage 12 M, and N = 3456 or 3457 for the rest of the models. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%. The coefficients are reported in number of days.*

In Table 10, the results indicate that mobile money usage, on average, increases the number of days in the past week that households had to eat less preferred food (0.237**, days), limit the variety of food (0.236**, days) and eat smaller portions (0.148*, days), and allocate less food for adults to prioritise children (0.128**, days). However, on average mobile money usage significantly decreases the number of days households had to borrow food (-0.113*, days). The results are quite reversed to the output in the OLS model.

Having a female-headed household shows a significant positive effect on reduced meals per day, increasing by, on average, approximately half a day (0.529*, days). Marital status, specifically not being single, is associated with a significant on average reduction in the number of days eating less preferred food (-0.490*, days) but an increase in days with fewer meals (0.305*, days).

Ownership of a fridge/freezer generally reduces food insecurity, with significant reductions in several measures. However, it unexpectedly increases reliance on borrowed food or help from friends on average (0.211*, days). Livestock ownership is associated with minor but significant reductions in food insecurity across several dimensions, while owning fields of land has mixed effects: on average it significantly decreases the number of days with less food for adults (-0.040**, days) but increases days with smaller portions (0.063**, days).

Household bank account ownership is associated with a significant decrease in food insecurity across nearly all measures, reinforcing findings from the OLS model. Similarly, exposure to droughts or floods significantly increases food insecurity, with strong positive effects observed across most measures, also reinforcing findings from the OLS model.

The R-squared values for the FE model range from 0.381 to 0.470, indicating that the model explains a moderate proportion of the variation in food insecurity outcomes.

6.3 OLS Models with Dependent Variables on Children's Anthropometric Measures

Table 11: OLS Regression Models on Children's Anthropometric Data

	Weight-to-Height Male	Weight-to-Height Female	Weight-to-Age Male	Weight-to-Age Female	Height-to-Age Male	Height-to-Age Female
(Intercept)	16.115***	14.959***	4.155***	4.277***	26.660***	28.325***
	(0.858)	(0.780)	(0.301)	(0.240)	(2.572)	(2.031)
MM Usage	−2.362*	−1.215	0.367**	0.252	2.126+	0.925
	(1.110)	(1.163)	(0.138)	(0.172)	(1.090)	(1.038)
Female HH Head	−0.887	0.849	−0.342	−0.426*	−2.577	−3.239+
	(0.886)	(0.666)	(0.300)	(0.209)	(2.618)	(1.828)
Marital Status	2.272+	2.207+	0.173	0.172	1.559	1.559
	(1.364)	(1.238)	(0.289)	(0.219)	(2.483)	(1.840)
# of Fridge/Freezer	−4.274+	−3.093*	0.228	0.379	1.160	3.713
	(2.364)	(1.575)	(0.319)	(0.385)	(2.609)	(3.103)
# Of Livestock	−0.118*	−0.079+	−0.003	0.005	−0.048	0.033
	(0.055)	(0.043)	(0.004)	(0.005)	(0.030)	(0.038)
Fields/Land	−0.709*	−0.394+	0.084+	−0.139***	0.812*	−0.962**
	(0.279)	(0.236)	(0.046)	(0.034)	(0.371)	(0.294)
HH Bank Account	−1.194	−0.965	−0.055	−0.245	−1.517	−2.021
	(0.965)	(1.054)	(0.157)	(0.184)	(1.235)	(1.329)
Mobile Phone	1.231+	1.277*	−0.021	0.118*	0.143	0.516
	(0.669)	(0.607)	(0.050)	(0.047)	(0.421)	(0.397)
Drought/Flood	7.836*	6.338*	−0.234+	0.085	−1.624	−0.215
	(3.414)	(2.901)	(0.124)	(0.137)	(1.034)	(1.034)
Num.Obs.	1733	1763	1466	1485	1466	1485
R2	0.012	0.009	0.017	0.022	0.015	0.023
R2 Adj.	0.007	0.004	0.011	0.016	0.009	0.017
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
***Note**: Table 11 shows 6 OLS effects regression models. The regressions measure the different effects of mobile money usage and control variables on children's anthropometric data. N = 1733 for Weight-to-Height Male, N = 1763 for Weight-to-Height Female, N = 1466 for Weight-to-Age Male and Height-to-Age Male, N = 1485 for Weight-to-Age Female and Height-to-Age Male. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%.*

In Table 11, we present the results of 6 OLS regressions analysing the relationship between mobile money usage and various measures of anthropometric data. The findings suggest that the effects of mobile money usage on these dependent variables are mixed. For male children, mobile money usage has a statistically significant negative effect on weight-to-height for male on average (-2.362*, kg/m) and a statistically significant positive effect on weight-to-age male (0.367**, kg/age). For female children, no significant effects of mobile money usage are observed across any of the anthropometric measures.

Additionally, having a female household head is associated with a statistically significant negative effect on weight-to-age for female children (-0.426*, kg/age), indicating potential vulnerabilities for female-headed households in supporting optimal nutritional outcomes for girls.

The R-squared values indicate that the explanatory power of the models is relatively low, suggesting that other unobserved factors may play a substantial role in determining child anthropometric outcomes.

6.4 FE Models with Dependent Variables on Children's Anthropometric Measures

Table 12: Fixed Effects Regression Models on Children's Anthropometric Data

	Weight-to-Height Male	Weight-to-Height Female	Weight-to-Age Male	Weight-to-Age Female	Height-to-Age Male	Height-to-Age Female
MM Usage	4.156	5.713*	0.126	0.469	0.632	−0.870
	(2.721)	(2.404)	(0.210)	(0.382)	(1.701)	(1.607)
Female HH Head	−7.170	−2.446	−0.679+	−0.137	−0.973	−2.228
	(6.028)	(3.996)	(0.382)	(0.527)	(4.033)	(4.823)
Marital Status	7.707	5.622	−0.038	0.714	4.777	2.997
	(5.805)	(3.780)	(0.332)	(0.498)	(3.249)	(4.211)
# of Fridge/Freezer	−5.617*	−8.768*	0.725+	−0.483	5.286	5.211
	(2.784)	(4.414)	(0.396)	(0.994)	(3.251)	(4.647)
# Of Livestock	−0.188*	−0.114+	−0.002	−0.006	−0.050	−0.047
	(0.086)	(0.066)	(0.009)	(0.007)	(0.078)	(0.055)
Fields/Land	−0.282	−0.195	−0.036	−0.085	−0.108	−0.654
	(0.264)	(0.299)	(0.067)	(0.056)	(0.522)	(0.460)
HH Bank Account	0.219	0.143	0.401	0.302	3.499	2.488
	(1.052)	(0.890)	(0.272)	(0.302)	(2.146)	(2.618)
Mobile Phone	0.050	0.691	−0.396**	0.234+	−3.084**	0.559
	(0.471)	(0.604)	(0.121)	(0.128)	(1.007)	(0.666)
Drought/Flood	10.392*	11.774*	0.096	−0.124	1.389	−4.184**
	(4.824)	(5.044)	(0.167)	(0.190)	(1.227)	(1.273)
Num.Obs.	1733	1763	1466	1485	1466	1485
R2	0.416	0.419	0.670	0.567	0.669	0.687
R2 Adj.	−0.111	−0.107	0.302	0.061	0.299	0.321
R2 Within	0.021	0.028	0.036	0.019	0.038	0.040
R2 Within Adj.	0.011	0.018	0.023	0.006	0.025	0.028
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI
FE: UPHI	X	X	X	X	X	X
FE: round	X	X	X	X	X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 12 shows 6 fixed effects regression models. The regressions measure the different effects of mobile money usage and control variables on children's anthropometric measures. N = 1733 for Weight-to-Height Male, N = 1763 for Weight-to-Height Female, N = 1466 for Weight-to-Age Male and Height-to-Age Male, N = 1485 for Weight-to-Age Female and Height-to-Age Male. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%.*

When we apply a FE model to the same regressions as shown in Table 11, the effects of mobile money usage are notably altered. The previously significant effects of mobile money usage on male anthropometric measures in the OLS model become insignificant, suggesting that these relationships may have been influenced by unobserved, time-invariant household characteristics. Interestingly, as can be seen in table 12, a new positive and statistically significant effect emerges for females, with mobile money usage being associated with weight-to-height (5.713*, kg/m).
The adjusted R-squared for this measure is negative, indicating that the FE models explain less variation than a simple mean-based model would. This suggests that much of the variability in weight-to-height for females remains unexplained by the included independent variables or fixed effects. The adjusted R-squared within is slightly positive across de outputs, reflecting the proportion of variation explained by time-varying factors, such as mobile money usage, within households. While small, this value suggests that the fixed effects model provides some insight into the dynamics of female anthropometric outcomes, even though its overall explanatory power remains limited.

6.5 The Models with Gender Interaction Term

To delve deeper into the dynamics between mobile money usage and food insecurity across different household structures, an interaction term between mobile money and gender was incorporated into the regression models. This addition allows for the examination of whether the impact of mobile money on food insecurity varies based on the gender of the household head.

6.5.1 OLS models on Food Insecurity with an Interaction Term

Table 13: OLS Regression Models on Food Insecurity with an Interaction Term

	Food Shortage 12M	Less Preferred Food	Limited Variety	Smaller Portions	Fewer Meals	Less Food for Adults	Borrowed Food	No Food in HH	No Meals for a Day
(Intercept)	0.262***	0.927***	0.434***	0.340***	0.742***	0.012	0.262***	0.106*	0.067***
	(0.031)	(0.137)	(0.090)	(0.084)	(0.144)	(0.043)	(0.061)	(0.050)	(0.019)
MM Usage	0.054**	−0.012	0.037	0.040	−0.109	0.053	−0.077*	−0.049*	0.008
	(0.020)	(0.072)	(0.063)	(0.046)	(0.068)	(0.032)	(0.034)	(0.025)	(0.015)
Female HH Head	0.034	0.340*	0.176	0.301**	0.392*	0.127*	0.124+	0.182**	0.023
	(0.034)	(0.155)	(0.109)	(0.101)	(0.163)	(0.062)	(0.071)	(0.071)	(0.023)
Marital Status	−0.005	−0.170	0.058	−0.035	−0.089	0.080+	−0.011	0.054	−0.010
	(0.029)	(0.127)	(0.084)	(0.079)	(0.132)	(0.041)	(0.054)	(0.048)	(0.017)
# of Fridge/Freezer	−0.117***	−0.084	−0.305***	−0.222**	−0.305***	−0.294***	0.095	−0.074*	−0.050+
	(0.028)	(0.140)	(0.076)	(0.073)	(0.089)	(0.068)	(0.106)	(0.032)	(0.026)
# Of Livestock	−0.006***	−0.015***	−0.005	−0.005**	−0.013***	−0.004***	−0.004***	−0.002***	−0.001**
	(0.001)	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)
Fields/Land	0.000	0.053*	−0.012	0.019	0.000	−0.021*	−0.021*	−0.023**	−0.010*
	(0.006)	(0.024)	(0.019)	(0.017)	(0.022)	(0.009)	(0.010)	(0.007)	(0.005)
HH Bank Account	−0.123***	−0.425***	−0.328***	−0.234***	−0.367***	−0.027	−0.026	−0.065**	−0.055***
	(0.018)	(0.068)	(0.049)	(0.042)	(0.058)	(0.037)	(0.040)	(0.021)	(0.012)
Mobile Phone	−0.008	−0.013	0.072**	0.034	0.024	0.096***	−0.019	−0.002	0.010
	(0.009)	(0.033)	(0.023)	(0.023)	(0.028)	(0.021)	(0.013)	(0.010)	(0.009)
Drought/Flood	0.247***	0.815***	0.399***	0.303***	0.601***	0.254***	0.072*	0.012	0.043*
	(0.020)	(0.088)	(0.071)	(0.059)	(0.088)	(0.049)	(0.036)	(0.026)	(0.018)
MM Usage:Female HH Head	−0.024	−0.335*	−0.077	−0.209+	−0.398*	−0.066	−0.032	−0.148**	−0.044
	(0.038)	(0.169)	(0.129)	(0.114)	(0.155)	(0.072)	(0.089)	(0.055)	(0.029)
Num.Obs.	3454	3457	3457	3457	3457	3457	3457	3457	3456
R2	0.084	0.062	0.024	0.030	0.048	0.028	0.009	0.015	0.009
R2 Adj.	0.081	0.059	0.021	0.027	0.046	0.025	0.006	0.013	0.006
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).* ***Note**: Table 13 shows 9 OLS regression models. The regressions measure the different effects of mobile money usage and control variables on food insecurity and include an interaction term between Female HH Head and MM Usage (MM Usage:Female HH Head). N = 3454 for Food Shortage 12 M, and N = 3456 or 3457 for the rest of the models. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%. The coefficients are reported in number of days.*

The results presented in Table 13 indicate that the interaction term is statistically significant and negatively associated with several food insecurity measures. Specifically, female-headed households using mobile money experience a reduction in the number of days they face food insecurity. For these households, on average, the number of days eating less preferred foods decreases by on average (-0.335*, days), eating fewer meals decreases by on average (-0.398*, days), and having no food in the household decreases by on average (-0.148** days). These effects suggest that mobile money usage provides greater food security benefits for female-headed households, potentially due to more effective allocation of financial resources within these households.

For male-headed households, the use of mobile money shows mixed effects. While mobile money usage increases the likelihood of reporting a food shortage over the past 12 months (0.054** days), it reduces, on average the number of days households had to borrow food by (-0.077*, days) and had no food in the household (-0.049*, days). However, the reduction in days without food in the household is more pronounced for female-headed households, as indicated by the significant interaction term. These findings highlight the nuanced role of gender in moderating the relationship between mobile money and food insecurity, suggesting that the benefits of mobile money may vary depending on household dynamics and decision-making structures.

The analysis also reveals that female-headed households that do not use mobile money are more vulnerable to food insecurity, as evidenced by statistically significant positive effects across nearly all measures. This suggests that the absence of mobile money usage disproportionately affects female-headed households, likely due to preexisting vulnerabilities or systemic inequalities that exacerbate food insecurity.

Turning to the control variables, the results are overall consistent with the findings in the OLS model in table 9, that is the same model but without the interaction term. The R-squared values for the models range from 0.009 to 0.084, indicating varying explanatory power depending on the food insecurity outcome. In the same way as in the model in table 9, the OLS without the interaction term, the explanatory value overall decreases as the dependent variable represents more severe levels of food insecurity.

6.5.2 FE Models on Food insecurity with an Interaction Term

Table 14: Fixed Effects Regression Models on Food Insecurity with an Interaction Term

	Food Shortage 12M	Less Preferred Food	Limited Variety	Smaller Portions	Fewer Meals	Less Food for Adults	Borrowed Food	No Food in HH	No Meals for a Day
MM Usage	0.003	0.280**	0.233*	0.122+	0.125	0.118*	−0.146**	−0.039	−0.010
	(0.026)	(0.092)	(0.093)	(0.065)	(0.103)	(0.050)	(0.052)	(0.035)	(0.022)
Female HH Head	0.098+	−0.226	0.290	0.107	0.653**	0.068	−0.090	0.040	−0.045
	(0.056)	(0.261)	(0.207)	(0.151)	(0.236)	(0.097)	(0.171)	(0.088)	(0.050)
Marital Status	0.068	−0.490*	0.133	0.024	0.304*	−0.021	−0.029	0.076	0.000
	(0.042)	(0.193)	(0.133)	(0.100)	(0.154)	(0.050)	(0.113)	(0.065)	(0.026)
# of Fridge/Freezer	−0.079*	0.130	−0.265*	−0.145	−0.300*	−0.290***	0.209*	−0.024	−0.001
	(0.037)	(0.136)	(0.106)	(0.094)	(0.119)	(0.072)	(0.106)	(0.052)	(0.035)
# Of Livestock	−0.004***	−0.008*	0.000	−0.007*	−0.011***	−0.004**	−0.004+	−0.004*	−0.001
	(0.001)	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)	(0.001)
Fields/Land	0.005	0.034	−0.017	0.063**	0.015	−0.040**	−0.012	−0.012	−0.004
	(0.008)	(0.033)	(0.028)	(0.023)	(0.028)	(0.015)	(0.014)	(0.011)	(0.006)
HH Bank Account	−0.070*	−0.193	−0.252**	−0.326***	−0.284*	0.025	0.043	−0.059+	−0.090**
	(0.031)	(0.120)	(0.083)	(0.097)	(0.111)	(0.074)	(0.079)	(0.033)	(0.031)
Mobile Phone	0.068***	−0.044	0.064+	0.046+	0.066+	0.071***	−0.046*	−0.048*	−0.005
	(0.011)	(0.043)	(0.034)	(0.028)	(0.038)	(0.021)	(0.022)	(0.020)	(0.011)
Drought/Flood	0.219***	0.786***	0.278**	0.221**	0.554***	0.275***	0.024	−0.034	0.059**
	(0.026)	(0.110)	(0.095)	(0.077)	(0.100)	(0.057)	(0.053)	(0.039)	(0.020)
MM Usage:Female HH Head	−0.001	−0.207	0.017	0.123	−0.273	0.047	0.160	−0.030	0.056
	(0.049)	(0.206)	(0.175)	(0.153)	(0.185)	(0.094)	(0.106)	(0.061)	(0.040)
Num.Obs.	3454	3457	3457	3457	3457	3457	3457	3457	3456
R2	0.470	0.457	0.381	0.407	0.445	0.396	0.399	0.386	0.404
R2 Adj.	0.199	0.180	0.065	0.104	0.162	0.088	0.092	0.073	0.100
R2 Within	0.056	0.036	0.012	0.017	0.025	0.029	0.007	0.011	0.009
R2 Within Adj.	0.052	0.032	0.008	0.012	0.021	0.024	0.003	0.007	0.005
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI
FE: UPHI	X	X	X	X	X	X	X	X	X
FE: round	X	X	X	X	X	X	X	X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
***Note**: Table 14 shows 9 fixed effects regression models. The regressions measure the different effects of mobile money usage and control variables on food insecurity and include an interaction term between Female HH Head and MM Usage (MM Usage:Female HH Head). N = 3454 for Food Shortage 12 M, and N = 3456 or 3457 for the rest of the models. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%. The coefficients are reported in number of days.*

When applying a FE model on the same regressions as in table 10, the significance of the interaction term between mobile money usage and a female household head disappears. Instead, the results indicate that a household with a male household head who uses mobile money will experience an increased amount of food insecurity. Specifically, the types of food insecurity that on average increase are less preferred food (0.280**, days), limited variety (0.233*, days), and less food for adults (0.118*, days). However, borrowing food is negative and statistically significant with an average of

(-0.146*, days). The control variables show approximately the same results as in the FE model without interaction term.

6.5.3 OLS Models on Children's Anthropometric Measures with an Interaction Term

Table 15: OLS Regression Models on Children's Anthropometric Data with an Interaction Term

	Weight-to-Height Male	Weight-to-Height Female	Weight-to-Age Male	Weight-to-Age Female	Height-to-Age Male	Height-to-Age Female
(Intercept)	16.021***	15.028***	4.159***	4.279***	26.635***	28.330***
	(0.828)	(0.757)	(0.300)	(0.241)	(2.566)	(2.036)
MM Usage	−3.181*	−1.841	0.383*	0.220	2.027+	0.788
	(1.466)	(1.519)	(0.153)	(0.203)	(1.201)	(1.132)
Female HH Head	−2.227+	−0.189	−0.316	−0.474*	−2.737	−3.440+
	(1.241)	(0.956)	(0.311)	(0.214)	(2.755)	(1.959)
Marital Status	2.695+	2.367+	0.163	0.184	1.625	1.606
	(1.490)	(1.300)	(0.286)	(0.220)	(2.467)	(1.845)
# of Fridge/Freezer	−4.123+	−3.185*	0.225	0.373	1.181	3.689
	(2.300)	(1.587)	(0.318)	(0.388)	(2.602)	(3.122)
# Of Livestock	−0.120*	−0.083+	−0.003	0.005	−0.048	0.033
	(0.056)	(0.045)	(0.004)	(0.005)	(0.030)	(0.038)
Fields/Land	−0.737*	−0.408+	0.085+	−0.140***	0.808*	−0.966**
	(0.292)	(0.241)	(0.046)	(0.034)	(0.371)	(0.293)
HH Bank Account	−1.179	−0.905	−0.055	−0.243	−1.515	−2.014
	(0.958)	(1.039)	(0.157)	(0.184)	(1.236)	(1.330)
Mobile Phone	1.210+	1.292*	−0.021	0.119*	0.140	0.521
	(0.660)	(0.616)	(0.050)	(0.047)	(0.419)	(0.398)
Drought/Flood	7.907*	6.368*	−0.235+	0.086	−1.616	−0.213
	(3.444)	(2.917)	(0.124)	(0.138)	(1.032)	(1.034)
MM Usage:Female HH Head	4.841*	3.137	−0.096	0.159	0.601	0.671
	(2.227)	(2.006)	(0.295)	(0.306)	(2.404)	(2.525)
Num.Obs.	1733	1763	1466	1485	1466	1485
R2	0.012	0.010	0.017	0.022	0.015	0.023
R2 Adj.	0.007	0.004	0.010	0.016	0.008	0.016
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

***Data Source**: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
***Note**: Table 15 shows 6 OLS regression models. The regressions measure the different effects of mobile money usage and control variables on children's anthropometric data. N = 1733 for Weight-to-Height Male, N = 1763 for Weight-to-Height Female, N = 1466 for Weight-to-Age Male and Height-to-Age Male, N = 1485 for Weight-to-Age Female and Height-to-Age Male. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%.*

In Table 15 children's anthropometric measures are reported in OLS regression models, including an interaction term between the household having a female household head and mobile money usage. The interaction term has a positive and statistically significant effect on weight-to-height male ratio (4.841*, kg/m). Further, mobile money usage with a male household head (MM Usage) has a

statistically significant and negative effect on average (-3.181*, kg/m) on the same ratio, male weight-to-height, also weight-to-age male has a significant effect with an on average increase of (0.383*, kg/age). A household with a female household head that does not use mobile money has a negative and statistically significant effect on weight-to-age for females on average (-0.474*, kg/age). There are also some significant effects at the 10% significance level, mobile money usage with a male household head on height-to-age male (2.027+, m/age) and none-mobile money usage with a female household head on weight-to-height male (-2.227+, kg/m) and height-to-age female (-3.440+, m/age), on average.

6.5.4 FE Models Children's Anthropometric Measures With An Interaction Term

Table 16: Fixed Effects Regression Models on Children's Anthropometric Data with an Interaction Term

	Weight-to-Height Male	Weight-to-Height Female	Weight-to-Age Male	Weight-to-Age Female	Height-to-Age Male	Height-to-Age Female
MM Usage	2.390	4.588*	0.115	0.351	0.441	−2.013
	(2.101)	(2.234)	(0.222)	(0.446)	(1.829)	(1.607)
Female HH Head	−13.347	−5.577	−0.726	−0.301	−1.819	−3.824
	(8.959)	(6.032)	(0.478)	(0.564)	(5.170)	(4.874)
Marital Status	7.939	5.483	−0.048	0.771	4.595	3.556
	(5.699)	(3.685)	(0.335)	(0.493)	(3.352)	(4.187)
# of Fridge/Freezer	−5.900*	−9.107*	0.723+	−0.513	5.262	4.915
	(2.877)	(4.449)	(0.396)	(0.987)	(3.249)	(4.725)
# Of Livestock	−0.201*	−0.123+	−0.002	−0.007	−0.051	−0.055
	(0.091)	(0.071)	(0.009)	(0.007)	(0.078)	(0.054)
Fields/Land	−0.265	−0.225	−0.036	−0.090	−0.103	−0.696
	(0.264)	(0.315)	(0.068)	(0.057)	(0.524)	(0.457)
HH Bank Account	−0.128	−0.215	0.401	0.283	3.503	2.305
	(1.079)	(0.981)	(0.272)	(0.300)	(2.149)	(2.592)
Mobile Phone	0.039	0.741	−0.397**	0.237+	−3.091**	0.588
	(0.474)	(0.606)	(0.121)	(0.127)	(1.007)	(0.663)
Drought/Flood	10.480*	11.802*	0.096	−0.125	1.384	−4.188**
	(4.855)	(5.055)	(0.167)	(0.189)	(1.230)	(1.272)
MM Usage:Female HH Head	14.058+	7.394	0.080	0.617	1.432	6.013+
	(8.059)	(5.734)	(0.415)	(0.541)	(3.585)	(3.228)
Num.Obs.	1733	1763	1466	1485	1466	1485
R2	0.418	0.420	0.670	0.568	0.669	0.689
R2 Adj.	−0.109	−0.107	0.301	0.061	0.298	0.323
R2 Within	0.023	0.029	0.036	0.021	0.038	0.045
R2 Within Adj.	0.013	0.018	0.022	0.006	0.024	0.031
Std.Errors	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI	by: UPHI
FE: UPHI	X	X	X	X	X	X
FE: round	X	X	X	X	X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Data Source*: Tanzania National Panel Survey (TNPS), Waves 2010/2011, 2012/2013, and 2014/2015, conducted by the Tanzania National Bureau of Statistics in collaboration with the World Bank's Living Standards Measurement Study (LSMS).*
Note*: Table 16 shows 6 OLS regression models. The regressions measure the different effects of mobile money usage and*

control variables on children's anthropometric data. N = 1733 for Weight-to-Height Male, N = 1763 for Weight-to-Height Female, N = 1466 for Weight-to-Age Male and Height-to-Age Male, N = 1485 for Weight-to-Age Female and Height-to-Age Male. The standard errors reported in parentheses are heteroskedasticity-robust, clustered at the household (UPHI) level. Significance levels are reported at 10%, 5%, 1% and 0,1%.

In the final regression shown in table 16, a FE model is applied to measures of children's anthropometric data, including an interaction term between mobile money usage and female household head. The results indicate that households with a female head who uses mobile money have a positive and statistically significant effect (at the 10% level) on weight-to-height for males (14.058+, kg/m) and height-to-age for females (6.013+, m/age). Additionally, mobile money usage in households with a male head (MM Usage) shows a positive and statistically significant effect on weight-to-height for females (4.588*, kg/m).

No other results regarding the interaction between mobile money usage and the gender of the household head are statistically significant. The findings suggest that while mobile money usage can positively influence some anthropometric measures, the effects are limited and vary by gender and household headship.

The R-squared and adjusted R-squared values are low across the models, and for some dependent variables, the adjusted R-squared is negative. This indicates that the fixed effects model explains only a small portion of the variability in children's anthropometric outcomes, potentially due to unobserved or time-varying factors not captured in the model.

7. Discussion

In the following section, we discuss the results of our analysis in relation to our initial hypotheses and address the methodological limitations identified during the study. The results of this study provide both support for and contradictions to our initial hypotheses.

Our first hypothesis "*Mobile money usage has a positive effect on food insecurity*" is somewhat in line with the findings from our OLS models, shown in table 9 and table 13. Specifically, mobile money usage is associated with reductions in various aspects of food insecurity, such as no food in households and reliance on borrowing food. These outcomes are consistent with the findings of Ajefu et al. (2024) and Murendo & Wollni (2016), who demonstrated that mobile money enhances food security by facilitating remittances and improving household financial management. However, the OLS models also reveal an increase in the likelihood of experiencing food shortages over the past year, a result that contrasts with much of the existing literature. This discrepancy may be due to unobserved household characteristics that the OLS models fail to account for.

Furthermore, the significant control variables in the OLS model highlights important factors to consider when analysing the effect on mobile money on the dependent variables on food insecurity. For instance, possessing a fridge or freezer, owning land or owning livestock are all associated with reduced food insecurity. Having a bank account also negatively affects food insecurity, indicating that financial inclusion contributes to better food security. However, this relationship may be biased, as factors such as wealth or education, which could be correlated with bank account ownership, might also influence food security. Additionally, environmental shocks negatively impact food insecurity, reinforcing the significance of this control variable in the OLS model.

Our third hypothesis, *"Female-headed households are more effective than male-headed households in leveraging mobile money to enhance food security and improve children's nutritional health*." is somewhat supported by our findings. The OLS model including the interaction term, as can be seen in table 13, reveals significant gender dynamics. Showing that mobile money usage significantly benefits female-headed households by reducing some measures of food insecurity. This supports the evidence found by Kamath and Dattasharma (2015) and Chant (2009), who suggests that female-headed households often prioritise welfare-oriented expenditures, thereby enhancing household nutrition and well-being. However, in the FE interaction models with food insecurity as the dependent variable, the positive effects for female-headed households decrease or even reverse. This suggests that when accounting for unobserved household characteristics over time, the initially observed advantages of female-headed households leveraging mobile money to enhance food security may not be as robust as previously thought and could be influenced by other unmeasured factors.

Overall, the OLS models indicate somewhat support for our hypotheses regarding food insecurity. However, when applying FE models to control for unobserved, time-invariant household characteristics, the relationship between mobile money usage and food insecurity becomes more complex. Contrary to the OLS results, mobile money usage in the FE models with dependent variables on food insecurity is linked to increases in days of eating less preferred foods and limited food variety, while it decreases the need to borrow food. These findings suggest that while mobile money may alleviate certain immediate food-related hardships, it might also worsen some cases of food insecurity. We cannot fully conclude why food insecurity increases in the FE models.

However, we believe that the FE models may be limited due to their reliance solely on within-household variation over time to identify predictor effects. If the interaction between mobile money usage and gender does not vary significantly within households during the observed period, the FE model may lack the necessary variation to detect its effect, rendering it insignificant. The interaction effect may primarily exist between different households (e.g., female-headed vs male-headed) rather than within the same household over time. Since FE models do not utilise between-household variation, the interaction term may lose its significance. Thus, this limitation may make the FE model less suitable for effectively analysing the interaction between mobile money usage and household head gender as we initially predicted.

Regarding our second hypothesis, "*Mobile money usage positively impacts children's food security, which in turn improves their anthropometric measures, indicating better nutritional health*," the results are mixed. We measure children's health through anthropometric indicators such as stunting and wasting. As discussed in Section 2, a significant proportion of the population in Tanzania suffers from malnutrition. Therefore, any improvements in the nutritional measures, i.e. increases in anthropometric ratios, would be interpreted positively, indicating better health outcomes. However, the effects of mobile money on children's nutritional outcomes are varied. In the OLS models, as can be seen in table 11 and 15, mobile money negatively impacts the weight-to-height ratio for male children but positively influences the weight-to-age male ratio, while no significant effects are observed for female children. Conversely, the FE models with an interaction term, as presented in Table 16, indicate that mobile money usage by males significantly enhances the weight-to-height ratio for female children, but has no significant effect on ratios for males. These findings are contradictory, and the results from the different models do not align with one another. Furthermore, the interaction term reveals that in female-headed households, mobile money usage positively affects the weight-to-height male ratios and the height-to-age female ratios, but only at a 10% significance level. Additionally, the low R-squared values observed in the models analysing children's anthropometric measures highlight the limited explanatory power of the included independent variables. This underscores the multifaceted nature of child nutritional health, indicating that factors beyond financial services play a crucial role. Future research should explore these additional determinants to provide a more comprehensive understanding of the drivers behind child nutrition outcomes.

Upon analysing the results, we believe that FE models are limited because their inherent focus on within-household variation over time may inadvertently exclude important effects, such as time-invariant household characteristics, that are crucial for understanding the full impact of predictors. The mixed results regarding children's nutritional measures and the low explanatory power of the models highlight the need for more comprehensive analyses. Future research should aim to decrease omitted variable bias and employ other modelling techniques to better understand the impacts of mobile money on household welfare and child nutrition.

Even though this study finds ambiguous results and fails to establish a robust causality between mobile money usage, food insecurity and children's nutritional health, some indications show that mobile money can improve the nutritional welfare of households without access to traditional financial services. As Donvan (2015) highlights, mobile money has become a pivotal tool in promoting financial inclusion, effectively bridging the gap for individuals excluded from traditional financial systems. Strategic initiatives in implementing mobile money policies could enhance financial inclusion and bolster household welfare.

8. Conclusion

To conclude, this study examines the impact of mobile money usage on food security and children's nutritional health within Tanzanian households, with a particular focus on the gender of the household head. Utilising OLS and FE models, the analysis uncovers the dynamics influencing these relationships. The OLS results suggest that mobile money usage can mitigate certain aspects of food insecurity, especially in female-headed households. However, the FE models do not provide as good as support for these hypotheses, rather the opposite.

The findings somewhat demonstrate that mobile money is a promising tool in decreasing food insecurity. However, the exact household contexts where mobile money is the most useful is not examined in this study and can therefore not be concluded. The inconsistent results related to children's nutritional outcomes indicate that the pathways through which mobile money influences household welfare are complex and require further investigation.

This study contributes to the expanding literature on financial inclusion by highlighting the gender dimensions of mobile money's impact on food security. By exploring the interaction between mobile money usage and gender dynamics, the analysis offers a more comprehensive understanding of how gender dynamics can affect the effect of mobile money on food insecurity and children's nutritional health. Future research should build on these findings and incorporate other methods to try and establish a robust causal link between mobile money usage, food insecurity and children's nutritional health. More research is needed to provide more definitive guidance for policymakers and stakeholders aiming to leverage mobile money to enhance food security and child nutrition in varied household settings.

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10. Appendix

10.1 AI Disclosure Section

The writers of this thesis have used AI tools in the process of writing and conducting this thesis/study. The AI tools that have been used are Chat-GPT 4o, o1, and 4o with canvas [Beta]. The main purpose of these tools has been to assist in RStudio, checking for errors and to help produce time-consuming code (for example to rewrite normal text to code in R that could then be used to produce descriptive tables of the meaning of variables). It has also been used to check if ideas are achievable in R.

Further, AI has been used sparingly in the writing process. The purpose has then been to ask for synonyms for words or phrases, make sentences clearer, and check for grammatical errors.

The tools have contributed to the quality of the thesis by enhancing the quality of the writing, limiting grammatical errors, and providing appropriate words and phrases. Further, it has helped to verify that the code in R is performing the correct operations and has decreased time-consuming error debugging by providing the possible reasons for why an error message occurs. The risks of these operations are rather limited. The two main risks identified are (1) the risk of relying too much on the information provided and (2) that the phrases in the text become repetitive and confusing. To mitigate the first risk, other sources have been used to verify that the code was working properly. These include previous seminars and different forums online where information on these matters can be found. Also, documentation for different packages and functions in R has been used. In this case, Chat-GPT has merely worked as a source among others that can assist with the right approach. Risk number (2) is also limited but has been considered. AI tools have a tendency to use the same phrases and wording often, however as the AI tool has not been used to produce text, merely to assist in minor changes of phrases and grammar, we conclude that this risk is not too high.

We conclude that AI tools such as Chat-GPT are great at assisting with minor tasks in a fast and rather accurate way. However, it should not be used for more advanced reasoning or as a source in any way. It fails to do these tasks well. Also, it cannot work as an only source of assistance as there are substantial risks that it provides inaccurate information.