Access to Credit and Child Nutritional Outcomes in Ghana

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ABSTRACT | Globally, and especially in developing economies, the quest to understand the impact of agricultural and food policies on nutritional outcomes has become a key policy issue. Typically, most agricultural policies highlight the critical role of credit in easing liquidity constraints of farm households as a means of spurring productivity under the belief that increased productivity would set the tone for boosting nutritional outcomes. This study estimates the effect of credit on anthropometric measures of children in the Savannah Accelerated Development Authority (SADA) zone of Ghana. The study argues that children's anthropometric measures share some relationship and thus must be modeled as a system. Therefore, we employ the three-stage system of simultaneous equations to deal with the structural system and endogeneity of credit. In addition, we test the pathways of credit to nutrition using data from the USAID Ghana Feed the Future (FTF) baseline survey. The results show that credit has a strong positive effect on the nutritional outcomes of children. Further, yield, market participation, income from crop sales, and nonfarm business ownership are the essential pathways credit influences nutrition. Therefore, the government should establish a full-blown farm credit policy through relevant institutions to provide credit to farm households.

KEYWORDS | credit, nutrition, anthropometric measures, agricultural policy, nonseparable, Ghana

JEL CLASSIFICATIONS | E51, G21, I12, H81, O13, P36

Africa is home to the most nutritionally challenged households globally. For example, in 2019, two out of five of all stunted children under 5, one-quarter of all overweight children under 5, and more than one-quarter of all wasted

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https://doi.org/10.5325/jafrideve.25.2.0131
Journal of African Development, Vol. 25, No. 2, 2024

(Received September 20, 2022; Accepted January 22, 2023)

children under 5 lived in Africa (UNICEF, WHO, and World Bank 2020). In specific terms, the percentage of stunted children under 5 (29.1%) in Africa is one of the highest in the world; and Africa is one of the regions where the number of stunted children under 5 has risen—a rise of about 15.7% from 49.7 million children under 5 in 2000 to 57.5 million children under 5 in 2016. There were 12.7 million wasted children under 5 (representing 6.4% of children in the continent), with 3.5 million severely wasted (representing 1.8% of children in the continent) in 2019. Though the prevalence of overweight children under 5 declined from 5% in 2000 to 4.7% in 2019, the number of overweight children increased from 6.5 million to 9.3 million, respectively.

Africa's nutritional challenges present a paradoxical situation as the continent's economy is driven by agriculture. The question that immediately comes to the fore is why is nutrition a challenge in Africa given that agriculture is the provider of food resources that drive nutrition? Perhaps this paradox is the driving force behind the recent calls for a more diagnostic look at the thematic area of the agriculture-nutrition nexus. For example, FAO (2013) noted the need for more attention on nutrition-sensitive agricultural policies and interventions to boost nutritional outcomes.

The fundamental issue that arises from the preceding is that Africa is an ideal experimental setting for assessing the agriculture-nutrition nexus. Numerous studies have examined specific issues in this thematic area in Africa (see Garrett and Ruel 1999; Kabubo-Mariara et al. 2009; Amugsi et al. 2017; Ngwira et al. 2017). However, one key area fundamentally underexplored in the literature is measuring the impact of agricultural and food policies on nutritional outcomes. Meanwhile, the implications of this assessment for rethinking the role of agricultural policies and programs in boosting nutritional outcomes cannot be overemphasized.

Ghana is noted for its numerous agricultural policies emanating from the Structural Adjustment Programme (SAP) and the Economic Recovery Programme (ERP) initiated in the 1980s and 1990s. Notable among these policies is the Food and Agriculture Sector Development Policy (FASDEP), which was launched in 2002 and later upgraded to FASDEP II in 2009. This policy is notable because it is the most nutrition-centered among agricultural policies in Ghana. The policy had a specific objective of achieving food security and emergency preparedness. The basic strategy for achieving this objective was increasing the productivity of basic staples by facilitating access to productive resources such as credit, irrigation, and mechanization. Thus, the policy recognized the role of credit in achieving this objective. This policy fitted perfectly into the adjacent financial sector policies that were aimed at liberalizing the sector to enhance accessibility to and usage of financial products and services.

The vision of the FASDEP was that enhancing access to finance would ease liquidity constraints of farm households and offer them the capacity to demand agro-inputs to boost productivity, production, and incomes, thus improving food security and nutritional outcomes. However, since its implementation, a formal empirical evaluation of the FASDEP's credit pathway to improving nutritional outcomes has not been conducted. The motivation of this article thus stems from the objective of delivering scientific evidence to contribute to policy formulation on the one hand and the existing literature on the other. Specifically, this article aims to (1) Estimate the effect of access to credit by households on the nutritional outcomes of children and (2) Identify and test the channels through which credit affects nutritional outcomes.

The article makes three key contributions to the literature. First, this article extends previous studies by arguing that nutritional outcomes of stunting, wasting, and being underweight are nonseparable and that estimating them in standalone models would lead to biased and inconsistent estimates. To the best of our knowledge, this is the first attempt at modeling nutritional outcomes through a structural system of equations. The gains from this methodological approach are nontrivial: unbiased, efficient, and consistent estimates. Second, the article uses unique nutritional data. The advantage of these data over datasets such as the Demographic and Health Surveys (DHS) and the Ghana Living Standards Surveys (GLSS) is its two-pronged specificity—thematically specific to nutrition and geographically specific to the hotspot of nutritional challenges in Ghana.

Third, this article represents one of few country-level attempts at exploring the effect of credit on nutritional outcomes. To the best of our knowledge, only Malapit and Quisumbing (2015) explored the relationship between empowering women in agriculture and nutritional outcomes. The main weakness of this study is the application of ordinary least squares (OLS), which, at best, could estimate an association between credit and nutritional outcomes and not a causal effect. This article uses more advanced econometric techniques to build on the study of Malapit and Quisumbing (2015). Other studies on nutrition in Ghana explored the generic drivers of nutrition, not credit policy. Notable studies in this regard include Darteh et al. (2014), Atsu et al. (2017), Aheto et al. (2017), Aheto et al. (2015), and Ali et al. (2017).

The high degree of diversity and heterogeneity of African economies (see Beck et al. 2015) warrants country experimental case studies. In light of this, Ghana represents a unique setting for investigating the agriculture-nutrition nexus. The second, and perhaps the most important rationale for the Ghana case study, is the availability of a rich and unique agricultural and nutritional outcomes dataset collected in Ghana's most nutritionally challenged part, the Savannah Accelerated Development Authority (SADA) zone. This dataset is the product of the Feed the Future (FTF) Initiative launched in 2010 by the United States government. Ghana is one of the initiative's 12 focus countries in Africa. The FTF initiative is mandated to tackle the "*root causes of hunger and poverty through the transformation of agricultural production and improvement in health and nutrition.*" Ghana's inclusion lends credence to the argument of her ideal setting for testing the effect of agricultural policies on nutritional outcomes.

The rest of the article is organized as follows. The next section "Review of Related Studies" presents a brief literature survey on the credit-nutrition linkage as well as the effect pathways. "Methodology" section describes the data, conceptual framework, and econometric model. In "Results and Discussions" section, we present and discuss results on the effect of credit policy on the nutritional status of children and the associated channels of effect. The final section presents the conclusion and policy implications.

REVIEW OF RELATED STUDIES

Doocy et al. (2005) examined the impact of a credit program on nutritional outcomes in Ethiopia using a sample of 819 households. The study compared the nutritional status of established clients and their families to those of incoming clients and community controls. The analysis of variance (ANOVA) showed that female clients and their children had superior nutritional status relative to the comparison groups. Furthermore, households of female clients had better food security than households of male clients. This study suggests that well-designed credit policies can help alleviate malnutrition and food insecurity. However, because ANOVA only shows correlation and not causation, the findings of this study have limited policy value. Bidisha et al. (2017) investigated the impact of different credit sources on food security and dietary diversity in Bangladesh. The results showed that households with access to credit from formal sources, informal sources, and microfinance companies had better food security and dietary diversity scores than their counterparts without access to credit. The authors believe credit improves nutritional outcomes through the income pathway.

In another study in Bangladesh, Islam et al. (2016) examined the effects of microcredit on a wide range of food security indicators for women and children. Three main findings emerged from this panel study. First, participation in credit programs and the amount of loans improve calorie intake and reduce food poverty, but participation does not improve dietary diversity. Second, the impact of credit on anthropometric indicators is inconclusive. While microcredit program participation reduces stunting in children under 5 years, the impact of participation on wasting and underweight children under 5 is weak and mixed. Again, while participation reduces the incidence of being underweight among women, it does not impact women's body mass index (BMI). Third, the impact of credit participation on food security is nonlinear. That is, microcredit participation may not significantly impact food poverty and calorie consumption in the short run, but the impact is significant in the long run.

Further, Islam et al. (2016) postulated three main channels through which microcredit could impact nutrition: investment, insurance, financial literacy, and nutrition education. The first argument is that credit promotes poor households' investment, increasing income, consumption, and wealth. Second, microcredit provides insurance for households by increasing their capacity to cope with the risk and uncertainty associated with agriculture and life. Third, microfinance programs often have educational components that sensitize clients to financial prudence, food security, and nutrition. However, Islam et al. (2016) did not proceed to test the efficacy of the channels outlined above. Again, the fixed-effect model adopted does not adequately address the endogenous nature of credit and other variables. We build on this study by identifying and testing the channels through which credit policies affect nutrition.

Malapit and Quisumbing (2015), in a study covering the northern part of Ghana, found that the empowerment of women strongly influences infant and young child feeding quality but only affects child nutrition weakly. Another interesting finding is that the empowerment of women in credit decisions positively affects their dietary diversity but not their BMI. These findings suggest that the empowerment of women does not have a wholesale impact on dietary diversity and nutritional outcomes but that it has specific indicators that it drives. In an earlier study in Nepal by Malapit et al. (2013), it was revealed that the empowerment of women significantly influenced the nutritional outcomes of mothers and their children, except for women's BMI. It is often believed that improvement in the nutrition of women will result in better nutritional outcomes for their children. However, the empirical evidence on this is mixed. For instance, Headey et al. (2012) found that while mothers' BMI affects stunting among children, mothers' BMI had no significant impact on the incidence of being underweight among children.

In a literature review study covering South Asia, Pandey et al. (2016) revealed that growing targeted nutrition-rich crops, backyard gardens, and agricultural diversification toward aquaculture, fruits, and vegetables improve nutritional outcomes of farm households. The empowerment of women and nutrition education were found to boost nutrition. Wadud (2013) established that credit improved farmers' efficiency, output, and income in Bangladesh. Other researchers identified productivity (Weinberger 2005; Kiresur et al. 2010) and consumption (Weinberger 2005; Kiresur et al. 2010;

Yu 2012; MacWilliam et al. 2018) as essential pathways through which agriculture impacts nutrition.

Our study builds on the above contributions by investigating credit policy's potential impact on children's nutritional outcomes using robust econometric techniques that address the nonseparable nature of nutritional outcomes and the endogenous nature of credit, among other variables. Building on these initial results, our study proceeds to test the impact pathways of credit.

METHODOLOGY

Conceptual and Theoretical Considerations

These two variables need to be appropriately conceptualized based on the main objective of estimating credit's effect on children's nutritional outcomes. Access to credit (credit policy) is the treatment variable. We used farmers' access to credit from the formal credit market as a proxy for credit flowing from the FASDEP II credit initiative. One advantage of this approach is that evidence of a positive effect of credit on nutritional outcomes would be a key policy message to policymakers to prioritize a strategy for developing an agricultural credit policy. Again, the government extends credit to farmers mainly through banks and other formal financial institutions. Access to credit is conceptualized as households who apply for and secure credit from formal credit sources. This implies that access to credit is a discrete outcome comprising two indicators, 0 and 1, respectively, representing households that did not receive credit and households that received credit.

The outcome variable is children's nutritional outcome, which is conceptualized as three distinct anthropometric measures of stunting, underweight, and wasting. The literature conceptualizes stunting as Height-for-Age (H/A) and measures it by its z-score (see Kabubo-Mariara et al. 2009; Zereyesus et al. 2014); underweight as Weight-for-Age (W/A) with its z-score as a measure (see Darteh et al. 2014; Zereyesus et al. 2014); and wasting as Weight-for-Height (W/H) with its z-score as a measure (see Darteh et al. 2014; Zereyesus et al. 2014). These three anthropometric measures are continuous variables.

The z-score, Z_{ij}, for the ith indicator for the jth child is computed as:

$$Z_{ij} = \frac{V_{ij} - V_{Mi}}{\sigma_{Mi}} \tag{1}$$

where V_{ij} represents the observed value of the ith indicator for the jth child, V_{Mi} and σ_{Mi}, respectively, represent the median and standard deviation of the ith indicator in the reference population. The WHO Anthro software (WHO 2011) was used to compute the z-scores for stunting (HAZ), underweight (WAZ), and wasting (WHZ) indicators. These estimates are used to indicate prevalence rates. A child with HAZ, WAZ, and WHZ less than –2 z-scores but greater than or equal to –3 z-scores are considered, respectively, moderately stunted, underweight, and wasted. Severe cases are when the z-scores are less than –3.

The conceptual framework, which illustrates the underlying pathways through which credit influences nutrition, is summarized in Figure 1. Figure 1 indicates that access to credit eases farmers' liquidity constraints (see, e.g., Feder et al. 1990). This offers them the opportunity to invest in either farm or nonfarm

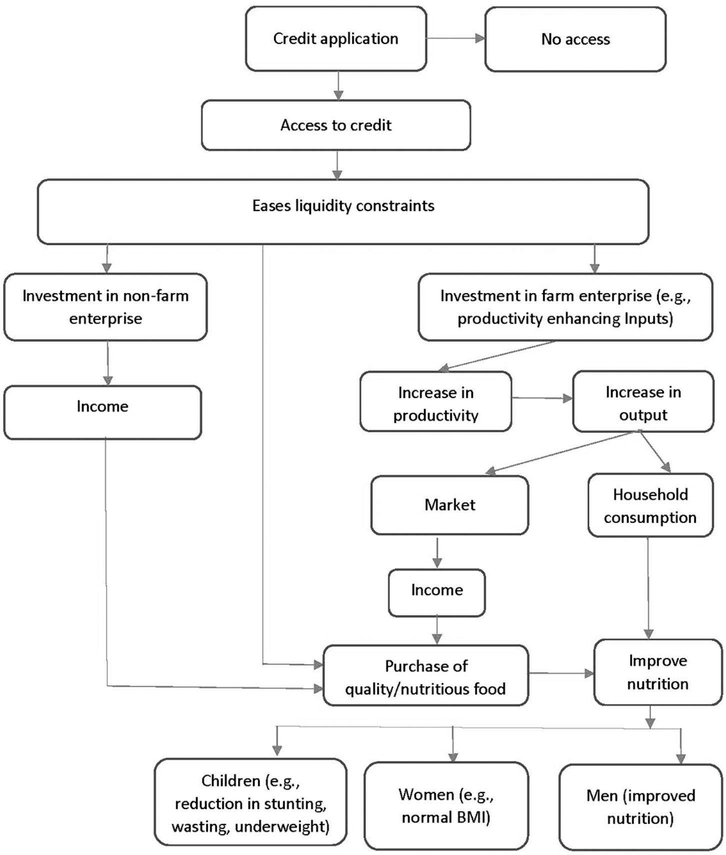

FIGURE 1 | Credit Pathways to Nutrition.

enterprises. Investments in farm enterprises involve adopting technology, potentially increasing production and productivity (Duong and Izumida 2002). Productivity and output growth enable households to consume their own produce and raise enough marketable surplus to participate in the market to raise incomes. Incomes from crop sales can be used to meet household consumption expenditures, such as purchasing quality and nutritious foods to supplement their own consumption. This assertion corresponds to the Ricardian trade theory, which postulates that farmers sell their produce to gain some utility by concentrating on the production of comparatively advantaged crops in exchange for products that have no comparative advantage (see Ricardo 1817). The combined effect of their own consumption and purchased nutritious products is an improvement in households' nutrition, primarily a reduction in stunting, wasting, and underweight in children.

Investment of credit in nonfarm enterprises (e.g., agro-processing, retail shops, and services) generates income, which aids in the purchase of nutritious products from the open market and hence improves nutrition. Further, liquidity from credit could be spent on nutritious foods, leading to improved nutrition.

Based on the foregoing discussion, the study seeks to test the following hypotheses:

H1: Access to credit by farm households reduces stunting, wasting, and being underweight in children.

H2: Credit influences nutritional outcomes through productivity, market participation, crop sale income, and nonfarm business equipment ownership.

Theoretically, nutritional outcomes (in this case, stunting, wasting, and underweight) are treated under production theory, where these outcomes are taken as outputs flowing from a production function (Behrman and Deolalikar 1988; Strauss and Thomas 1995; Garrett and Ruel 1999) and imply that a specific technology maps some inputs into these outcomes. Thus, we can mathematically represent the output (nutritional outcomes) of a household, NO_{ij} and a set of household inputs, X_i in a typical nutrition production function as:

$$NO_{ij} = f\left(X_i\right) \tag{2}$$

where this typical nutrition production function is derived from a maximization of a household utility function from first principles; i represents a household and j indicates the specific outcome (i.e., $j = 1, 2, 3$). Generally, various proxies of social, economic, locational, and biological characteristics (Garrett and Ruel 1999) can be used to represent the arguments in Equation (2).

This implies that the nutrition function for children based on Equation (2) can be presented as:

$$NO_{ij}^{c} = f\left(CC_i, WC_i, HC_i\right) \tag{3}$$

where CC_i, WC_i, and HC_i, respectively, define vectors of child, woman, and household characteristics. However, considering the hypotheses underlying this study, we need to include among the arguments in Equations (2) and (3) a household credit indicator (policy) variable, $CRED_i$. Thus, Equations (2) and (3) transform to:

$$NO_{ij}^{c} = f\left(CC_i, WC_i, HC_i, CRED_i\right) \tag{4}$$

Econometric Specifications and Estimation

A notable implication of Equation (4) is that appropriate proxies of CC_i, WC_i, and HC_i should serve as control factors for an unbiased and consistent effect of $CRED_i$ to be estimated. The literature and the data at hand influence this study's choice of explanatory variables. UNICEF (1990) identifies three key input factors: meal frequency, quantity of food per meal, and energy and nutrient density. Since we do not have these specific variables, we proxy them using some household characteristics that measure caloric intake, such as annual per capita food expenditure, number of crops cultivated, ownership of animals, and dietary diversity.

Following the theoretical models in Equations (3) and (4), the empirical model to be estimated is:

$$NO_{ij}^{c} = \delta_0 + \delta_1 \boldsymbol{CC_{ij}} + \delta_2 \boldsymbol{WC_{ij}} + \delta_3 \boldsymbol{HC_{ij}} + \delta_4 \boldsymbol{CRED_{ij}} + \varepsilon_{ij} \tag{5}$$

where NO_{ij}^{c} is children's nutritional outcomes proxied by anthropometric measures of HAZ, WAZ, and WHZ; *CC*, *WC*, *HC*, and *CRED* are as defined before; δ_0, δ_1, δ_2, δ_3, δ_4 are the parameters to be estimated; and ε_{ij} is the stochastic error term. The parameter of interest is δ_4 since it captures the effect of credit policy on children's nutritional outcomes.

However, two notable issues can constrain an unbiased estimate of the effect of $CRED_i$ on nutrition, even if the relevant control factors are included. First, $CRED_i$ is potentially endogenous to NO_{ij}^{c}. Thus, potentially, unobserved factors that determine access to credit may also determine the nutritional outcomes of children. In addition, selectivity bias resulting in nonrandomness in credit access causes endogeneity. Ignoring potential endogeneity would bias the effect. Second, the three outcomes of children (stunting, wasting, and underweight) share some relationship. Though the literature is inconclusive on the relationship among these indicators (Richard et al. 2012a), we find vital evidence on the type and nature of association these outcomes share (Doherty et al. 2001; Dewey et al. 2005; Richard et al. 2012b; Prentice et al. 2013; Ngwira et al. 2017). Guided by these association pieces of evidence, modeling children's outcomes as separable and standalone models may lead to bias. These two issues imply that an appropriate econometric model must make provisions to resolve endogeneity and nonseparability. The well-known impact evaluation estimation techniques, such as propensity score matching and difference-in-differences, cannot address nonseparability.

We propose a three-stage estimation for systems of simultaneous equations (reg3) model. This model estimates a system of structural equations, permitting the inclusion of endogenous explanatory variable(s), with an estimation through three-stage least squares (3SLS). The structural equation system component of the model deals with the second econometric issue (nonseparability of outcomes), and the endogenous explanatory variable(s) component deals with the first econometric issue (endogeneity of credit access). Essentially, reg3 follows an instrumental variable (IV) approach, which introduces another confounding challenge since an IV estimation's success relies on the instruments' reliability and validity. The dataset has a variable on membership of a household in the credit and microfinance group that can potentially serve as an instrument. However, this variable is likely to correlate with other model variables. Therefore, we rely on an approach used by Strauss (1986) and Mwabu (2009) to construct a cluster-level variable from the membership variable to be used as the instrument. This cluster-level instrument is the proportion of households in a cluster who are credit group members. The argument for the exogeneity of this instrument is that a typical household does not have any influence on the number of households in a cluster that belong to credit groups. Thus, by implication, this instrument affects access to credit directly but is orthogonal to nutritional outcomes.

The first stage of the reg3 model is to obtain estimates of the regression:

$$CRED_i = \phi_0 + \phi_1 \boldsymbol{WC_i} + \phi_2 \boldsymbol{HC_i} + \phi_3 \boldsymbol{CRDGR_i} + \psi_i \tag{6}$$

where $CRDGR_i$ is the instrument (cluster-level proportion of households in a credit group). From the regression in Equation (6), predicted values, $\widehat{CRED}_i$ are obtained. The second stage is the internal estimation of the covariance matrix of the equation disturbances from the residuals of a two-stage least squares (2SLS) estimate of each of the four equations in the system. Finally, the third stage is the application of the generalized least squares estimator (see Aitken 1936) using the covariance matrix and the instrumented values to derive the estimates of the parameters of the system:

$$NO_{ij}^{c} = \delta_0 + \delta_1 \boldsymbol{CC_{ij}} + \delta_2 \boldsymbol{WC_{ij}} + \delta_3 \boldsymbol{HC_{ij}} + \delta_4 \widehat{\boldsymbol{CRED}}_{\boldsymbol{i}} + \varepsilon_{ij} \tag{7}$$

In Equation (7), δ_4 is the unbiased and consistent estimate of the effect of credit on child nutritional outcomes.

For the second objective, from the conceptual model (Figure 1), we identified four channels supported by the data through which credit can affect children's nutritional outcomes. These are productivity, market participation, crop sales income, and nonfarm business equipment ownership. We used mediation analysis to evaluate these channels. The first step of the mediation analysis—to estimate the effect of credit on nutritional outcomes to test whether credit significantly influences nutritional outcomes—is simply the 3SLS estimation of Equation (7). The second step is to evaluate whether credit significantly influences these four channels. Since market participation and ownership of nonfarm business equipment are dummy variables (see Table 1), extended probit (eprobit) that permits the modeling of endogenous covariate (credit) models are estimated to account for possible endogeneity of credit and these variables. For productivity and crop sale income, linear regression that permits the modeling of an endogenous covariate (eregress) is applied to account for the endogeneity of credit and these variables. The final step in the mediation analysis is to estimate the effect of credit on nutritional outcomes while including these four channels in the model. This is a re-estimation of Equation (7) with the inclusion of these four-channel variables. For these channels to possess the power of mediation for credit, credit should no longer be a significant determinant or have a weak effect on nutritional outcomes.

Data

This study used the USAID Ghana FTF baseline survey data. The data were first collected in 2012 in the SADA region comprising Northern, Upper West, Upper East, Northern Volta, and Brong Ahafo by the Monitoring Evaluation and Technical Support Services with support from the Kansas State University, University of Cape Coast, the Institute of Statistical, Social and Economic Research at the University of Ghana, and the Ghana Statistical Service (GSS).

TABLE 1 | Description and Measurements of Variables

Description	*Measurement*
Outcome and treatment characteristics	
Height-for-age (H/A)	H/A z-score
Weight-for-age z-score (W/A)	W/A z-score
Weight-for-height z-score (W/H)	W/H z-score
Access to formal credit	Dummy: 1 = if received formal credit; 0 = otherwise
Household characteristics	
Age of head	Number of years
Male head	Dummy: 1 = if yes; 0 = otherwise
Household size	Number of people in household
Head can read and write in English	Dummy: 1 = if yes; 0 = otherwise
Area of residence	Dummy: 1 = if rural; 0 = otherwise
Number of group membership of head	Count of membership in 4 groups[a]
Number of crops grown	Count of 3 crops cultivated[b]
Household has animals	Dummy: 1 = if yes; 0 = otherwise
Annual per capita food expenditure	Food expenditure per household member (Ghana cedi (GHS)/person)
Number of agricultural land owned	Hectares
Joint crop and livestock decision-making	Dummy: 1 = if head and spouse decide; 0 = otherwise
Yield	Total output per total farm size (kg/ha)
Sold crop	Dummy: 1 = if yes; 0 = otherwise
Crop sale income	Ghana cedi (GHS)
Ownership of nonfarm business equipment	Dummy: 1 = if yes; 0 = otherwise
Women characteristics	
Age of woman	Number of years
Woman can read and write in English	Dummy: 1 = if yes; 0 = otherwise
Height of woman	Centimeters
Number of food groups consumed	Count of nine food groups consumed[c]
Child characteristics	
Age of child	Number of months
Male child	Dummy: 1 = if yes; 0 = otherwise
Child's birth order	Birth order number
Regional and cluster characteristics	
Northern	Dummy: 1 = if in Northern; 0 = otherwise
Brong-Ahafo	Dummy: 1 = if in Brong_Ahafo; 0 = otherwise
Upper East	Dummy: 1 = if in Upper East; 0 = otherwise

Description	*Measurement*
Upper West	Dummy: 1 = if in Upper West; 0 = otherwise
Membership in credit group	Proportion

Note: [a] Groups are agricultural/livestock, trade and business, civic and mutual help; [b] Crops grown are maize, rice, and soya; [c] Food groups are starchy staples, dark green leafy vegetables, other vitamin-A rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes and nuts, and milk and milk products.

The SADA region covers a land area of 123,141 square kilometers, representing about 52% of the total land area in Ghana (see Figure A1 in Appendix). It houses 61 administrative districts: all 26 in Northern, 9 out of the 29 in Brong Ahafo, all 15 in Upper East, and all 11 in Upper West. The area's total population in 2010 was 4,933,838 million, accounting for about 20% of Ghana's population (GSS 2019). Agriculture is the region's mainstay, accounting for over 80% of the economic activities. The justification for the concentration in the SADA areas was based on the realization that poverty, malnutrition, and stunting among children under five years were high, so by concentrating efforts in these areas, actions could be stimulated to tackle the situation.

A total of 4,410 households were interviewed across the zone, including 3,361 children (0–59 months) and 4,513 women (15–49 years). However, after merging the data from the various modules, the final sample was 2,085 households comprising 3,179 children (0–59 months) and women (15–49 years). The specific variables used in the analysis are presented in Table 1.

Joint crop and livestock decision-making is introduced as a variable to measure women's level of empowerment and engagement in the crop and livestock together with their spouses, which boosts food security and nutrition (see Asitik and Abu 2020; Quisumbing and Maluccio 2003). Since credit may provide the opportunity for households to invest in nonfarm enterprises, which then provides income that can boost nutrition through purchases or farm investment to expand output, ownership of nonfarm business equipment is used as a proxy for nonfarm enterprises and included as a transmission channel for credit. As presented in Figure 1, productivity, which is measured as kg/ha, is a crucial channel for credit because credit stimulates technology adoption and thus increases agricultural output (see Duong and Izumida 2002; Nwosu and Orji 2017). Market participation, measured as the decision of farmers to sell their crop output (i.e., a dummy variable), is expected to improve nutrition through income from crop sales (see Haji 2022; Nkegbe and Abdul Mumin 2022). The data do not capture children's dietary diversity (i.e., the number of food groups consumed). But since dietary diversity influences nutrition (see Khamis et al. 2019; Aboagye et al. 2021; Seid and Cherie 2022), the dietary diversity of mothers (i.e., women) is used to proxy for that of children because it can be inferred that children will basically take what their mothers take. Key household characteristics such as ownership of animals and the number of crops grown are expected to boost nutrition. For example, the number of crops grown is an indicator of household production diversity that can provide enough food for its own consumption and surplus for market engagement that raises income to purchase food not produced by the household. Ownership of animals can provide an important source of protein and help smoothen consumption by providing income when crop failures come.

RESULTS AND DISCUSSIONS

Descriptive Statistics of Outcome and Explanatory Variables

The descriptive statistics of anthropometric indicators of children and credit are presented in Table 2. Before applying the WHO anthropometric standards, only HAZ had valid estimates for all the 3,179 children, with a mean of –1.23 and ranging from –11.88 to 25.15. WAZ and WHZ had respective valid estimates for 3,164 and 3,141 children with means of –0.55 and 0.35 with respective ranges of –9.55 to 63.48 and –14.23 to 85.51. Thus, 15 and 38 estimates of WAZ and WHZ, respectively, were missing due to weights or heights, which were not in the range that "Anthro" software accepts.

To ensure that extreme *z*-scores do not distort analysis, WHO has provided guidelines on *z*-scores that qualify as outliers and should be eliminated. For HAZ, when the *z*-score for a child is greater than 6 or smaller than –6; for WAZ when the *z*-score is greater than 5 or smaller than –6; for WHZ when the *z*-score is greater than 5 or smaller than –5, such observations should be flagged and removed from the analysis. After applying these standards, 398 observations (12.5% of the sample of 3,179) were dropped, leaving the final sample for analysis as 2,781. Therefore, after applying the WHO standards, the mean HAZ is –1.28 with a minimum of –5.99 and a maximum of 6.0; the mean WAZ is –0.90 with a minimum of –5.23 and a maximum of 4.29; the mean WHZ is –0.23 with a minimum of –4.97 and a maximum of 4.98. The sex distribution of these anthropometric indicators shows that, except for the WHZ indicator, girls have better *z*-scores than boys for all the indicators.[1] Now focusing on the prevalence of stunting, underweight, and wasting, the results in Table 2 show that 34.7% of children (964 children 0–59 months old) are stunted, 18.3%

TABLE 2 | Descriptive Statistics of Anthropometric Indicators and Credit

Variable	*Sample*	*Mean*	*S.D.*	*Min.*	*Max.*
Before WHO standard reference					
Height-for-age *z*-score (HAZ)	3,179	−1.232	3.021	−11.88	25.15
Weight-for-age *z*-score (WAZ)	3,164	−0.554	2.756	−9.55	63.48
Weight-for-height *z*-score (WHZ)	3,141	0.349	3.969	−14.23	85.51
After WHO standard reference					
Height-for-age *z*-score (HAZ)	2,781	−1.280	1.961	−5.99	6.00
Boys	1,412	−1.361	1.975	−5.99	5.72
Girls	1,369	−1.197	1.945	−5.91	6.00
Weight-for-age *z*-score (WAZ)	2,781	−0.903	1.328	−5.23	4.29
Boys	1,412	−0.925	1.352	−5.19	4.29
Girls	1,369	−0.881	1.303	−5.23	4.04
Weight-for-height *z*-score (WHZ)	2,781	−0.227	1.633	−4.97	4.98
Boys	1,412	−0.206	1.670	−4.97	4.97
Girls	1,369	−0.249	1.595	−4.97	4.98
Prevalence rates					
Stunting (HAZ < −2SD)	2,781	0.347	0.476	0.00	1.00
Boys	1,412	0.368	0.483	0.00	1.00
Girls	1,369	0.324	0.468	0.00	1.00
Underweight (WAZ < −2SD)	2,781	0.183	0.387	0.00	1.00
Boys	1,412	0.184	0.388	0.00	1.00
Girls	1,369	0.182	0.386	0.00	1.00
Wasting (WHZ < −2SD)	2,781	0.111	0.314	0.00	1.00
Boys	1,412	0.111	0.314	0.00	1.00
Girls	1,369	0.111	0.314	0.00	1.00
Credit access					
Before WHO reference	2,085	0.258	0.438	0.00	1.00
After WHO reference	1,820	0.170	0.376	0.00	1.00

(509 children 0–59 months old) are underweight, and 11.1% (309 children 0–59 months old) are wasted. The sex distribution of prevalence indicates that boys (36.8%) are more stunted than girls (32.4%), and boys (18.4%) are slightly more underweight than girls (18.2%). The wasting prevalence (11.1%) is the same for boys and girls.

The results for the treatment variable (credit) in Table 2 show that from the initial 2,085 households, 25.8% have access to formal credit. After dropping observations with flagged anthropometric scores, 17.0% of the remaining observations (1,820) have access to credit. This observation implies low access to credit and agrees with previous findings on access to financial services in Ghana (see Abu and Issahaku 2017; Sekyi et al. 2017) and data from the Global Findex. The descriptive statistics for all other variables used in the econometric estimations are reported in Table 3.

TABLE 3 | Descriptive Statistics of the Analytical Sample

	Credit (n = 465)		*No credit (n = 2,316)*			*Overall (n = 2,781)*	
Variable	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean Diff.*	*Mean*	*S.D.*
Access to formal credit						0.168	0.374
Anthropometric indicators							
Height-for-age *z*-score (HAZ)	−0.656	2.890	−1.405	1.689	0.750***	−1.280	1.961
Weight-for-age *z*-score (WAZ)	−0.228	1.617	−1.039	1.218	0.811***	−0.903	1.328
Weight-for-height *z*-score (WHZ)	0.294	2.359	−0.332	1.422	0.626***	−0.227	1.633
Household characteristics							
Age of head	41.06	12.62	40.373	13.341	0.683	40.487	13.223
Male head	0.856	0.352	0.881	0.324	−0.025	0.877	0.329
Household size	7.699	3.914	7.734	3.922	−0.035	7.728	3.920
Head can read and write in English	0.301	0.459	0.122	0.328	0.179***	0.152	0.359
Area of residence	0.738	0.440	0.843	0.364	−0.106***	0.826	0.380
Number of group membership of head	0.538	0.706	0.339	0.584	0.199***	0.372	0.610
Number of crops grown	1.331	0.899	1.206	0.831	0.126***	1.227	0.844
Household has animals	0.733	0.443	0.725	0.446	0.008	0.727	0.446
Annual per capita food expenditure	763.1	695.6	634.6	716.3	128.4***	656.1	714.4
Number of agricultural land owned	5.099	7.184	3.428	4.308	1.671***	3.707	4.946
Joint crop and livestock decision-making	0.159	0.366	0.078	0.268	0.081***	0.092	0.289
Yield	478.0	500.0	370.2	414.5	107.9***	388.2	431.8
Sold crop	0.520	0.500	0.508	0.500	0.012	0.510	0.500
Crop sale income	269.9	661.7	102.2	317.4	167.8***	130.2	401.1
Ownership of nonfarm business eq.	0.277	0.448	0.225	0.417	0.053**	0.233	0.423
Women characteristics							
Age of woman	30.21	7.325	29.93	7.573	0.280	29.98	7.532
Woman can read and write in English	0.135	0.343	0.088	0.283	0.048***	0.096	0.294

Variable	Credit (n = 465) Mean	S.D.	No credit (n = 2,316) Mean	S.D.	Mean Diff.	Overall (n = 2,781) Mean	S.D.
Height of woman	159.3	8.384	159.2	7.969	0.081	159.2	8.038
Number of food groups consumed	4.574	2.459	4.123	1.722	0.452***	4.198	1.873
Child characteristics							
Age of child	27.98	17.34	29.18	16.28	−1.199***	28.98	16.47
Male child	0.523	0.500	0.505	0.500	0.018	0.508	0.500
Child's birth order	1.467	0.796	1.440	0.714	0.026	1.445	0.728
Regional and cluster characteristics							
Northern	0.598	0.491	0.708	0.455	−0.110***	0.690	0.463
Brong-Ahafo	0.108	0.310	0.098	0.297	0.010	0.100	0.300
Upper East	0.174	0.380	0.116	0.320	0.058***	0.126	0.332
Upper West	0.120	0.326	0.078	0.268	0.043***	0.085	0.279
Proportion in credit group	0.407	0.222	0.281	0.202	0.126***	0.302	0.210

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$ Sampling weights are used in deriving the various statistics.

Effect of Formal Credit on Nutritional Outcomes of Children

Before estimating the baseline 3SLS model, we first estimated the structural system of HAZ, WAZ, and WHZ separately using OLS. The results of both the OLS and 3SLS are presented in Table 4 where columns 2, 3, and 4 are the OLS standalone estimates, and columns 5, 6, and 7 are the structural estimates of the 3SLS. We checked the relevance of the instrument used in the 3SLS estimates by examining whether it is strongly or weakly correlated with credit using the rule of thumb suggested by Staiger and Stock (1997). According to this approach, the instrument is weakly identified if the *F*-statistic in the estimates of Equation (6), the first stage regression of the 3SLS, is less than 10. The results of the estimates are presented in Table A1 in Appendix, which shows that the *F*-statistic is 17.28, which signifies that the instrument is strongly identified. The statistically significant effect of the instrument on credit access in Table A1 strengthens its relevance. In addition, an exogeneity test of the instrument was conducted by estimating an OLS regression of the outcomes on the instrument (see Table A2 in Appendix). The results show that the instrument is not statistically significant in any of the models, indicating that it is exogenous. This further confirms the validity of the instrument.

Turning to the results in Table 4, we found that after controlling for relevant factors, the effect of formal credit on anthropometric indicators is positive and statistically significant in all three indicators for both the OLS and the 3SLS estimates. This implies that access to formal credit increases HAZ, WAZ, and

TABLE 4 | Determinants of Child Anthropometric Indicators

	OLS			*3SLS*		
Variable	*HAZ*	*WAZ*	*WHZ*	*HAZ*	*WAZ*	*WHZ*
Access to formal credit	0.438***	0.658***	0.677***	1.302***	1.713***	1.603***
Household characteristics						
Age of head	0.005	0.003	0.001	0.004	0.002	0.000
Male head	−0.143	−0.039	0.066	−0.113	−0.002	0.099
Household size	0.025**	0.013*	−0.006	0.022**	0.009	−0.009
Head can read and write in Eng.	0.367***	0.116	−0.135	0.220*	−0.063	−0.292**
Area of residence	−0.074	−0.017	0.055	−0.017	0.053	0.117
No. of group mem. of head	−0.109**	−0.159***	−0.162***	−0.170***	−0.232***	−0.227***
Number of crops grown	0.121***	0.089***	0.019	0.094**	0.055*	−0.011
Household has animals	0.436***	0.353***	0.172**	0.458***	0.380***	0.195**
Log of annual p.c. food exp.	0.076***	0.096***	0.078***	0.060**	0.076***	0.060***
Joint crop/live. decision	0.560***	0.417***	0.138	0.484***	0.324***	0.056
Woman characteristics						
Age of woman	−0.001	−0.001	−0.002	−0.001	−0.001	−0.002
Woman read and write in Eng.	−0.098	0.026	0.090	−0.091	0.035	0.097
Height in centimeters	0.014***	0.009***	0.002	0.015***	0.010***	0.002
No. of food groups consumed	0.257***	0.148***	−0.004	0.250***	0.140***	−0.011
Child characteristics						
Age of child	−0.031***	−0.009***	0.012***	−0.031***	−0.009***	0.013***
Male child	−0.137**	−0.037	0.032	−0.146**	−0.047	0.022
Child's birth order	−0.008	−0.072*	−0.083	−0.015	−0.081**	−0.090*
Regional characteristics						
Northern	−0.209*	−0.126	0.046	−0.163	−0.069	0.095
Brong_Ahafo	0.103	0.225**	0.305**	0.129	0.257**	0.333**
Upper East	−0.147	−0.285***	−0.250*	−0.143	−0.280***	−0.246*
Constant	−4.674***	−3.686***	−1.493**	−4.770***	−3.803***	−1.596**
Observations	2,781	2,781	2,781	2,781	2,781	2,781
F-statistic	37.061***	29.719***	8.352***	35.238***	23.668***	5.710***
R-square	0.220	0.184	0.060	0.195	0.103	0.019
Log likelihood	−5473.532	−4451.068	−5223.786		−10108.805	

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; HAZ is height-for-age *z*-score; WAZ is weight-for-age *z*-score; WHZ is weight-for height *z*-score; Endogenous variables are HAZ, WAZ, WHZ, and Credit; Exogenous variables are all the above explanatory variables including the instrument (proportion of households in credit group in a cluster). See definitions of variables in Table 1.

WHZ, and this effect is robust for the two models. However, the OLS estimates are consistently lower in magnitude. These downwardly biased OLS estimates arise from two likely sources: endogeneity of credit and nonseparability of child nutritional outcomes. Thus, we concentrate our discussion on the estimates of 3SLS, which have accounted for endogeneity and nonseparability. In specific terms, the 3SLS estimates indicate that access to credit respectively increases HAZ, WAZ, and WHZ by 1.302, 1.713, and 1.603. These findings indicate that credit positively affects the nutritional outcomes of children. The positive effect of credit on nutritional outcomes can be attributed principally to easing farmers' liquidity constraints by offering the capital to invest in adopting technology, which potentially leads to increases in productivity and stimulating their own consumption and income from crop sale to finance the purchase of quality and nutritious foods at the open market. This capital can also be invested in non-farm businesses to generate income to purchase quality and nutritional foods. Therefore, the finding confirms the conceptual model in Figure 1.

This finding conforms with some literature. For example, Kiresur et al. (2010) observed that providing productive assets such as credit to poor farm households would stimulate nutritional outcomes by boosting productivity. In addition, Webb and Block (2012) indicated that supporting agriculture reduces stunting and wasting. In part, the finding also corroborates Malapit and Quisumbing (2015) regarding the effect of the empowerment of women in credit decisions on child nutritional outcomes. They found that the active participation of women in credit decisions positively influences WHZ and increases the number of food groups consumed as well as the probability of female children consuming minimum acceptable diets.

The results of significant control factors are in three classes: control factors that simultaneously correlate with all three indicators (ownership of animals, number of group membership, annual per capita food expenditure, and age of child), control factors that simultaneously correlate with only two anthropometric indicators (number of crops cultivated, joint crop and livestock decision making, height of woman, and number of food groups consumed by the woman which positively correlate with HAZ and WAZ; head able to read and write in English which, respectively, positively and negatively correlate with HAZ and WHZ; birth order of child which negatively correlates with WAZ and WHZ; Brong_Ahafo dummy which positively correlates with WAZ and WHZ; and Upper East dummy which negatively correlates with WAZ and WHZ) and control factors that are nonsimultaneous correlates—those that influence only one anthropometric indicator (household size and male child dummy influencing HAZ).

To provide further robustness to the 3SLS estimates, we estimated the effect of credit on the standalone anthropometric measures using the propensity score matching (PSM). The results of the logit estimates on which the propensity scores are estimated are reported in Table A3 in Appendix, while the estimated average treatment effects are reported in Table A4. The estimates of the effects are positive and statistically significant. Though these estimates are lower in magnitude relative to the 3SLS estimates—but higher than the OLS estimates—they show that credit's effect on children's nutritional outcomes is robust to alternative econometric specifications.

After the baseline model, we estimated a model to test the moderating effect of gender on the link between access to credit and child nutritional outcomes (see Table A5 in Appendix). The results reveal that there is no moderating effect of gender on the link between credit access and nutritional outcomes of children, as the interaction is not statistically significant. This implies that there is no gender bias in the effect of credit on the nutritional outcomes of children.

Channels Through Which Credit Impacts Nutritional Outcomes

The first step of the mediation analysis—to estimate the effect of credit on nutritional outcomes to test whether credit significantly influences nutritional outcomes—has been evaluated (i.e., Table 4), and the evidence shows that there is ground for mediation since credit is a significant determinant of nutritional outcomes. The results of the second step of the mediation analysis, which is to evaluate whether credit significantly influences these channels, are reported in Table 5 (i.e., eregress estimates for productivity and income from crop sale channels) and Table 6 (i.e., eprobit estimates for market participation and ownership of nonfarm business channels).

The results in Tables 5 and 6 show that the coefficients of the credit variable in the productivity, sales income, market participation, and ownership of nonfarm business equipment models are positive (0.625, 0.903, 0.297, and 0.203, respectively) and statistically significant. These imply that households with access to credit are 62.5% more productive, earn 90.3% more income from crop sales, and are more likely to sell crops they produce and own nonfarm business equipment than those who do not have access to credit, respectively. The significant effect of credit on these four channels provides another ground for mediation. The final step in the mediation analysis is to estimate the effect of credit on nutritional outcomes while including these channels in the model (Table 7).

The results show that after including these mediation variables in the model, the effect of credit on nutritional outcomes is not only weak (in terms of the level of significance and magnitude), but it does not simultaneously affect all the measures of nutritional outcomes. However, the transmission channels all significantly affect nutritional outcomes. Due to the weak effect of credit on HAZ and WAZ, these transmission channels partially mediate the effect of credit on the nutritional outcomes of children. Therefore, credit fuels productivity gains by providing capital to invest in adopting productivity-enhancing technology. Gains in productivity then allow households to produce more for consumption, raise marketable surpluses for sale, and subsequently increase income from crop sales to enable them to purchase diverse foods they do not grow on their farms. Thus, incomes from crop sales can be used to meet household consumption expenditures, such as purchasing quality

TABLE 5 | Estimates of Determinants of Productivity and Income from Crop Sales

	Productivity		*Income from crop sales*	
Variable	*Yield*	*Credit*	*Sales*	*Credit*
Access to formal credit	0.625***		0.903***	
Age of head	−0.005*	0.000	−0.009***	0.000
Male head	0.746***	−0.053**	0.341***	−0.055**
Household size	0.035***	0.002	−0.027*	0.002
Head can read and write in English	−0.059	0.227***	−0.102	0.227***
Area of residence	0.750***	−0.072***	−0.147	−0.074***
Number of group membership of head	0.069	0.041***	0.086	0.041***
Number of crops grown	1.378***	−0.021**	0.545***	−0.024**
Household has animals	0.257***	−0.024	−0.321***	−0.026
Log of annual p.c. food expenditure	−0.011	0.030***	−0.051*	0.030***
Joint crop and livestock decision-making	−0.167		−0.237*	
Log of yield			0.492***	0.002
Log of agricultural land owned		0.146***		0.148***
Age of woman	0.000	−0.000	−0.008	−0.000
Woman can read and write in English	−0.373***	−0.023	−0.298**	−0.022
Dietary diversity score (DDS)	−0.023	−0.014***	0.094***	−0.014***
Northern	0.248**	0.015	0.937***	0.012
Brong_Ahafo	−0.532***	0.034	1.464***	0.032
Upper East	−0.357**	0.089***	0.258	0.087***
Proportion in credit group		0.435***		0.423***
Constant	1.672***	−0.099	−0.998***	−0.097
Observations	3,179			3,179
F-statistic	93.545***		153.077***	
Corr(credit and yield)	−0.116***			
Corr(credit and sales)			−0.058	

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; The dependent variables are in logs; Sampling weights used in estimations.

and nutritious foods to supplement their own consumption. Credit also provides capital for investment in nonfarm enterprises, which generates income for purchasing nutritious products from the open market and improves nutrition.

The cautious conclusion from these findings is that access to credit promotes nutrition by easing liquidity constraints for farmers and increasing productivity, market participation, nonfarm engagements, and income. This is consistent with our conceptual model and the findings of Duong and Izumida (2002) and Kiresur et al. (2010).

TABLE 6 | Estimates of Determinants of Market Participation and Nonfarm Business

	Market participation		*Nonfarm business*	
Variable	*Sold crop*	*Credit*	*Equipment*	*Credit*
Access to formal credit	0.297**		0.203*	
Age of head	−0.004*	0.000	−0.005**	0.000
Male head	0.036	−0.055**	−0.254***	−0.055**
Household size	−0.021***	0.002	0.001	0.002
Head can read and write in English	0.008	0.227***	−0.013	0.227***
Area of residence	0.147*	−0.074***	−0.233***	−0.074***
Number of group membership of head	0.062	0.041***	0.185***	0.041***
Number of crops grown	0.243***	−0.024**	−0.008	−0.024**
Household has animals	−0.144**	−0.026	−0.024	−0.025
Log of annual p.c. food expenditure	−0.035**	0.030***	−0.017	0.030***
Log of agricultural land owned		0.148***		0.147***
Joint crop and livestock decision-making	−0.235***		−0.273***	
Log of yield	0.477***	0.002	−0.001	0.002
Age of woman	−0.000	−0.000	0.005	−0.000
Woman can read and write in English	−0.247**	−0.022	−0.026	−0.022
Number of food groups consumed	0.062***	−0.014***	0.072***	−0.014***
Northern	0.580***	0.012	−0.005	0.013
Brong-Ahafo	0.929***	0.032	0.034	0.033
Upper East	0.228*	0.087***	−0.365***	0.088***
Proportion in credit group		0.425***		0.428***
Constant	−3.142***	−0.098	−0.488**	−0.100
Observations	3,179		3,179	
F-statistic	38.727***		6.903***	
Corr(credit and participation)	−0.108*			
Corr(credit and nonfarm business)			−0.016	

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; sampling weights used in estimation.

CONCLUSION AND POLICY IMPLICATIONS

This study used credit from formal sources to assess the effect of credit policy on the nutritional outcomes of children in the SADA zone of Ghana. We used anthropometric indicators of height-for-age, weight-for-age, and weight-for-height *z*-scores to proxy for child nutritional outcomes of stunting, underweight,

TABLE 7 | Mediation Effect of Transmission Channels

Variable	*HAZ*	*WAZ*	*WHZ*
Access to formal credit	0.005*	0.016*	0.011
Log of yield	0.095***	0.091***	0.050**
Log of income from crop sale	0.063**	0.053***	0.028**
Sold crop	0.275**	0.193**	0.088**
Ownership of nonfarm business equipment	0.355**	0.125*	0.095*
Age of head	0.003	0.002	0.000
Male head	−0.053	0.072	0.151
Household size	0.023**	0.010	−0.008
Head can read and write in English	0.196	−0.082	−0.299**
Area of residence	0.021	0.109	0.160*
Number of group membership of head	−0.144**	−0.219***	−0.228***
Number of crops grown	0.243***	0.205***	0.075
Household has animals	0.477***	0.402***	0.210***
Log of annual p.c. food expenditure	0.052**	0.071***	0.060***
Joint crop/livestock decision-making	0.443***	0.294***	0.048
Age of woman	−0.001	−0.001	−0.002
Woman can read and write in English	−0.132	−0.002	0.080
Height in centimeters	0.014***	0.009***	0.002
Number of food groups consumed	0.259***	0.144***	−0.012
Age of child	−0.030***	−0.009***	0.013***
Male child	−0.140**	−0.042	0.026
Child's birth order	−0.008	−0.075*	−0.088*
Northern	−0.130	−0.032	0.117
Brong_Ahafo	0.111	0.240**	0.323**
Upper East	−0.209	−0.321***	−0.252*
Constant	−4.415***	−3.504***	−1.461**
Observations	2,781	2,781	2,781
F-statistic	31.079***	22.049***	5.475***
R-square	0.196	0.101	0.019
Log likelihood		−10102.947	

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$; Source: Produced by the author using the GLSS6 Data.

and wasting. In addition, we validated a transmission mechanism of credit policy by estimating the pathways through which credit affects nutritional outcomes. In terms of econometric approaches, we argued that stunting, underweight, and wasting of children have an intrinsic relationship and should be modeled as a system. Credit is endogenous to these outcomes. Consequently, we applied the three-stage estimation for systems of the simultaneous equations (reg3) model to deal with the structural system and endogeneity of credit access. In addition, we employed eregress and eprobit models to test the pathways of credit to nutrition.

The entire results can be summarized into two key findings. First, while there may be numerous ways of improving children's nutritional outcomes, this study demonstrates that providing farm households with credit is one of the ways of making child-centered nutritional improvements in a household. Credit access trickles down to improving children's nutritional outcomes through investments in farm and nonfarm enterprises. Finally, credit works through yield, market participation, income from crop sales, and nonfarm business enterprises to affect nutritional outcomes. Based on these findings, this study concludes that a credit policy targeted at farm households will positively affect nutritional outcomes in Ghana and that this effect will impact children the most.

The policy implication of the conclusion of this study is that to retool agriculture to respond to burgeoning calls for nutrition-sensitive agriculture, the Government of Ghana, specifically through collaboration among the Bank of Ghana, the Ministry of Food and Agriculture, and financial institutions, should prioritize and develop an agricultural credit policy to offer credit to farm households. Since Ghana already has the Agricultural Development Bank, a bank established mainly to provide low-cost credit to agriculture, this collaboration should use this bank to develop a well-targeted credit policy that would ensure that barriers to credit such as collateral requirements, high interest rates, bureaucratic procedures, and tedious paperwork among others are removed to make formal credit accessible to farm households. For a successful credit policy, the bank's liquidity should be augmented, and the government should sustain the political will for the bank to stay within its mandate.

For people with low incomes and those experiencing chronic hunger, a targeted nutrition-sensitive credit policy is what is required to address their peculiar problems. This will involve the government and other development agencies deliberately targeting these people to ease access to credit and nutritional packages. Because of their disadvantaged situation, these poor individuals do not have the social connections and economic muscle to compete with those with the wherewithal for credit in the open and competitive financial marketplace. Thus, they will require a "big push" from policymakers to fully participate in the formal financial system and leverage the resources to improve their livelihood and nutrition.

The main weakness of this study is the use of several proxies to measure key variables due to data limitations. For example, there is no information on the ownership of nonfarm enterprises and operational details, including the profitability of the enterprises. The best information available is what has been used—ownership of nonfarm business equipment. However, equipment ownership does not necessarily mean the enterprise is operational or profitable. The data also do not provide information on meal frequency, the quantity of food per meal, and energy and nutrient density of food. Therefore, some household characteristics such as per capita food expenditure, number of crops cultivated, and ownership of animals are used as proxies. While these are appropriate given the circumstances, it would have been more insightful to use direct measures of meal frequency, the quantity of food per meal, and the energy and nutrient density of food.

APPENDIX

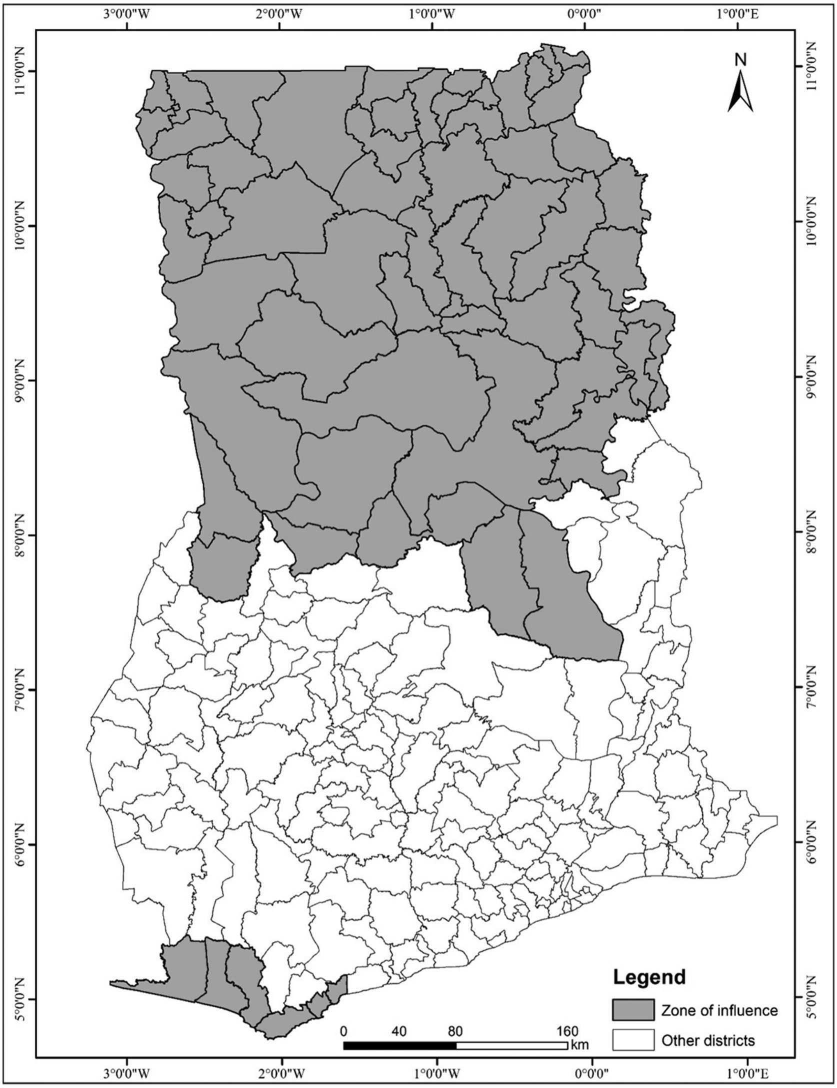

FIGURE A1 | Feed the Future (FTF) Zone of Influence in Ghana. Source: Malapit and Quisumbing (2015) and sources therein. The FTF zone of influence includes the Brong Ahafo, Northern, Upper East, and Upper West regions, and coastal areas benefiting from marine fisheries.

TABLE A1 | First-Stage Regression of Credit in 3SLS Regression

Variable	*Coefficient*	*Std. error*
Age of head	0.001	0.001
Male head	−0.021	0.022
Household size	0.002	0.002
Head can read and write in Eng.	0.156***	0.021
Area of residence	−0.055***	0.019
No. of group mem. of head	0.047***	0.011
Number of crops grown	0.033***	0.009
Household has animals	−0.022***	0.017
Annual p.c. food exp.	0.016***	0.004
Joint crop/live. decision	0.078***	0.024
Age of woman	−0.000	0.001
Woman read and write in Eng.	−0.005	0.025
Height in centimeters	−0.000	0.001
No. of food groups consumed	0.010***	0.004
Age of child	−0.000	0.000
Male child	0.010	0.013
Child's birth order	0.008	0.011
Northern	0.000	0.025
Brong_Ahafo	0.059*	0.033
Upper East	0.073**	0.031
Proportion in credit group	0.364***	0.034
Constant	−0.096	0.154
Observations		2,781
F-statistic		17.28***
R-square		0.116

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

TABLE A2 | Exogeneity Test of Instrument

Variable	*HAZ*	*WAZ*	*WHZ*
Proportion in credit group	0.474	0.623	0.583
Age of head	0.005*	0.004*	0.002
Male head	−0.141	−0.038	0.065
Household size	0.026**	0.013*	−0.005
Head can read and write in English	0.423***	0.205***	−0.042
Area of residence	−0.089	−0.042	0.028
Number of group membership of head	−0.109*	−0.152***	−0.152***
Number of crops grown	0.137***	0.112***	0.042
Household has animals	0.430***	0.342***	0.160*
Log of annual p.c. food expenditure	0.081***	0.104***	0.086***
Joint crop and livestock decision-making	0.585***	0.458***	0.180*

Variable	HAZ	WAZ	WHZ
Age of woman	−0.001	−0.002	−0.002
Woman can read and write in English	−0.097	0.027	0.090
Height in centimeters	0.014***	0.009***	0.002
DDS	0.264***	0.158***	0.006
Age of child	−0.031***	−0.010***	0.012***
Male child	−0.133**	−0.030	0.038
Child's birth order	−0.004	−0.067*	−0.077
Northern	−0.163	−0.069	0.095
Brong_Ahafo	0.205	0.357***	0.427***
Upper East	−0.048	−0.155	−0.129
Constant	−4.896***	−3.968***	−1.751**
Observations	2,781	2,781	2,781
F-statistic	26.983***	19.954***	5.964***
R-square	0.216	0.162	0.043

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$; Source: Produced by the author using the GLSS6 Data.

TABLE A3 | Logit Determinants of Access to Credit

Variable	Coefficient	Std. error
Age of head	0.001	0.004
Male head	−0.372**	0.151
Household size	0.016	0.015
Head can read and write in English	1.321***	0.138
Area of residence	−0.508***	0.131
Number of group membership of head	0.280***	0.077
Number of crops grown	−0.078	0.073
Household has animals	−0.208	0.139
Log of annual p.c. food expenditure	0.227***	0.036
Log of number of land owned	0.865***	0.051
Log of yield	0.005	0.027
Age of woman	−0.001	0.007
Woman can read and write in English	−0.102	0.174
Number of food groups consumed	−0.091***	0.026
Northern	0.070	0.182
Brong_Ahafo	0.232	0.251
Upper East	0.576***	0.219
Proportion in credit group	2.786***	0.245
Constant	−3.820***	0.466
Observations		3,179
Wald Chi-square		945.813***
Pseudo *R*-square		0.261
Log likelihood		−1338.788

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$; Source: Produced by the author using the GLSS6 Data.

TABLE A4 | PSM Estimates of the Effect of Credit on Child Nutrition

	Estimate		
Effect	*HAZ*	*WAZ*	*WHZ*
ATE	0.455***	0.915***	1.167***
	(0.153)	(0.145)	(0.180)

Note: Standard errors in parentheses; nearest neighbor matching algorithm used. ATE: Average treatment effects.

TABLE A5 | Moderating Effect of Gender on Credit's Effect on Child Nutritional Outcomes

Variable	*HAZ*	*WAZ*	*WHZ*
Access to formal credit	0.227**	0.315**	0.347**
Male head	–0.191	–0.116	–0.008
Credit*Male	0.245	0.397	0.382
Age of head	0.005*	0.003	0.001
Household size	0.025**	0.012	–0.007
Head can read and write in English	0.368***	0.118	–0.133
Area of residence	–0.076	–0.020	0.052
Number of group membership of head	–0.106*	–0.154***	–0.157***
Number of crops grown	0.122***	0.090***	0.020
Household has animals	0.438***	0.355***	0.174**
Log of annual p.c. food expenditure	0.076***	0.095***	0.077***
Joint crop/livestock decision	0.558***	0.414***	0.134
Age of woman	–0.001	–0.002	–0.002
Woman can read and write in English	–0.095	0.032	0.095
Height in centimeters	0.014***	0.009***	0.002
Number of food groups consumed	0.257***	0.147***	–0.004
Age of child	–0.031***	–0.009***	0.013***
Male child	–0.137**	–0.036	0.033
Child's birth order	–0.006	–0.070*	–0.080
Northern	–0.208*	–0.124	0.048
Brong_Ahafo	0.106	0.229**	0.309**
Upper East	–0.144	–0.280***	–0.245*
Constant	–4.622***	–3.602***	–1.413**
Observations	2,781	2,781	2,781
F-statistic	35.417***	28.635***	8.098***
R-square	0.220	0.186	0.061
Log likelihood		–9929.775	

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$; Source: Produced by the author using the GLSS6 Data; Credit*Male is the interaction term of credit and gender.

NOTES

The authors gratefully appreciate very helpful comments by David Sahn and Germano Mwabu, and participants at the review workshops for the collaborative research project on Impact of Agricultural and Food Policies on Nutrition Outcomes in Africa – Country Case Studies (AFPON Project).
This study was supported with a grant (Grant No. RC18522) from the African Economic Research Consortium.
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

1. Though only the estimates of HAZ shows a statistically significant difference.

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