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Ameliorating Food and Nutrition Security in Farm Households: Does Informatization Matter?

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Received: 13 December 2019; Accepted: 7 January 2020; Published: 10 January 2020

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Abstract: Improving food and nutrition security in Sub-Saharan Africa's farm households has become a prominent priority subject for researchers and policymakers alike. Interestingly, it is realized through enhancement in dietary diversity and quality. To this end, better access to food and information is considered a prerequisite. Given that mobile phone coverage offers new prospects for increasing rural households' access to information, can informatization (mobile phone used as a concrete example) possibly influence dietary diversity and quality? Cross-sectional data collected from farm households in Zambia is used to address this topic by applying the ordinary least square and endogenous switching regression (ESR). Household dietary diversity score was constructed based on a 7-days recall approach to measure consumption patterns. Our robust regression result indicates that mobile phone use positively and significantly influences dietary diversity and quality. Particularly, gender-disaggregated regression reveals that male-headed households have stronger positive associations than their counterparts. We also find that in comparison to non-adopters, adopters consume three more foods weekly. This is attributable to the income gains and increased frequency in information access on account of mobile phone adoption. Conversely, average consumption would increase by two more foods weekly if mobile phones were adopted in non-adopting households. Therefore, our study puts forwards substantial empirical evidence to warrant policy formulation directed at promoting informatization among farm households. Eventually, this could possibly recuperate dynamism in agricultural food production as food and nutrition security in farm households ameliorates.

Keywords: dietary diversity and quality; mobile phones; informatization; farm households; Zambia

1. Introduction

Two billion people across the planet suffer from nutrient deficiencies. Ironically, even in Sub-Saharan Africa (SSA) where smallholder farm households dominate, numbering 33 million (80% of all the farms) and contribute about 90 percent of food production [1], households suffer from poor dietary quality and malnutrition [2,3]. This could be largely attributed to inadequate and inappropriate diets on account of limited access to food and nutrition information. Consequently, the number of active farmers in recent times has drastically reduced, triggering the failure of the agricultural system to provide foods that allow for nutritious, affordable, diverse, and sustainable diets for all. As a matter of fact, this poses a risk to the future of agriculture, a major driver of African economies. For that reason, food and nutrition security (FNS) in farm households ought to be a serious policy concern [4] because farmers are important nutrition providers of any community worldwide [5,6].

While combining the concepts of food security and good nutrition, FNS recognizes the prominence of key nutrition concerns for achieving food security. According to UNICEF [7], it is realized when adequate food is available and accessible for and satisfactorily used and utilized by all individuals at all times to live a healthy and active life. In fact, the embedding of "nutrition" between "food" and "security" accentuates that improving nutrition is the ultimate goal. Thus, FNS could aid in addressing the burdens of malnutrition (stunted growth, underweight and obesity) in farm households. Intuitively, malnutrition occurrence is a function of the accessibility and availability of various foods for sustainable and healthy diets all year round [8–10]. In support, a myriad of literature documents that there is a significant association between micronutrient adequacy and a varied diet, which eventually results in positive health outcomes [11–17]. Impliedly, there may be increased risk of underweight and stunted growth that may even lead to cognitive deficits in the case of a less diversified diet [18–20]. Therefore, there is a strong case for ameliorating FNS, especially that this is also one of the most effective approaches to avert hidden hunger sustainably.

In view of the aforementioned, dietary diversification is fundamental. However, increasing agricultural production and access to sufficient calories remains the focus of food security policy and is held as a main solution, particularly in low-income countries. Unfortunately, calories are not all equal. Thus, this school of thought has created a blind spot with respect to the role of nutrition and health information access, which is often overlooked but may be significant for dietary diversification for the rural poor. In agreement, research has demonstrated that increasing social innovation such as informatization (the extent by which society is becoming information-based) is pivotal for driving significant changes in the way we currently live or consume [21]. Particularly, mobile phone use (used as a concrete example of informatization) is a vibrant and rapidly emerging act that could influence FNS. With the swift growth of the mobile phone coverage lies the great prospects for increasing rural households' access to useful information on a variety of topics. For instance, the adoption of mobile telephony technologies has significantly improved farmers' household income [22,23], access to information [24,25], marketing decision [26], diversification to high-value crops [27], greater market participation [28], agricultural production patterns [29,30], and agricultural productivity [31].

In Zambia, despite the potential of the food and agriculture system to improve FNS especially that it is backed up by government policy, the incidence of malnutrition remains high at about 40 percent [8]. Particularly in farm households, apart from adults, majority of children suffer from overweight and stunted growth. In addition, consumption is characterized by a mono-diet culture heavily dependent on cereals [32]. With such a scenario, it cannot be business as usual because malnutrition has various adverse effects, such as immune deficiency [33], high risk of morbidity and mortality [34], and suboptimal brain development [35] which may lead to decreased participants in food production (agriculture).

Given the rising food production and crop production index (Figure 1), mobile phone use by households could aid in addressing undernourishment through disruption of routines. Evidently, adoption of mobile phones in the country has been very rapid since 2000, and it is extensively used as a platform for communication and information access even by poor farm households in remote rural locations. Therefore, since information access enhances awareness [36], empowering individuals to 'switch off the autopilot mode' (observe and change previous unconscious habits), mobile phone adoption holds the potential to diminish unsustainable and unconscious dietary choices [37]—by augmenting income [31] and increasing information access frequency [38] which could smooth food accessibility, availability, and use. Although seemingly simple, food choice is among the most frequent and complex human behavior. Thus, new insights, particularly the realization that much decision making about diet occurs at a non-conscious level (probably play a more important role in food-related behavior as indicated by Köster [37]), should lead to a rethinking of the role information access plays. Ultimately, it is such intuitive reasoning that will provide a basis for thorough understanding on how to improve FNS in farm households.

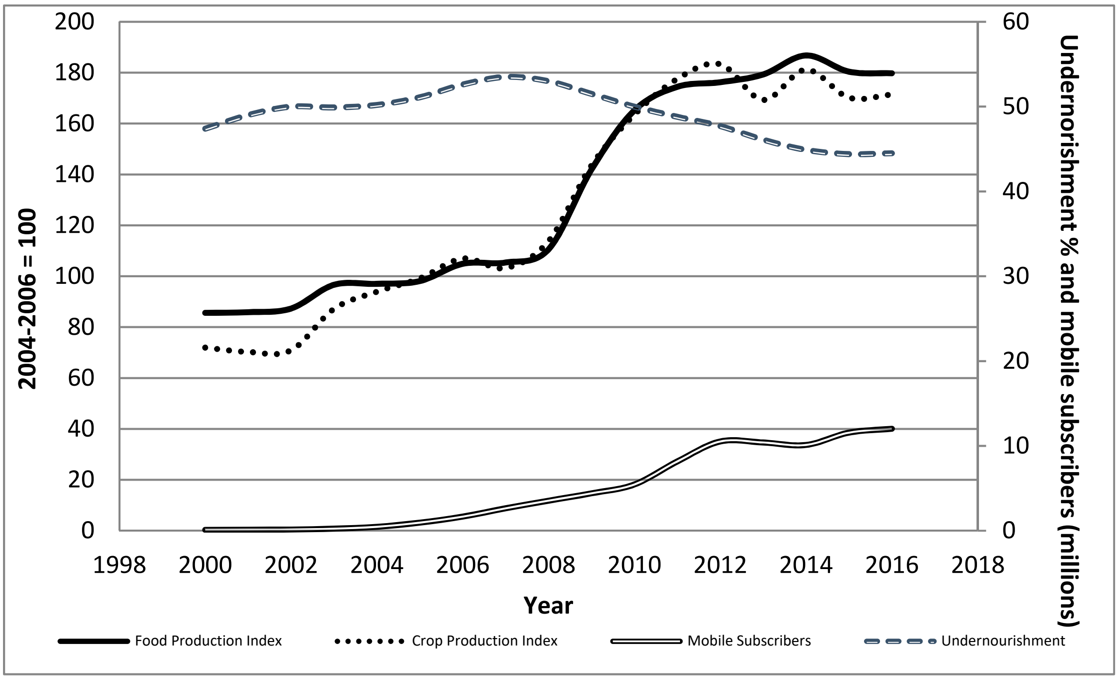

Figure 1. Undernourishment percentage and mobile phone subscription in Zambia. Source: WBdataset [39].

While a few scholars have abstractly examined how the use of the mobile phones could impact on welfare dimensions such as food security, empirical evidence on FNS is limited and not cogent to warrant the much needed policy action. For instance, discourse by Thomas [40] and Quisumbing and Maluccio [41] reveal that women tend to do better than their counterparts in dietary diversity without empirical evaluation as to whether improvement in FNS is realized. To begin to fill this gap, this study aims at answering the following questions: (i) Can mobile phones possibly have an effect on dietary diversity, a measure of FNS? (ii) How can mobile phones improve farm households' FNS? Comprehension of such mechanism is essential especially against the background of United Nations' vision 2030 as the purview is beyond a narrow category of economic development indicators.

Consequently, the study adds value to the literature in three aspects. First, we analyze informatization effects on FNS using robust econometrics approaches which correct for biases from endogeneity and selection bias. Unlike previous studies, we provide a discourse on how mobile phone use by farm households can translate to improved FNS. In the interest of adequate policy formulation, this is useful and obligatory because food is a very basic need for all. Second, we go beyond assessing associations by also quantifying the increased dietary diversity and quality levels in both male-headed and female-headed households and what it would be had non-adopting households adopted. This is distinctly fundamental under the sustainable development goals (SDGs) framework which advocates for the elimination of malnutrition and world hunger in all forms by 2030 and safeguard access to abundant and nutritious food for all. Finally, the study indirectly lobbies for the nutrition enhancement in farm households especially that the welfare (dietary diversity and quality) of the most important contributors of nutrition worldwide (farm households) is at the core of the investigation. Since farm households' well-being is linked to agriculture's success, analysis in the present study has significant policy implication for the sustainability of food production.

2. Materials and Methods

2.1. Data

The empirical analysis is based on the data extracted from a household survey conducted in 2018 in central Zambia where farm households significantly contribute to the national basket. The survey was a baseline study for a project envisioned to empower farm households through the introduction of mobile phone-based technologies for welfare information searching. The primary objective of the project is to promote and contribute to the four pillars of sustainability—social, economic, environmental, and human. The authors are not directly or indirectly linked to the project.

The area under study is covered by at least one mobile network operator which also offers mobile money services, weather forecasts updates, job alerts, and internet services. Farm households in these camps grow maize as their primary crop, in addition to beans, groundnuts, millet, cassava, cotton, sorghum, sweet potato, and tobacco. Dairy and fish farming are also prevalent. The area is typical of the rural African setup and as such most of the food consumed is from their produce or derived from hunting. Household income is from sales of their produce and off-farm employment highly unlikely. The majority of households residing far from markets rarely visit the market centers except during sale of their produce. Such visits are also an opportunity for purchasing of foods which are not commonly consumed.

Four different ways of determining a sample size are identified by Israel [42] and Singh and Masuku [43]—carrying out a census for finite and small populations, using tested and published tables, imitating sample sizes of other related or similar studies, and using determined formulae to calculate a sample size. By imitating sample size used in similar/related studies [44–46], we used a two-stage sampling procedure to select households for the study. In the first stage, three agricultural camps (Fiwila, Lweo, and Nshinso) in Mkushi district were randomly selected out of 22. Then, a random selection of 201 farm households was performed using the list from the Ministry of Agriculture. Fortunately, all the selected households responded positively and an adult household head was the source of information.

A structured questionnaire, constructed using standard layouts for agricultural household surveys [47], was used for data collection which took five months (July–November 2018). A pilot study was also done in order to pre-test suitability, validity, and applicability. Details regarding ethical approval of the study can be found in Mwalupaso et al. [48]. The instrument focused on crop production, income, nutrition, and other socio-demographic details. In addition, food types consumed within a given period was explicitly asked in order to accurately understand farm households' consumption pattern. Like Mwalupaso et al. [49], measurement error was minimized via use of trained enumerators, and pre-testing in the local setting.

2.2. Variable Selection and Measurement

2.2.1. Key Explanatory Variable

Mobile phone use (MPuse) is our key explanatory variable. It is captured through a dummy where 1 = households who owned and used mobile phones for information access during the survey year and 0 otherwise. Such measurement of mobile phone use was employed in a recent study by Sekabira and Qaim [50]. This variable is also the treatment variable upon which treatment effects are calculated.

2.2.2. Outcome Variables

Dietary diversity and quality are the outcome variables of interest which are measures of food consumption. They are based on food access and consumption patterns [50–54] and the household dietary diversity (HDD) scores which are a count of the different groups of food consumed over a specific time are used. To adequately evaluate whether informatization matters in enhancing FNS of farm households, a 7-day food consumption recall with 12 foods is constructed to calculate the HDD scores. The foods considered are: cereals (tubers and white roots); vegetables; fruits; poultry and meat; eggs; fish; legumes, pulses and nuts; milk and milk products; oils and fats; honey and sugar; and spices, beverages, and condiments. Regarding dietary quality (diversified and healthy diet), 9 food groups (healthy foods) are considered because HDDS is not necessarily a good indicator of dietary quality when all 12 foods are incorporated [50]. Thus, we exclude three groups (oils and fats, honey and sugar, and spices, beverages, and condiments) which are calorie dense but have little contribution to micronutrient consumption [55]. Tentatively, 12 and 9 food groups portray dietary diversity and quality respectively as measures of FNS.

In addition, household income in Zambian kwacha (ZMK) is another outcome variable in the endogenous switching regression (ESR) to understand the underlying mechanism of the impact of mobile phones on FNS.

Similarly, information access frequency, an outcome variable in ESR, is captured through the number of times a household accessed nutrition and health information within a week during the survey year.

2.3. Analytical Framework and Empirical Strategy

The ordinary least square regression (OLS) is adopted to model the influence of the mobile phone adoption on dietary diversity and quality whereas ESR is applied to understand the causal impact. All statistics were implemented in stata (version 14; Stata Corporation, College Station, TX, USA).

Two categories are defined to satisfactorily assess the difference in dietary diversity between gender, i.e., female-headed (FHHs) and male-headed households (MHHs). FHHs consist one of the following: (i) women in polygamous marriages recognized as household head given that their spouse is absent for a considerable portion of time; (ii) they are unmarried and; (iii) those in monogamous marriage, but the husband is absent for more than six months. MHHs capture single and married men who are acknowledged as household head.

2.3.1. Influence of the Mobile Phone Use on Dietary Diversity and Quality

OLS was applied to determine the effect of mobile phone adoption on dietary diversity and quality. The OLS is specified as follows:

$$HDD_i = \beta_1 MP_{use_i} + \beta' G_i + \varepsilon_i \tag{1}$$

where HDD_i is the outcome variable representing dietary diversity and quality, β' is a vector of parameters to be estimated, G_i is a vector of factors affecting dietary diversity and quality, β_1 is the coefficient of MP use, and ε_i is the error term for the OLS.

However, mobile phone use is potentially endogenous. Therefore, in the interest of robust estimates, we derived a matched sample through "1-to-1 nearest neighbor matching without replacement" using propensity score matching (PSM) technique. This implies that each adopter was matched with their comparable non-adopter by means of the propensity score or probability $(T_i = 1|X_i)$ of receiving treatment (T_i) conditional on covariates (X_i). The major advantage of this approach is that it imposes a region of common support, thereby controlling for biases emanating from observed variables [56,57].

2.3.2. Modeling Possible Mechanisms

The impact of mobile phones on dietary diversity is less straightforward because it may evolve through several avenues, possibly including frequency of nutrition and health information access, and income gains. In an attempt to meticulously identify causal pathways, ESR is applied to gain further insights into possible mechanisms.

The choice to adopt mobile phones and its implication on dietary diversity can be modeled in a two-stage treatment, although we adopt a simultaneous estimation procedure (an efficient procedure) developed by Lokshin and Sajaia [58] that uses full information maximum likelihood (FIML) method. In the first stage of ESR, a dichotomous choice criterion function is modeled and estimated using a probit model. In view of the expected benefits, households evaluate whether or not to adopt mobile phones for information access. This is most likely done on the basis of information access options and other socioeconomic factors. The expected utility of adoption is compared to that of non-adoption because only when the former is greater than the latter will a household adopt. The Probit model can be written in simplified form as:

$$T^* = M'\alpha + \varepsilon_v \; with \; T = \begin{cases} 1 \; if \; T^* > 0 \\ 0 \; otherwise \end{cases} \tag{2}$$

where T^* is not observable, but we observe T, a binary indicator variable that equals 1 if a household adopts mobile phone use and 0 otherwise, M includes a variety of household and farm characteristics, α is a vector of parameters to be estimated, and ε_v is a random error term with mean zero and variance σ^2.

In the second stage, two regime equations can be specified explaining the relationship between the outcome variables (dietary diversity, information access and income) and technology adoption (mobile phone use) based on the results of the estimated criterion function. This is done with selectivity correction and specified for each regime as:

$$\text{Regime 1}: \quad Y_{Adopter} = X'\beta_{Adopter} + \varepsilon_a \tag{3a}$$

$$\text{Regime 2}: \quad Y_{Non-adopter} = X'\beta_{Non-adopter} + \varepsilon_n \tag{3b}$$

where X represents a vector of covariates, and β is a vector of parameters to be estimated.

Using ordinary least squares (OLS), the estimation of $\beta_{Adopter}$ and $\beta_{Non-adopter}$ might lead to biased estimates, since conditional on the criterion function, the expected values of the error terms (ε_a and ε_n), are non-zero. In as much as the variables in M' and X′ can overlap, at least one variable in M' must not appear in X′ to achieve proper identification. Therefore, the selection criterion is estimated based on one or more instruments plus all exogenous variables specified in the regime equations. The error terms (ε_a, ε_n *and* ε_v) are assumed to follow a tri-variate normal distribution with zero mean and a non-singular covariance matrix specified as [59]:

$$Cov\ (\varepsilon_a,\ \varepsilon_n, \varepsilon_v,\ ) = \begin{bmatrix} \sigma_a^2 & \sigma_{an} & \sigma_{av} \\ \sigma_{an} & \sigma_n^2 & \sigma_{nv} \\ \sigma_{av} & \sigma_{nv} & \sigma_v^2 \end{bmatrix} \tag{4}$$

where σ_a^2, σ_n^2, and σ_v^2 are the variances, assumed to be one [60] of the error terms ε_a, ε_n, and ε_v, respectively. σ_{an} is the covariance of ε_a and ε_n; σ_{av} is the covariance of ε_a and ε_v; and σ_{nv} is the covariance of ε_n and ε_v.

Under these assumptions, the truncated error terms $(\varepsilon_a|T = 1)$ and $E(\varepsilon_n|T = 0)$ are:

$$\begin{aligned} E(\varepsilon_a|T = 1) = \ E(\varepsilon_a\big|\varepsilon > \ -M'\alpha) = \sigma_{av}\frac{\phi(M'\alpha/\sigma)}{\Phi(M'\alpha/\sigma)} = \sigma_{av}\lambda_a \\ E(\varepsilon_n|T = 0) = \ E(\varepsilon_n\big|\varepsilon \ \le -M'\alpha) = \sigma_{nv}\frac{\phi(M'\alpha/\sigma)}{\Phi(M'\alpha/\sigma)} = \sigma_{nv}\lambda_n \end{aligned} \tag{5}$$

where λ_a and λ_n are the inverse Mills ratios (IMRs) evaluated at $M'\alpha$ while ϕ and Φ are the probability density and cumulative distribution functions of the standard normal distribution, respectively.

To derive the average treatment effects (average treatment effect on the treated (ATT) and untreated (ATU)), the expected outcome values of the adopters and non-adopters in actual and counterfactual scenarios can be calculated and compared. The ESR framework permits the computation of the expected values in the real and hypothetical scenarios [58] defined as follows:

Adopters with adoption (observed):

$$E\big(Y_{Adopter}\big|T = 1; X\big) = X'\beta_{Adopter} + \ \sigma_{av}\lambda_a \tag{6}$$

Adopters had they decided not to adopt (counterfactual):

$$E\left(Y_{Non-adopter}\middle|T=1;X\right)=X'\beta_{Non-adopter}+\sigma_{nv}\lambda_a \tag{7}$$

Non-adopters had they decided to adopt (Counterfactual):

$$E\left(Y_{Adopter}\middle|T=0;X\right)=X'\beta_{Adopter}+\sigma_{av}\lambda_n \tag{8}$$

Non-adopters without adoption (Observed):

$$E\left(Y_{Non-adopter}\middle|T=0;X\right)=X'\beta_{Non-adopter}+\sigma_{nv}\lambda_n \tag{9}$$

Following Di Falco et al. [61] and Carter and Milon [62], ATT and ATU are computed as follows:

$$ATT=E\left(Y_{Adopter}\middle|T=1,X\right)-E\left(Y_{Non-adopter}\middle|T=1,X\right) \tag{10}$$

$$ATU=E\left(Y_{Adopter}\middle|T=0,\ X\right)-E\left(Y_{Non-adopter}\middle|T=0,\ X\right) \tag{11}$$

2.3.3. Determinants of Mobile Phone Adoption for Information Access

The Probit function was employed in evaluating the factors affecting mobile phone adoption. However, biased estimates are expected due to potential selection bias and endogeneity. For robust estimates, endogeneity was also tested using a control function (CF) technique. The grounds for selecting this procedure are: (i) regardless of weak instruments, it is efficient, (ii) unlike other instrumental variable (IV) approaches, Wooldridge [63] proposes that it is exceptionally efficient for binary endogenous variables. For the two-stage endogeneity test, estimating exogenous variables (control variables and instruments satisfying orthogonality condition of IVs) that influence mobile phone ownership with the aid of a Probit function specified in Equation (12) makes up the first stage. Generalized residuals (GR) were then calculated.

The second stage of the CF involved the actual estimation of the outcome variable of interest (mobile phone use against mobile phone ownership and other covariates). To ensure estimations are exempt from biases, GR together with other control variables, are included in this stage [64].

$$\text{CF Stage 1}:\ \ MP_{ownership_i}=\alpha' z_i+u_i \tag{12}$$

$$\text{CF Stage 2}:\ \ MP_{use_i}=\beta_1 MP_{ownership_i}+\beta' X_i+u_i+w_i \tag{13}$$

where $MP_{ownership_i}$ is a dummy (1 = owns mobile phone and 0 otherwise), MP_{use_i} is also a dummy as already established, α', β_1, and β' are parameters to be estimated, z_i and X_i are vector of factors affecting mobile phone ownership and use respectively, u_i and w_i are error terms.

3. Empirical Results and Discussion

3.1. Descriptive Statistics

Table 1 presents summary statistics of the outcome and explanatory variables used in the study. Households consume three healthy foods out of 6 weekly consumed foods. Two possible reasons for this might be accessibility and costs [65] i.e., apart from their own produce, it is easy to access food at affordable prices from local markets especially for adopters who live close to market centers. However, for both adopter and non-adopters there is a remarkable improvement especially that majority of the population in the country have a monotonous, cereal-based diet that lacks diversity [8]. Particularly, households heavily rely on maize and with the declining productivity, the nation is at crossroads with politicians calling for households to engage in nutritious and sustainable diets [66].

Despite the average income being fairly good, the income distribution is not balanced. This explains why only 21 percent of households are actually engaged in using the mobile phone. Income is a significant determinant of mobile phone ownership, an important factor in influencing adoption of mobile phone for information access. However, in areas where the income disparity is high, it is unlikely that adoption would be preferred in poor households. In addition, in view of the very low number of households that have access to power, lower adoption rates are expected. It is thus, not surprising that majority of households, who have lived more than four decades, have subscribed to cooperatives which are alternative or complementary sources of information.

Majority of households have an average of six members with slightly more males than females. In addition, household heads and their spouses in adopting households are more educated than their counterparts and this could have influenced their adoption decision and dietary diversity improvement [26]. Although considering the distance from the market for non-adopting households, they may have some difficulties in accessing network on their phones [67] as well as other required foods that are not produced in their communities [27,68,69]. Lastly, most households are male-headed owing to the fact that marriage is prevalent among the households.

We also performed t-test to show the differences in the mean of household characteristics between adopters and non-adopters. These results in the last two columns of Table 1 suggest that the models employed for analysis must account for the heterogeneity in characteristics otherwise biased estimations would be the outcome if a naïve estimator is employed.

Table 1. Descriptive statistics.

Category	Description	Pooled	Adopters	Non-Adopters
Outcome variable				
Dietary Diversity	HHD Scores for 9 foods	3.41 (0.18)	5.33 (0.34)	2.91 (0.13) ***
Dietary Quality	HHD Scores for 12 foods	5.80 (0.14)	8.33 (0.34)	5.13 (0.18) ***
Income	Income from farming and non-farming activities (ZMK)	8142.49 (376.05)	9251.07 (1057.72)	7849.65 (383.41) *
Info access freq	Access information on diet and nutrition	1.67 (0.06)	2.05 (0.10)	1.57 (0.07) ***
Explanatory variables				
Market	Distance to the nearest market (kilometers)	8.50 (0.26)	6.48 (0.53)	9.04 (0.28) ***
Age	Age of the household head (years)	41.71 (0.94)	38.64 (1.68)	42.52 (1.10) *
Msize	Number of males in a household	3.77 (0.21)	3.98 (0.47)	3.71 (0.23)
Fsize	Number of females in a household	2.40 (0.07)	2.33 (0.13)	2.41 (0.08)
Household Size	Number of people in a household	6.14 (0.23)	6.31 (0.50)	6.09 (0.26)
Power Access	Household has access to power (1 = access)	0.29 (0.03)	0.26 (0.07)	0.30 (0.04)
COP	Membership to cooperative (1 = member)	0.93 (0.02)	0.79 (0.06)	0.97 (0.01) ***
Edu	Number of years of schooling	5.24 (0.25)	8.62 (0.28)	4.35 (0.26) ***
Mstatus	Marital status of household head (1 = married)	0.77 (0.03)	0.69 (0.07)	0.79 (0.03)
SEdu	Attainment of basic education by household head' spouse (1 = attained)	0.52 (0.04)	0.69 (0.07)	0.48 (0.04) ***
Gender	Sex of household head (1 = male)	0.83 (0.02)	0.86 (0.06)	0.83 (0.03)
MPownership	Mobile phone ownership status (1 = owns mobile)	0.54 (0.04)	0.98 (0.02)	0.42 (0.04) ***
Land per capita	Land size per person within a household	1.62 (0.08)	1.15 (0.17)	1.74 (0.10) ***

Note: Figures in parentheses are standard errors of the mean. *** $p < 0.01$, * $p < 0.1$.

3.2. *Association of Mobile Phone Use with Dietary Diversity and Quality*

Table 2 presents the results of determinants of dietary diversity and quality for the matched sample. When compared to the estimations from the unmatched sample (Appendix A; Table A1), it is evident that the results in Table 2 are more robust. This is so because matching addresses the differences in observed characteristics shown in Table 1.

We find that the factors influencing dietary diversity and quality in FHHs and MHHs are not the same apart from mobile phone adoption, household income, and membership to cooperatives. Precisely, the use of mobile phones and income gains positively and significantly impacts on farm households' dietary diversity and quality in MHHs and FHHs. This is reasonable because information access (leading to appropriate food use based on knowledge of basic nutrition and care) and affordability (having sufficient resources to obtain appropriate foods for a nutritious diet) are key in attaining FNS [70]. The large and significant coefficients of MP use suggest that mobile phone use has a stronger positive association with dietary diversity and quality for MHHs than FHHs. However, both households benefit over-proportionally. Our result is consistent with the hypothesis by Nakasone and Torero [30] and the finding of Sekabira and Qaim [50]. Regarding the nature of mobiles phone use, it was revealed during questionnaire pre-testing and focus group discussion that voice calls and text messages are frequently exchanged with friends, Ministry of Agriculture officers and family on the importance of nutrition, and dietary diversity in particular. Also, farmers assiduously participate in accessing news and other information on healthy consumption patterns through social media platforms (Whatsapp and Facebook especially). From these facts, it is straightforward to deduce that mobile phone use is likely to have a very significant positive impact on dietary diversity and quality improvement. This finding is agreement with Aina [71] and Nakasone and Torero [30] who concludes that proactive access to information produces the desired results.

On the other hand, while membership to cooperative negatively influences dietary diversity and quality in MHHs, it significantly does the opposite in FHHs. In this case, membership to a cooperative does not help MHHs in improving their consumption patterns. One of the possible reasons is that males rarely discuss dietary issues [14,16] and so is the case for most male-dominated cooperatives [72]. Otherwise, cooperatives are a good source of information for farm households. The significant positive effect on dietary diversity and quality in FHHs suggests that females in cooperative are more receptive than males with regard to information (a key pillar in FNS). This is consonant with the assertion that information sources tend to have a more significant positive effect on consumption patterns for female than males [40].

Other factors influencing dietary diversity and quality in FHHs are distance from the market, marital status, education of the spouse and household head, and the age of household heads. Attainment of basic education by household head is significantly relevant in improving the dietary diversity and quality levels while education of the spouse has a negative impact in MHHs. This is inconsistent with the discourse by Waswa et al. [73] who pointed out that improved education is cardinal for ameliorating FNS. It is also no surprise that FHHs further away from markets tend to keep enough and various types of food which positively contribute to their dietary diversity more than those near markets where food could be expensive, thus difficult to afford [74]. However, the expectation is that households nearer to the market tend to have more information on dietary diversity and quality. Therefore, the plausible explanation could be that they may not have the various foods that allows for diverse diet.

Consistent with the discourse by Burchi et al. [75], increase in age in FHHS positively impacts on consumption of healthy foods significantly. As household head advances in age, consumption of nutritious or vegetable-oriented diets becomes prevalent in an attempt to ensure healthy living. This is expected to be true for both MHHs and FHHS although not the case for MHHs in the study area. In most cases, increase in age leads to upholding the value of a nutritious diet. This finding is also in agreement with Otsuka et al. [15]. Likewise, being married is associated with improved dietary diversity and quality levels. This is consistent with reality in the African rural setup in that marriage is believed to improve dietary diversity and quality. Unless cases where there is inadequate household income.

Finally, the number of males in a household has a varied impact on dietary diversity and quality in the household. For instance, it is negatively associated with dietary diversity in MHHs but positive in FHHs. This seems to contradict most findings that indicate that females tend to have more effects on consumption patterns than their counterparts [41,76]. However, in this case, this could be because a high number of males in the household will most likely stir up production of various foods. Bear in mind that males make up a significant component of labor in rural communities. For a society that is typical of African customs and traditions, women participation in food production is minimal [77,78]. Therefore, the results should not be over-interpreted. It is not that males contribute to dietary diversity and quality more than females, but rather their presence in households has a strong association with improved food accessibility, affordability and use.

Table 2. Robust regression estimation.

Variables	Dietary Diversity		Dietary Quality	
	MHHs	**FHHs**	**MHHs**	**FHHs**
MPuse	4.417 (0.642) ***	2.379 (0.886) **	3.471 (0.600) ***	2.467 (0.414) ***
Info access freq	−0.005 (0.197)	0.370 (0.273)	−0.064 (0.181)	−0.051 (0.056)
Income	0.061 (0.026) **	0.294 (0.072) ***	0.043 (0.023) *	0.735 (0.176) ***
COP	−2.014 (0.758) **	3.518 (1.195) **	−1.771 (0.754) **	3.917 (0.611) ***
Market	0.142 (0.096)	0.320 (0.103) **	0.161 (0.068) **	0.187 (0.086) *
Msize	−0.189 (0.091) **	0.652 (0.328) *	−0.084 (0.077)	−0.394 (0.206) *
Fsize	0.312 (0.254)	0.352 (0.301)	0.166 (0.211)	−0.281 (0.108) **
Edu	1.152 (0.665) *	−0.458 (0.695)	1.008 (0.591) *	−0.725 (0.414)
Age	−0.447 (0.379)	0.702 (0.925)	−0.257 (0.274)	2.164 (0.664) **
Mstatus	2.406 (1.201) *	2.891 (2.227)	2.339 (0.903) **	0.748 (1.572)
SEdu	−2.226 (0.826) ***	0.380 (0.670)	−2.001 (0.607) ***	−0.071 (0.474)
Constant	5.303 (2.008) **	−5.460 (2.553) *	2.497 (1.841)	−7.615 (1.885) ***
Model Diagnostics				
R-squared	0.546	0.782	0.530	0.845
F (OLS)	8.93 ***	7.09 *	9.45 ***	10.27 ***
N	63	19	63	19

Notes: Figures in parenthesis are standard error of the coefficient. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To keep the analysis from being a moot point, we also re-estimated this model (dietary diversity as the outcome variable) using a different mix of the explanatory variables (Table 3). This approach also gives a hint to the possible pathways of the impact of mobile phone adoption on FNS and proves that the finding is not spurious. The variables being altered in different specifications are—MP use, household income, and information access frequency. Column A shows that mobile phone adoption significantly impacts on dietary diversity yet the other two variables are omitted. This suggests that adoption may directly influence FNS through the different content adopters' access. This finding is in agreement with Sekabira and Qaim [50] who also contended that MP use may have direct impact on nutrition. Columns B and C reveal that the frequency in information access is insignificant while income is significant when individually controlled for in the estimations. In column D, mobile phone adoption is excluded but the two variables are included and we observe that the coefficients of the two added variables are significant. In view of the discourse by Parlasca et al. [38] who contends that effect size increases with frequency of mobile phone use, adoption may impact on dietary diversity through increased information access frequency. When all variables are controlled for in the model (column E), income and mobile phone adoption are significant while information access frequency is insignificant. Following the finding in column D, this suggests that information access frequency has an indirect influence on dietary diversity through mobile phone adoption or that mobile phone adoption could impact through increased frequency.

Finally, the bottom part of Table 3 reveals different R-squared for each respective model. R-squared is a statistical measure of how close the data are to the fitted regression line. Higher R-squared in general imply that the model fits the data best. We observe that when mobile phone adoption is excluded, R-squared is low and this implies that the variable is a significant explanatory variable in the model. When compared to the R-squared in column E, it is clear that the impact of adoption on dietary diversity is not spurious. This is also true for dietary diversity as can be seen in Table A2. Such impact is also reported by Hailu and Woldemichael [79] who found that mobile phone use influenced dietary diversity in pregnant women and Parlasca et al. [38] who also discovered that mobile phone adoption increases dietary diversity of households in pastoral communities in northern Kenya.

Table 3. Regression estimation of the matched sample.

Explanatory Variables	A	B	C	D	E
MPuse	4.281 (0.635) ***	4.202 (0.626) ***	4.238 (0.632) ***		4.046 (0.619) ***
Info access freq		0.077 (0.176)		0.509 (0.220) **	0.180 (0.175)
Income			0.043 (0.026) *	0.074 (0.025) ***	0.052 (0.024) **
COP	−1.189 (0.777)	−1.142 (0.817)	−1.427 (0.826) *	−2.155 (1.073) **	−1.366 (0.855)
Market	0.126 (0.087)	0.128 (0.087)	0.142 (0.084) *	0.084 (0.087)	0.152 (0.084) *
Msize	−0.142 (0.103)	−0.150 (0.103)	−0.141 (0.097)	0.009 (0.118)	−0.160 (0.096) *
Fsize	0.112 (0.215)	0.120 (0.216)	0.097 (0.203)	−0.069 (0.238)	0.113 (0.200)
Edu	1.597 (0.585) ***	1.640 (0.622) **	1.451 (0.586) **	−0.305 (0.699)	1.522 (0.607) **
Age	0.025 (0.318)	0.016 (0.322)	−0.204 (0.335)	−0.601 (0.451)	−0.270 (0.338)
Mstatus	3.195 (1.076) ***	3.211 (1.089) ***	2.719 (1.098) **	−0.237 (1.499)	2.660 (1.120) **
SEdu	−1.994 (0.910) **	−2.013 (0.920) **	−1.910 (0.906) **	0.096 (1.370)	−1.938 (0.932) **
Constant	3.116 (1.635) *	2.927 (1.763) *	3.990 (1.724) **	8.410 (1.817) ***	3.722 (1.786) **
Model Diagnostics					
R-squared	0.464	0.466	0.483	0.219	0.490
F (OLS)	9.086 ***	8.421 ***	8.274 ***	2.200 **	7.779 ***

Notes: Figures in parenthesis are standard error of the coefficient. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.3. Towards Explaining Possible Mechanisms

The critical policy and scholarly question is how can mobile phone use improve farm households' dietary diversity and quality? In view of the finding in Table 3, two probable pathways could possibly facilitate FNS effects. First, mobile phone use enhances income gains which are typically linked to ameliorated dietary diversity and quality [55]. Since mobile phone use reduces transaction costs, thereby improving access to information, technology, and markets, the possible impact of mobile phone adoption on household income is fairly straightforward. Table 4 provides evidence indicating that it is rational for both adopters and non-adopters in MHHs and FHHs to adopt. Precisely, non-adopters would experience income gains had they adopted. We also find a similar pattern with dietary diversity—had non-adopters adopted, they would relatively have a diverse diet in both MHHs and FHHs. Therefore, the reasonable conclusion would be that income gains on account of the mobile phone use facilitate improved dietary diversity.

Second, as a platform for accessing various news services and information, mobile phones increase farm households' healthy consumption pattern awareness and knowledge which could also culminate in better dietary practices [80]. Consistent with this assertion, Table 4 suggests that mobile phones could directly improve household diets. Both adopters and non-adopter would benefit more from adoption—increased frequency of access to information. Ultimately, food choices and dietary behavior could be influenced as better access to nutrition and health information could be enabled through mobile phone adoption [50].

Finally, through the aforementioned mechanism, adopters in MHHs and FHHs consume about three and two more foods weekly. Had non-adopting households adopted mobile phones for information access, they would consume about two more foods within a seven-day period. Going by the higher dietary diversity, adopters may have better nutritional knowledge [81], market information [26], and may negotiate for lower prices [82,83]. However, more research is required to substantiate such assertion. More to that, Figure 2 reveals that adopters consume more healthy and nutritious products consistent with the objectives of FNS as pointed out by Capone et al. [70]. Particularly, MP adoption shifts diets to more balanced diets while reducing on fat and sugar intake. Interestingly, contrary to current literature which concludes that women are doing far better than men [50,78,80], we find significant improvement by both as the performance of MHHs is competitive to FHHs. Male household heads are showing interest in issues of dietary diversity just as much as females do. The consequence of such occurrence according to Quoquab and Mohammad [84] is improved quality of life on account of improved FNS.

Table 4. Average treatment effect on the treated (ATT) and untreated (ATU).

Outcome Variable	Treatment Effect	MHHs			FHHs			Pooled		
		Mean with Adoption	Mean without Adoption	Average Treatment Effect	Mean with Adoption	Mean without Adoption	Average Treatment Effect	Mean with Adoption	Mean without Adoption	Average Treatment Effect
Information access frequency	ATT	0.85	0.85	0 (0.10)	1.09	0.54	0.54 (0.08) ***	0.89	0.79	0.10 (0.08)
	ATU	1.17	0.59	0.58 (0.05) ***	1.55	0.45	1.11 (0.13) ***	1.22	0.57	0.65 (0.05) ***
Income	ATT	9612.57	5842.29	3770.28 (1001.14) ***	7363.79	6239.36	1124.43 (1244.34)	9237.77	5908.47	3329.31 (864.91) ***
	ATU	11,971.61	7773.25	4198.35 (563.38) ***	8898.74	8389.87	508.88 (1583.11)	11546.43	7858.57	3687.86 (537.50) ***
Dietary Diversity	ATT	8.52	4.95	3.57 (0.22) ***	7.32	4.43	2.88 (0.57) ***	8.32	4.86	3.45 (0.22) ***
	ATU	8.07	5.15	2.92 (0.09) ***	7.17	4.91	2.26 (0.19) ***	7.95	5.12	2.83 (0.08) ***

Notes: Figures in parenthesis are standard error of the coefficient. *** $p < 0.01$.

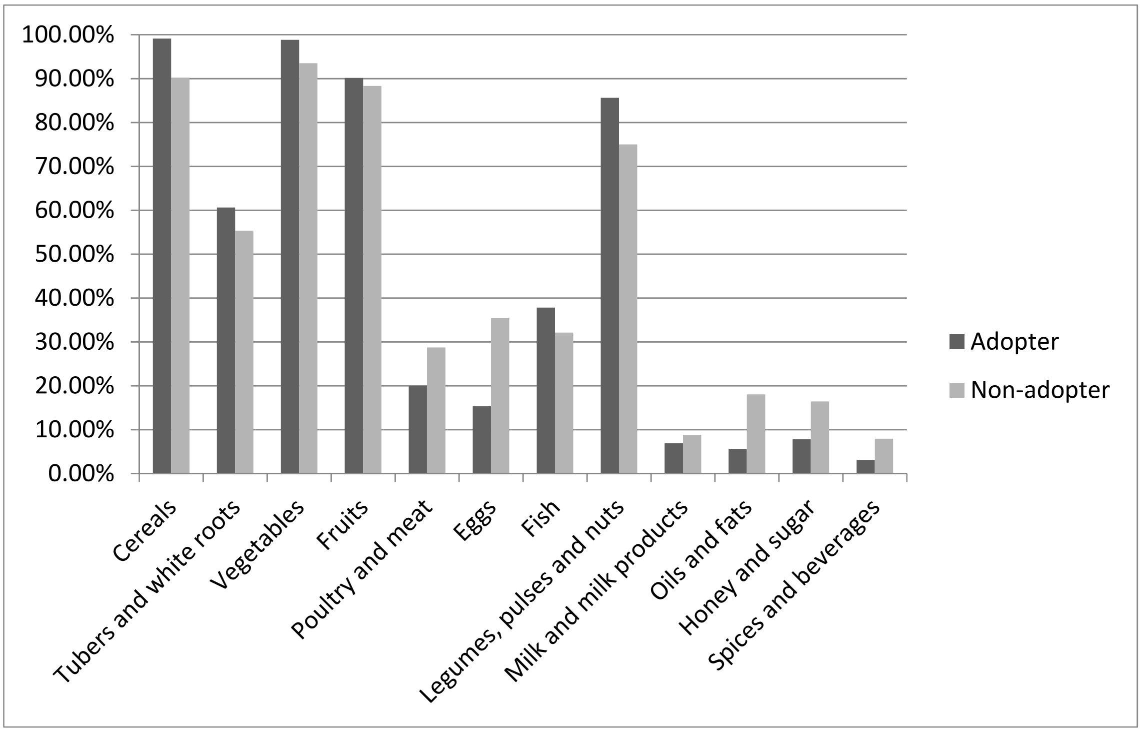

Figure 2. Food consumption intensity.

3.4. Factors Influencing Mobile Phone Use among Farm Households

After establishing the effect of mobile phone adoption in improving FNS, it is pivotal for policymakers to comprehend the determinants of adoption. Therefore, Table 5 provides evidence of the factors affecting adoption of the mobile phone. As indicated earlier, this is the second stage of the CF approach. Estimation of the first stage of CF from which GR was calculated is shown in Table A3.

Table 5. Determinants of mobile phone adoption.

MPuse	Coef. (Std.Err.)	Average Marginal Effects
MPownership	4.508 (0.963) ***	0.406 (0.063) ***
Gender	−1.185(0.690) *	−0.107 (0.059) *
Land per capita	0.211 (0.207)	0.019 (0.019)
COP	−1.427 (0.477) ***	−0.129 (0.040) ***
Market	−0.078 (0.061)	−0.007 (0.006)
Household size	0.192 (0.109) *	0.017 (0.009) *
Edu	0.495 (0.117) ***	0.045 (0.010) ***
SEdu	−0.100 (0.103)	−0.009 (0.009)
Age	−0.011 (0.033)	−0.001 (0.003)
Power Access	−1.084 (0.495) **	−0.098 (0.047) **
GR	−0.723 (0.513)	−0.065 (0.044)
Constant	−4.034 (1.626) **	
Model Diagnostics		
Log pseudolikelihood	−16.512	
N	201	
McFadden's Pseudo r-squared	0.705	
Chi-square	44.56 ***	
Correctly classified values	92.93%	

Note: Figures in parentheses are standard errors of the coefficients, while *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Results indicate that mobile phone ownership positively and significantly influences the adoption of mobile phones to access information. The discerned relationship is plausible because ownership is fundamental in stirring use of any device. This is also critical to acknowledge because Tadesse and Bahiigwa [26] caution that mere availability of the mobile phones does not inherently indicate that households are making use of them as a solution to their information problems.

In the same way, household size and attainment of basic education by household head positively impacts on adoption. Particularly, the likelihood of owning and using a mobile phone in larger families increases due to the need for frequent communication as pointed out by Potnis [85]. In addition, educated household heads tend to influence regular use of mobile phones for information access. This is in agreement with that conclusion by Islam and Grönlund [86] and Tadesse and Bahiigwa [26] that education is a factor in scaling up use of the device in information acquisition.

On the contrary, membership to a cooperative, gender of household head and access to power negatively and significantly affect the probability of mobile phone adoption. Regarding cooperatives, if and only if they serve as a great and convenient source of information, would membership have a negative impact on mobile phone adoption. Since cooperatives are held as information machines [87], a higher number of households are subscribed. Therefore, membership is likely to have a negative impact on the adoption of mobile phones.

The impact of gender on mobile phone adoption is mixed. However, Kyun Choi et al. [88] indicate that females use the mobile phone more than males. Consistent with this, we find that FHHs are more likely to adopt than MHHs.

Unexpectedly, household with access to power are not likely to adopt. This contradicts common sense because it is anticipated that power access would increase the chances of adoption. In the case that access to power is expensive, such a finding is reasonable. As found by Aker [89], only when search costs (which also include power access) are low, will households adopt mobile phones.

3.5. Policy Implication

Our results provide insight for policymakers to comprehend the importance of informatization in ameliorating FNS in farm households. Mobile phone adoption is the case in point. It holds double effects—income gains, and increased information access frequency that could lead to improved dietary diversity. To improve the adoption rates, empowering households with mobile phones and improvement in education levels is essential. Eventually, *ceteris paribus*, FNS would be realized in both MHHs and FHHs, which depicts healthy and sustainable diets and also guarantees little to no prevalence of chronic diseases [33–35]. Therefore, while food security actions should be directed at making certain that food systems provide farm households with stable access to sufficient, appropriate and safe food, nutrition-oriented measures should ensure that households have necessary knowledge to warrant adequate nutritional benefit from the food. Emphasis must be placed on the need for greater integration of nutrition into food security policies and programs because food security is a prerequisite to adequate nutrition [70].

Overall, policy aimed at promoting adoption would contribute towards the four pillars of sustainability—human, social, economic, and environmental. We observe that the use of mobile phones is at a mind-boggling scale. For instance, adopters access and utilize more healthy foods than their counterparts within 7 days which indicates efforts towards social sustainability, attributable to the income gains (economic sustainability) and increased knowledge (human sustainability—aims to maintain and improve human capital in society and as such under its umbrella is access to knowledge [18]). Regarding implication on environmental sustainability, we observe that the pressure that is exerted on four food groups by non-adopters is spread on eight by adopters. Thus, based on the consumption pattern of adopters, the implication is that the demand for different food groups is moderated, facilitating for sustainable supply with assumedly less environmental degradation due to reduced production pressure. According to Lefin [90], environmental degradation in agriculture is prompted by augmented demand for specific food groups which prompt farmers to overuse chemicals to boast production. In agreement Jing et al. [65] also conclude that lack of diversity in diet, exerts huge pressure on production that warrants failure to promote FNS.

4. Conclusions

In developing countries, particularly among farm households, malnutrition is a problem of significant magnitude posing a threat to the sustainability of agriculture and food systems. Thus, improvement in food and nutrition security is paramount. To this end, diversifying diets and increased access to information is widely perceived as a solution. However, empirical evidence regarding the link of the latter with households' dietary diversity is limited. In view of the rapid spread of mobile phones in rural Sub-Saharan Africa, which has offered the possibility for increased information access, we investigate whether informatization (mobile phone use used as a concrete example) has an association with improved dietary diversity and quality.

Our results indicate that mobile phone use is positively associated with dietary diversity and quality. In fact our results reveal that both MHHs and FHHs are worse off without mobile phone adoption, leading to our conclusion that informatization does matter in ameliorating food and nutrition security in farm households. With such findings, we have reasons to be optimistic despite the burdens of malnutrition facing farm households today. Therefore, in an attempt to scale up mobile phone use among farm households, we strongly recommend policy directed at empowering households with mobile phone ownership, making mobile phone use easier and inexpensive and establishing reliable information centers addressing food and nutrition security. This is consonant with sustainable development goals and has great potential to realize sustainable development especially that 'a healthy farm household is a healthy farm'.

Finally, our study has important implications for future research. First, there are other broader benefits like positive environmental externalities that were not analyzed in the present study. Future studies looking beyond farm household level with broader implications would be useful. Second, informatization depends on households' capacity to adapt to local circumstances and thus impacts may change over time. This was not examined in this study owing to the use of cross-sectional data. Therefore, use of panel data to appropriately understand the impact dynamics in terms of how informatization influences dietary patterns choices over time is strongly encouraged.

Author Contributions: Conceptualization, G.E.M.; data curation, G.E.M. and A.M.E.; formal analysis, G.E.M., S.W., and X.T.; funding acquisition, G.E.M. and X.T.; investigation, G.E.M.; methodology, G.E.M., S.W., and A.M.E.; project administration, X.T.; resources, X.T.; software, G.E.M., S.W., A.M.E., and X.T.; supervision, X.T.; validation, G.E.M. and X.T.; writing—original draft, G.E.M.; writing—review and editing, G.E.M., S.W., A.M.E., and X.T. All authors have read and agreed to the published version of the manuscript.

Funding: This project was funded by the National Natural Science Foundation of China (Project ID: 71473123), Prince G Academy and Consultancy (Project ID: PR2018-1) and the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD).

Acknowledgments: Sincerely gratitude to Eunice Nalwembe Matafwali and Sanzidur Rahman for the constructive and helpful comments.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Regression estimation of unmatched sample.

Variables	Dietary Diversity			Dietary Quality		
	FHHs	MHHs	Pooled	FHHs	MHHs	Pooled
MPuse	2.571 (1.424) *	3.143 (0.515) ***	3.056 (0.461) ***	1.409 (1.092)	2.499 (0.466) ***	2.415 (0.424) ***
Info access freq	0.315 (0.350)	−0.113 (0.173)	0.037 (0.166)	0.378 (0.342)	−0.113 (0.147)	0.023 (0.148)
Income	−0.233 (0.671)	0.516 (0.329)	0.558 (0.297) *	−0.148 (0.419)	0.415 (0.266)	0.457 (0.247) *
COP	3.788 (0.965) ***	−1.306 (0.688) *	−0.981 (0.706)	4.213 (0.830) ***	−1.224 (0.632) *	−0.901 (0.663)
Market	0.257 (0.114) **	−0.004 (0.051)	0.028 (0.049)	0.201 (0.093) **	0.017 (0.038)	0.037 (0.035)
Msize	0.371 (0.172)	0.075 (0.077)	0.069 (0.072)	0.086 (0.199)	0.075 (0.058)	0.053 (0.056)
Fsize	0.061 (0.249)	0.009 (0.217)	−0.029 (0.170)	−0.188 (0.175)	−0.040 (0.170)	−0.123 (0.134)
Edu	−0.532 (0.957)	0.242 (0.462)	0.414 (0.429)	−0.920 (0.584)	0.419 (0.378)	0.513 (0.358) *
Age	0.958 (0.580)	−0.535 (0.281) *	−0.465 (0.246) *	1.593 (0.534) ***	−0.455 (0.217) **	−0.323 (0.358)
Mstatus	−4.954 (1.778) **	−0.073 (0.666)	0.022 (0.479)	−3.031 (1.885)	−0.037 (0.466)	0.122 (0.347)
SEdu	7.724 (2.166) ***	0.217 (0.440)	0.375 (0.416)	6.283 (2.024) ***	0.277 (0.300)	0.414 (0.292)
Constant	−2.824 (6.096)	2.600 (3.396)	0.954 (3.105)	−6.159 (3.754)	0.810 (2.700)	−0.710 (2.592)
Model Diagnostics						
R-squared	0.703	0.310	0.301	0.774	0.326	0.305
N	29	172	201	29	172	201

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2. Regression estimation of determinants of dietary quality.

Dietary Quality	A	B	C	D	E
MPuse	3.215 (0.566) ***	3.189 (0.562) ***	3.185 (0.567) ***		3.083 (0.564) ***
Info access freq		0.025 (0.171)		0.345 (0.196) *	0.095 (0.167)
Income			0.031 (0.023)	0.052 (0.021) **	0.035 (0.021) *
COP	−0.966 (0.782)	−0.950 (0.821)	−1.134 (0.826)	−1.704 (1.010) *	−1.102 (0.853)
Market	0.129 (0.060) **	0.130 (0.060) **	0.141 (0.059) **	0.094 (0.063)	0.146 (0.059) **
Msize	−0.075 (0.082)	−0.077 (0.082)	−0.074 (0.080)	0.045 (0.092)	−0.084 (0.080)
Fsize	−0.040 (0.174)	−0.038 (0.175)	−0.051 (0.167)	−0.182 (0.188)	−0.042 (0.166)
Edu	1.262 (0.532) **	1.276 (0.569) **	1.158 (0.536) **	−0.197 (0.563)	1.196 (0.560) **
Age	0.177 (0.251)	0.174 (0.253)	0.014 (0.264)	−0.272 (0.365)	−0.021 (0.259)
Mstatus	3.019 (0.824) ***	3.024 (0.831) ***	2.681 (0.832) ***	0.442 (1.008)	2.650 (0.827) ***
SEdu	−1.925 (0.646) ***	−1.931 (0.647)	−1.866 (0.634) ***	−0.331 (0.851)	−1.881 (0.636) ***
Constant	0.839 (1.497)	0.777 (1.643)	1.458 (1.595)	4.889 (1.623) ***	1.317 (1.684)
Model Diagnostics					
R-squared	0.438	0.438	0.452	0.214	0.455
F (OLS)	8.191 ***	7.369 ***	7.845 ***	2.279 ***	6.988 ***

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3. Factors affecting mobile phone ownership.

MPownership	Coef.	St.Err	t-Value	*p*-Value	Sig.
Age	−0.026	0.014	−1.88	0.061	*
Edu	−0.116	0.227	−0.51	0.608	
Household size	−0.083	0.050	−1.66	0.096	*
Power Access	−0.195	0.218	−0.90	0.371	
Land per capita	−0.151	0.109	−1.39	0.164	
COP	−0.198	0.389	−0.51	0.611	
Market	−0.013	0.028	−0.46	0.644	
Mstatus	−0.364	0.254	−1.43	0.152	
Income	0.889	0.215	4.14	0.000	***
Constant	−5.186	1.658	−3.13	0.002	***
Model Diagnostics					
Mean dependent var	0.537		SD dependent var	0.500	
Pseudo r-squared	0.165		Number of obs	201	
Chi-square	31.352		Prob > chi2	0.000	
Akaike crit. (AIC)	251.823		Bayesian crit. (BIC)	284.856	

Notes: *** $p < 0.01$, * $p < 0.1$.

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