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All that is gold does not glitter: Income and nutrition in Tanzania

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ABSTRACT

A substantial acceleration in improving nutrition is required to eradicate malnutrition by 2030. Income growth and increased labor productivity are key to realize this, but some income sources and employment sectors might be more effective in reducing malnutrition than others. We investigate the link between income and nutrition in rural Tanzania, using two rounds of the Tanzania National Panel Survey. We use both monetary and non-monetary measures of food consumption, and analyze besides caloric intake also the intake of important micronutrients, such as iron, zinc and vitamin A, and nutrient deficiencies. We compare income by employment sectors and by gender of the earner. We find that income growth is important for improving household nutrition, both in terms of food quantity and quality. We find that a higher share of income from agricultural self-employment as well as jointly earned income is strongly correlated with caloric and micronutrient intake across households. We do not find evidence to support the assertion that a higher share of income earned solely by women is associated with improved nutrition. Our results imply that closing the labor productivity gap between agriculture and rural non-farm sectors, and raising rural incomes from within agriculture, is a more effective strategy to improve nutrition in rural Tanzania than diversifying income away from agriculture.

1. Introduction

The second sustainable development goal (SDG) is to eradicate hunger and all forms of malnutrition by 2030. While important progress has been made since 2000, hunger is on the rise again globally and remains highest in Sub-Saharan Africa (SSA) (von Grebmer et al., 2019). Recently more attention is paid to food quality rather than solely focusing on food quantity as micronutrient deficiencies can lead to major health problems, particularly among mothers and (young) children (Black et al., 2013). One of the main pathways to reduce malnutrition is to increase labor productivity and household income (Masters et al., 2018). Stable economic growth in poor countries is considered to be essential to improve welfare and to achieve several SDGs, including the eradication of malnutrition (Smith and Haddad, 2015).

However, not every source of income or labor productivity growth is equally effective in improving nutrition. Both macro- and microeconomic studies on labor and welfare point to higher income effects from off-farm and non-agricultural employment, but larger poverty reducing effects from agricultural labor (Christiaensen et al., 2011; Frelat et al., 2016). Lately, there is a resurgence in research on agriculture-nutrition pathways, largely pointing to important micro-economic linkages between agricultural production and nutrition (Carletto et al., 2015; Pingali and Sunder, 2017; Gillespie et al., 2019). In addition, who earns the income might matter for nutritional outcomes. It is often asserted that income earned or controlled by women is spent differently and more strongly associated with household - and especially child - nutrition than income earned by men (Malapit and Quisumbing, 2015).

Despite an extensive literature on income and nutrition, there are some major gaps and shortcomings. Many studies focus on the relation between income and food security, or investigate the income elasticity of caloric intake. Little evidence is available on the quality aspect of food consumption or micronutrient deficiencies (Colen et al., 2018). In addition, few studies directly compare the effectiveness of different sources of income from different employment sectors, which may mask important nuances in the income-nutrition debate (Villa et al., 2010; Kirk et al., 2018). Moreover, in studying gender-disaggregated income little attention is paid to jointly earned income, which may result in an underestimation of the importance of cooperation within a household for nutrition (Doss et al., 2018). Finally, data quality remains an issue, as most studies are based on specific case studies or cross-sectional data.

In this paper we investigate the link between income and nutrition in rural Tanzania, analyzing nationally representative household survey

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data from two panel rounds in 2011 and 2013. We use both monetary and non-monetary measures of food consumption, and analyze besides caloric intake also the intake of important micronutrients, such as iron, zinc and vitamin A, and nutrient deficiencies. We explicitly distinguish between different income sources by comparing employment sectors, including agricultural and non-agricultural wage and self-employment, and by comparing the gender of the earner, including male, female and jointly earned income. We estimate both random and fixed effects models to reveal nuanced, complementary information. Our focus on Tanzania is relevant as it is one of the poorest countries in the world with a high undernourishment rate (ranked 95th out of 117 countries) and large micronutrient deficiencies, particularly for iron and vitamin A (MoHCDGEC et al., 2018; von Grebmer et al., 2019). These problems are more manifested in rural areas, where income diversification is more prevalent. This justifies our particular focus on rural Tanzania, where there is a need to understand the effectiveness of different income sources in improving nutrition.

2. Literature review

2.1. Income-nutrition elasticities

The literature on the link between income and nutrition finds its origins in Engel's law, which states that food budget shares decline when income rises (i.e. food demand is income inelastic). However, empirical studies that investigate food-income elasticities find very heterogeneous results. On the one hand, some (older) studies argue that food demand is completely income inelastic, as households are able to smooth consumption even if income levels vary (e.g. Behrman and Deolalikar, 1987; Bouis and Haddad, 1992; Skoufias et al., 2011). On the other hand, recent review studies for low- and middle-income countries demonstrate that food-income elasticities are generally significantly different from zero, but that they tend to decline when income increases (e.g. Ogundari and Abdulai, 2013; Colen et al., 2018). This implies that particularly for poorer countries, where food-income elasticities are generally higher, income growth might lead to substantial food consumption improvements. Nevertheless, both macro- and micro-economic studies show that income growth alone does not suffice, and that additional measures, such as access to safe water and sanitation, women empowerment, awareness campaigns and biofortification, are required to further reduce malnutrition (Haddad et al., 2003; Alderman et al., 2006; Ecker et al., 2010; Smith and Haddad, 2015).

The debate on income and nutrition is further complicated by two important nuances. A first nuance is that most studies analyze income elasticities of overall food expenditures or calories, thereby focusing on the quantity aspect of food consumption. Yet, income growth does not necessarily lead to improvements in quality of food. On the one hand, households who are budget constrained may increase consumption of calorie-dense but nutritious-poor food when income increases. On the other hand, beyond a certain income threshold, increasing income may be associated with overconsumption and obesity. This is not limited to high-income countries but also increasingly an issue in urban areas in poor countries (Ameye and Swinnen, 2019). Colen and co-authors (2018) have conducted a meta-analysis on income elasticities of food consumption of different food groups (e.g. vegetables, meat, fruit and cereals) and nutrients (fats, proteins and carbohydrates), including 66 studies covering 48 African countries. They find large differences in income elasticities, with nutritious foods being more elastic. Empirical evidence for micronutrients, such as vitamins and minerals, is quite scarce. Important exceptions are studies by Abdulai and Aubert (2004), who show that the demand for vitamins A and B_{12} as well as calcium and zinc increases with rising income in Tanzania; Ecker and co-authors (2010), who find that income elasticities are higher for iron and zinc than for vitamin A in rural Rwanda, Uganda and Tanzania; and Ali et al. (2018), who demonstrate that micronutrient elasticities are larger for households with a lower caloric intake in Nepal.

A second important nuance in the debate on income and nutrition is that the type of income matters. Basic household models predict that the level of consumption is determined by the budget constraint, so that increases in income from any source may lead to better food consumption by relaxing this constraint (Kirk et al., 2018). Yet, various studies show that some types of income are more effective in improving food consumption, implying that nutrition is influenced through other channels besides relaxing the budget constraint. These channels can be summarized as changes in direct and indirect access to food on the one hand and intra-household effects on the other hand[1].

2.2. Direct and indirect access to food

Changes in direct and indirect access to food are largely associated with a transition from subsistence farming over commercially oriented agriculture towards non-farm activities. Recently, attention is paid to the role of agriculture and how agricultural income growth may contribute more effectively to improved nutrition (Carletto et al., 2015; Pingali and Sunder, 2017; Gillespie et al., 2019). As the large majority of the poor derive their main livelihood from cropping and livestock-rearing, growth in agriculture is found to be more pro-poor (Christiaensen et al., 2011) and more nutrition-sensitive (Headey, 2013), although the linkages are quite complex and highly context specific. Participation in agriculture affects household nutrition through direct consumption of own production, particularly when markets are imperfect (Muller, 2009). Other studies point to the importance of agriculture in indirect access to food. Increased farm income, either from higher productivity (Slavchevska, 2015; Darko et al., 2018; Kim et al., 2019) or from increased commercialization (von Braun, 1995; Ogutu et al., 2019), is found to be linked with improved nutrition, while nutritional benefits from crop diversification are found to be relatively small (Sibhatu and Qaim, 2018; Lovo and Veronesi, 2019).

Another strand in the literature focuses on the role of the rural non-farm economy in general and non-agricultural income in particular. Many studies in different settings find a positive correlation between non-agricultural income and food security; e.g. in Nigeria (Babatunde and Qaim, 2010), Ghana (Owusu et al., 2011; Tsiboe et al., 2016) and Ethiopia (Ali and Peerlings, 2012). Most studies do not control for total income or other income sources, making it difficult to conclude on the effectiveness of non-agricultural income vis-à-vis income from other activities. Villa and co-authors (2010) explicitly compare different income sources among pastoralist households in Ethiopia and Kenya, and find that the elasticity to dietary diversity is larger for non-farm income (including wage and self-employment). Kirk et al. (2018) show that non-farm self-employment is more strongly correlated with reduced malnutrition among children in rural Uganda than crop and livestock production.

2.3. Intra-household effects and nutrition

Intra-household effects may determine how income earned by different household members is spent on food. Cooperative models predict that by increasing women's share over total income their bargaining power increases, so they might have a larger say in expenditure decisions. If women have higher preferences towards (nutritious) food, an increase in female earned income might lead to increased food expenses. This has been empirically validated for e.g. Niger (Hopkins et al., 1994) and Côte d'Ivoire (Hoddinott and Haddad, 1995). Non-cooperative models, on the other hand, assume separate spheres of

[1] Growth in the agricultural sector might also influence nutrition through changes in food prices. This channel occurs at the macro-economic level, while we focus in this paper on the micro-economic channels.

decision making, so that only one spouse is responsible for a particular expenditure category and no bargaining is involved. This is associated with mental accounting, where income from certain activities is used for specific expenditures. Duflo and Udry (2004) show this to be the case for Côte d'Ivoire, where yam cultivation is typically male dominated and its profits are spent on education and food.

Studies investigating intra-household effects that go beyond food expenditures are relatively scarce and come to diverse conclusions. Aromolaran (2010) looks at caloric intake and quality of food calorie source in Nigeria, and finds that redistributing household income from men to women would neither reduce undernourishment nor improve nutrition. Dzanku (2019) does find a stronger positive association between off-farm income and food energy intake for female- than for male-headed households in five out of six African countries. Van den Broeck et al. (2018) demonstrate for Senegal that women's off-farm employment leads to an improvement in self-reported food security while male employment does not. These heterogeneous results might be explained by different effects of female income increases on time use, especially for preparing meals. Recent studies find that the negative offset depends on the specific context, and which time use data and analytics are used (Johnston et al., 2018; Komatsu et al., 2018; Stevano et al., 2019).

In general, analyzing intra-household effects on nutrition and disaggregating income according to gender represents a daunting challenge. Researchers have recently made important progress in understanding and measuring women's (economic) empowerment and its relation to nutrition, but significant knowledge gaps remain (Kadiyala et al., 2014; Malapit et al., 2015). Often the focus has been on women's own income while income earned by both men and women jointly has received less attention (McCarthy and Kilic, 2017). In addition, surveys that quantitatively measure gender disaggregated income based on husband's and wife's perspectives find large discrepancies on final authority (Anderson et al., 2017). Despite these challenges, investigating the link between intra-household income effects and nutrition is possible but requires careful intermediate research steps. Our study is one of the first to do so.

2.4. Nutrition in Tanzania

Despite recent improvements in per capita food and calorie consumption, malnutrition remains widespread in Tanzania. The share of undernourished people is high (31%) and has not dropped proportionally to growth in consumption, pointing to rising inequality between urban and rural areas (von Grebmer et al., 2019). Child undernourishment has improved considerably during 1992–2015, but progress has been stagnant lately with high rates of wasting (15%) and stunting (32%) in 2018 (MoHCDGEC et al., 2018). Considerable heterogeneity across regions exists, with largest malnutrition rates in southern and south-western regions (Ruvuma, Iringa, Rukwa, Kigoma, Njombe and Songwe). Also micronutrient deficiencies are common; e.g. 28% of women aged 15–49 years suffers from anemia caused by iron deficiency[2]. These deficiencies are caused by a lack of diversity in rural households' diets. Starchy foods, including maize, rice, potatoes and cassava, constitute the main share of a typical Tanzanian diet and provide most of the calories. Up to 50% of total calorie uptake is sourced from home production (FAO, 2018). As only 30% of domestic production is surplus that can be sold, food price volatility can be a major concern for rural households, especially for nutritious foods that are purchased on the market, such as vegetables, meat, fish and dairy.

[2] Recent nationally representative data for other micronutrients are missing.

3. Data and methods

3.1. Data

We use secondary household survey data from the publicly available Tanzania National Panel Survey (NPS) and focus on two panel rounds: NPS 2010–2011 and NPS 2012–2013[3]. The survey is part of the Living Standard Measurement Studies – Integrated Surveys on Agriculture (LSMS-ISA), implemented by the national statistical office with assistance from the World Bank. The survey consists of four different quantitative questionnaires (household, agriculture, fishery and community), comprising several modules. Data includes information on household demographic characteristics, various income sources, assets and living standards, food and non-food expenditures, and food consumption[4].

The survey is designed to be representative at the national and regional level. A two-stage stratified random sampling strategy is used based on a national census. The original sample (surveyed in 2008–2009) consists of 3,265 households in 409 enumeration areas. These households are revisited for the two consecutive rounds NPS 2010–2011 (3,924 households) and NPS 2012–2013 (5,010 households). Substantial effort was done to track all households, even if they moved to a new location, or when an individual left the original household to start a new household. As a result, attrition rates are fairly low and range between 3% and 5%. Data were collected from October 2010 to September 2011, and from October 2012 to October 2013.

For this paper we limit the sample to households living in rural areas (2,456 households in NPS 2010–2011 and 2,374 households in NPS 2012–2013), of which 2,277 are observed in both survey rounds. Although attrition rates for the overall survey are low, we check the probability of attrition between two survey rounds and find that 179 households are observed in NPS 2010–2011 but not in NPS 2012–2013. Analyzing a weighted logit model and controlling for household size and composition, household head characteristics, productive and non-productive assets, distance to road and nearest town, and dummies for month of interview and region, we find that attrition is higher among better endowed and less remote households with a younger, female head, more adult men and fewer children (Table A1 in Appendix). We do not control for attrition in our analysis, as we assume that household and time fixed effects as well as time variant observable characteristics included in our regression models capture any remaining unobserved heterogeneity that might jointly predict the likelihood of attrition and the outcome variables[5].

3.2. Income calculations

We calculate total net household income following the cross-country comparable Rural Income Generating Activities (RIGA) income aggregate methodology[6]. All income values are converted to real 2011 international dollar (Int. $) using purchasing power parities derived from the World Development Indicators. We distinguish between non-labor income, including transfers, pensions and remittances, and income earned from labor activities. We specify labor income in two different ways: by sector and by gender. First, we use four different categories for labor income by sector: 1) agricultural self-employment, comprising net income from all cropping and livestock activities a

[3] Data from the first panel round NPS 2008–2009 are not used because the wording of the questions on wage employment changed too much compared to the next rounds.

[4] More information can be retrieved from NBoS (2011).

[5] We cannot empirically test this assumption, which is equivalent to the assumption of selection on observables.

[6] More information on RIGA is available on http://www.fao.org/economic/riga/riga-database/en/.

household is involved in[7], 2) agricultural wage employment, comprising net wages from all household members who work for somebody else for pay in the agricultural sector, 3) non-agricultural self-employment, comprising net income from all household's non-farm enterprises, and 4) non-agricultural wage employment, comprising net wages from all household members who are wage employed in industry or services. Crops and livestock products that are destined for own consumption are valued at market prices and are included in income from agricultural self-employment.

Second, we use three different income categories by gender: 1) jointly earned income, comprising net income from joint agricultural self-employment and jointly managed non-farm enterprises, 2) male earned income, comprising net wages in the agricultural and non-agricultural sector and net income from male agricultural self-employment and non-farm enterprises managed by a man, and 3) female earned income (calculated in a similar way). While it is straightforward to disaggregate income according to gender for wage employment and non-farm enterprises, we need to make some assumptions for agricultural self-employment. We use the data on who decides what to do with the earnings from crops and livestock sold on the market to disaggregate gross revenues by men only, women only or by men and women jointly. Crops and livestock products that are used for own consumption are valued at market prices and allocated to jointly earned income[8]. We extrapolate these shares to net farm income, as cost data are asked at plot level (pesticides, fertilizer, labor), crop level (seeds) or farm level (equipment) while revenues are asked at crop level. This is also the reason why we do not use variables at plot level to disaggregate gender, such as plot ownership or management.

3.3. Nutrition calculations

We use both monetary and non-monetary measures for household nutrition: food expenditures and nutritional intake. To measure household food expenditures, we use the food consumption aggregate constructed by the national statistical office, which is part of the publicly available NPS data. Food consumption is asked for the last week prior to the survey and includes all possible sources of consumption (i.e. not only food purchased on the market or meals eaten away from home but also food that was produced by the household or received as a gift). Non-purchased food is valued at market prices. In addition, only food that was actually consumed is taken into account as food expenditures, as opposed to total food purchases or total home-produced food. Similar to income, expenditure values are converted to real international $. To control for household size, we calculate food expenditures per adult equivalent[9] (AE).

To measure household nutritional intake, we calculate the average daily calorie (kcal), vitamin A (vit A), Iron (Fe) and Zinc (Zn) consumption, based on the seven-day food consumption module. This is reported at the household level, so there is no information available on individual food consumption or intra-household food allocation patterns. Therefore, we assume an equal food distribution proportional to each household member's individual physiological nutrient requirements and divide total household nutritional intake by the number of AE. We convert food consumption into nutritional intake following several steps. First, we express the consumed quantities in kilograms. Quantities expressed in liter are converted using densities from the FAO/INFOODS density database (Charrondiere et al., 2012)[10]. If a non-standard unit is used, we apply the conversion factors from the community questionnaire. Second, we use the Tanzania Food Composition Tables to convert the kilograms of consumed food into kcal, vit A, Fe and Zn amounts (Lukmanji et al., 2008). Before aggregating the nutritional values per food item at household level, we replace biologically implausible levels by the median of that particular food item. Last, we winsorize the distribution of the aggregated daily consumption levels per AE at the one percent level, to minimize the effects of potential remaining outliers after aggregation.

In addition to total household nutritional intake, we assess nutritional deficiencies. We follow the guidelines from various international health and food organizations (UNHCR, UNICEF, WFP, & WHO, 2004) and define undernourishment or energy deficiency if average daily calorie consumption is below 2,100 kcal/AE. The cut-off values for vit A, Fe and Zn deficiencies are respectively 625 μg retinol equivalents, 18 mg and 15 mg.

Nutritional status can also be assessed through anthropometric indicators (e.g. weight-for-height, height-for-age, weight-for-age). While the NPS includes these data, we do not use them for the analysis in this paper for two reasons. First, as we have only two years in between survey rounds, we are more interested in short-term nutritional effects. Anthropometric effects typically measure long-term effects of malnutrition, while food consumption is directly affected (de Haen et al., 2011). Second, nutrition influences individuals' health – as proxied by anthropometry – through people's actual food consumption. In this paper we focus on the more direct link between income and food consumption, and not on the indirect link between income and health effects of food consumption.

3.4. Econometric models

We estimate two econometric models to investigate which income source is more effective in improving household nutrition. Model 1 tests whether changes in nutrition are related to the employment sector in which income is generated while model 2 tests whether the gender of the earner matters:

$$Y_{it} = \beta_0 + \beta_I \log(I)_{it} + \left(\frac{\boldsymbol{I}_{\boldsymbol{it}}^{\boldsymbol{S}}}{\boldsymbol{I}_{\boldsymbol{it}}}\right)\beta_S + \boldsymbol{X}_{\boldsymbol{it}}\beta_X + \alpha_i + \upsilon_{it} \tag{1}$$

$$Y_{it} = \beta'_0 + \beta'_I \log(I)_{it} + \left(\frac{\boldsymbol{I}_{\boldsymbol{it}}^{\boldsymbol{G}}}{\boldsymbol{I}_{\boldsymbol{it}}}\right)\beta_G + \boldsymbol{X}_{\boldsymbol{it}}\beta'_X + \alpha'_i + \upsilon'_{it} \tag{2}$$

where Y_{it} represents various measures for consumption of household i in year t; I is total annual net income; I^S is annual net income from sector S; I^G is annual net income from gender G; X is a vector of time-variant observable household characteristics; β_0, β_I, β_S and β_X are different parameters to be estimated; α_i represents unobserved time-constant factors; and υ_{it} unobserved time-variant factors.

The outcome variables of interest are food expenditures, average daily nutritional intake per AE (measured in kcal, vit A, Fe and Zn), and nutritional deficiencies. We take the logarithm of both food expenditures and annual net income to estimate income elasticity of food demand. We add the share of total income for 1) each of the four employment sectors: agricultural self-employment, agricultural wage employment, non-agricultural self-employment and non-agricultural wage employment; and 2) each of the three gender specifications: income earned by men, women and jointly. As base category we use non-labor income. We use shares instead of log values because we are interested in whether a specific income source is more strongly correlated with

[7] Income from agricultural self-employment is based on household production data and not on consumption data. Production data are collected for the 12-months period before the survey, while consumption data are only collected for a seven-days period. This makes the production data less volatile to price fluctuations, temporal shortages and/or excesses.

[8] As there is no data on decision-makers of earnings from permanent crops or milk (in second round), we allocate these to jointly earned income. The major share of these products is destined for own consumption, so this is not a strong assumption.

[9] We use the adult-equivalent scale by gender and age proposed for Tanzania by NBoS (2011).

[10] For food items that are not included in the density database, the (average) density of similar food items is used.

Table 1
Summary statistics of demographics and assets for two survey rounds.

	2010–2011 (2,277 obs)		2012–2013 (2,277 obs)	
	Mean	*St. Dev.*	*Mean*	*St. Dev.*
Demographic characteristics				
Number of male adults (19+)	1.14	0.83	1.17	0.85
Number of female adults (19+)	1.26	0.74	1.29	0.74
Number of children (19−)	3.19	2.52	3.15	2.49
Share of literate male adults	0.67	0.45	0.66	0.46
Share of literate female adults	0.58	0.46	0.56	0.47
Head's age (years)	47.98	15.87	49.59	15.70
Male head	0.77	0.42	0.76	0.43
Literate head	0.71	0.45	0.72	0.45
Asset ownership				
Landholdings (ha)	2.26	3.36	2.44	3.36
Tropical livestock units°	1.83	5.87	2.19	8.72
Asset index°°	−0.38	0.74	−0.36	0.79
Distance to nearest road (km)	23.84	25.37	23.68	25.32
Distance to nearest town (km)°°°	51.20	40.51	51.09	40.66

Notes: Sample includes rural households that are observed in the two waves.
° In tropical livestock units a cow has a weight of 1, a donkey 0.8, and sheep/goat 0.2
°° Asset index is based on a factor analysis on durable goods ownership and housing conditions.
°°° Town is defined as a population center of at least 20.000 inhabitants.

nutrition when controlling for total income. If log values of the different income sources are used, the log of total income would be omitted, resulting in a very different interpretation. Moreover, using shares circumvents the problem that some households do not derive any income from a specific sector or have negative values (which might occur in case of self-employment)[11]. In addition, shares do not overweight large-income households and are plausibly less susceptible to large income fluctuations over time.

As time-variant observable household characteristics we include control variables for household composition (number of adult men, women and children, and share of literate adult men and women), household head (gender, age and literacy level), assets (landholdings, livestock units and non-agricultural assets[12]), and distances to the nearest concrete road and nearest town. In addition, we control for year, region and month of interview fixed effects. The latter is necessary to control for intra-annual trends in food consumption, as this is asked for the week prior to the survey and not for the whole year.

We estimate both random effects (RE) and fixed effects (FE) models as they convey complementary information. An RE model assumes that there is no correlation between the observed explanatory variables and α_i, so the parameters β can be interpreted as across-household variation. An FE model assumes that α_i is correlated with the observed explanatory variables and uses the within-household variation over time to remove α_i. The parameters β are now interpreted as within-household variation, so both estimation strategies reveal complementary information on correlations. We clearly want to stress that we do not investigate causal relationships; we investigate whether correlations with nutrition are stronger for specific sources of income while controlling for total income.

4. Results

4.1. Descriptive statistics

Table 1 presents summary statistics of household demographic characteristics and asset ownership for the two survey rounds. In general, these statistics do not vary much over time. Households are rather small with on average 1.3 men, 1.3 women and 3.2 children. About two thirds of men can read and write, while this holds for only half of the women. The household head is on average 50 years old in 2013 and most of them are men (76%) and literate (72%). Households have on average 2.3 ha of land and 1.8 to 2.2 livestock units, but large disparities exist between households for both agricultural and non-agricultural assets. They live on average 24 km from the nearest concrete road and 51 km from the nearest town, pointing to remoteness of rural areas and plausible large market transaction costs.

Table 2 describes summary statistics on total household net income, and income (shares) from different sources, and Table 3 reports participation rates in different employment sectors for the two survey rounds. In general, average values for the rural sample do not differ much over time, probably due to the relatively short time period between survey rounds. However, within-variation is considerable – but lower than between variation – pointing to increases for some households and decreases for other households. Total annual income is about 2,600 int. $ and most of this income (49%) is derived from agricultural self-employment. On average 86% of households participate in crop and/or livestock production, making this by far the most important sector in terms of employment. The second most important sector is non-agricultural self-employment, both in terms of participation (38%) and average share of total income (18%). Note that the difference in participation rates is much larger than the difference in income share. An equal share of households (25%) participates in agricultural and non-agricultural wage employment, but while the former only represents 6% of total income on average, the latter represents 13%. Jointly earned income coincides largely with income from agricultural self-employment, as a high share of this income is either destined for own consumption or sold jointly on the market. Few non-farm enterprises are jointly managed and are mostly run by men or women separately. While 55% of the households have income earned solely by men and 42% have income earned solely by women, male income represents on average 21% of total income and female income only 10%. This is partly due to men being more employed in non-agricultural wage employment, which is typically a more remunerative sector. Though we focus our analysis on income earned through labor, nonlabor income is not negligible. About two thirds of households receive some type of money transfer, and this contributes on average 13% to total income.

[11] The share of negative income values is truncated at zero. There are very few negative income values; only 2.8% of agricultural self-employment and 0.2% of non-agricultural self-employment.

[12] This is an index derived from a factor analysis based on durable assets and living standards.

Table 2
Summary statistics of income sources.

	2010–2011 (2,277 obs)		2012–2013 (2,277 obs)		Pooled (4,554 obs)			
	Mean	*St. Dev.*	*Mean*	*St. Dev.*	*Mean*	*St. Dev. Overall*	*St. Dev. Between*	*St. Dev. Within*
Income (int. $)								
Total income	2,575.25	3,974.34	2,664.13	3,025.49	2,619.69	3,531.82	2,947.39	1,946.41
Ag. self-empl.	860.97	1,264.67	930.47	1,166.72	895.72	1,217.04	1,057.23	603.08
Non-ag. self-empl.	725.66	2,850.70	882.96	3,009.02	804.31	2,931.66	2,280.17	1,842.99
Ag. wage empl.	68.47	207.18	123.66	357.69	96.07	293.56	219.08	195.42
Non-ag. wage empl.	553.92	1,902.72	689.85	2,647.89	621.89	2,306.36	2,043.23	1,070.23
Joint income	768.96	1,207.43	847.59	1,139.34	808.28	1,174.41	979.09	648.71
Male income	708.91	2,867.74	1,006.96	2,939.87	857.93	2,907.53	2,172.97	1,932.09
Female income	257.03	858.58	327.42	1,171.97	292.23	1,027.79	814.39	627.10
Non-labor income	112.26	265.38	201.32	590.54	156.79	459.91	339.84	309.92
Income shares								
Ag. self-empl.	0.50	0.38	0.48	0.37	0.49	0.37	0.32	0.19
Non-ag. self-empl.	0.19	0.31	0.18	0.30	0.18	0.31	0.26	0.16
Ag. wage empl.	0.06	0.16	0.07	0.18	0.06	0.17	0.13	0.11
Non-ag. wage empl.	0.13	0.29	0.13	0.28	0.13	0.29	0.25	0.13
Joint income	0.45	0.37	0.44	0.35	0.44	0.36	0.31	0.19
Male income	0.20	0.30	0.22	0.29	0.21	0.30	0.23	0.19
Female income	0.11	0.24	0.09	0.19	0.10	0.22	0.17	0.13
Non-labor income	0.11	0.22	0.14	0.24	0.13	0.23	0.19	0.13

Notes: Sample includes only rural households that are observed in the two waves. All income values are net values converted to int. $. Non-labor income includes transfers and other sources.

Table 3
Summary statistics of household participation rates for two survey rounds.

	2010–2011 (2,277 obs)	2012–2013 (2,277 obs)
Ag. self-empl.	0.86	0.87
Non-ag. self-empl.	0.39	0.37
Ag. wage empl.	0.25	0.26
Non-ag. wage empl.	0.26	0.25
Joint income	0.81	0.85
Ag. self-empl.	0.81	0.85
Non-ag self-empl.	0.02	0.01
Male income	0.48	0.61
Ag. self-empl.	0.25	0.23
Non-ag self-empl.	0.39	0.22
Ag. wage empl.	0.09	0.17
Non-ag wage empl.	0.07	0.21
Female income	0.37	0.48
Ag. self-empl.	0.18	0.18
Non-ag self-empl.	0.08	0.21
Ag. wage empl.	0.07	0.16
Non-ag wage empl.	0.03	0.07
Non-labor income	0.65	0.65

Notes: Sample includes only rural households that are observed in the two waves. Non-labor income includes transfers and other sources.

Fig. 1 presents the income shares in function of total income. Poorer households derive most of their income from agricultural self-employment, while for relatively better-off households' income from non-agricultural employment (both wage and self-employment) is more important. Agricultural wage employment does not contribute substantially to total income across the household income distribution, but it is more important for poorer households. The pattern for joint income is in line with agricultural self-employment; its share decreases when income increases. Relatively better-off households derive most of their income from male income, pointing to a shift in the gender of the main earner when household welfare improves. Like agricultural wage employment, income earned solely by women does not contribute substantially to total income across the income distribution. Only the relatively better-off households derive equal shares from female income and joint income.

Table 4 describes summary statistics of household food consumption. Households spend annually about 780 to 850 int. $ per capita on food, which comprises a large part of their total household budget. Again, large disparities across households exist. Average daily energy intake is about 2,400 kcal in 2011 and 2,370 kcal in 2013, and 44% and 46% of households are undernourished in 2011 and 2013 respectively. Micronutrient deficiency rates are quite high: more than half of the rural households suffer from vit A deficiency, almost two thirds face Fe deficiency, and nearly 90% cope with Zn deficiency.

Table 5 summarizes the share of households that consume different food groups, and the share of households that derive (part of) their consumption from own production. Nearly all households have eaten at least once during the past seven days some type of cereals (mainly maize), vegetables (mostly onions and tomatoes) and legumes, nuts and beans. Also roots and tubers are quite common (76%), followed by fish and seafood (67%). About half of them have consumed any type of fruit and meat. The consumption of dairy products (29%) and eggs (13%) is quite low, especially when taking into account that these shares do not say anything about absolute values consumed. Consumption from own production is quite important for the main food groups with about half of households relying (partially) on this direct access to food. For eggs and dairy products, that are consumed by fewer households, own production is important, indicating that market purchases of these food groups might be more difficult. Fish and seafood, which is consumed by more households, is mostly obtained through market purchases.

Fig. 2 presents food expenditures in function of income shares, with the more specialized households at the right end of the horizontal axis. Household food expenditures decrease with the importance of income from agricultural self-employment and agricultural wage employment, and are lower for the latter. The reverse holds for non-agricultural employment. Food expenditures increase with specialization in non-agricultural wage employment and non-agricultural self-employment, and more rapidly so for the former. Looking at the gender of the earner, we observe a negative correlation between joint income and food expenditures, and a positive correlation with male and female income. Specialization in male income is associated with higher expenditures than specialization in female income. These graphs do not control for total income, so we cannot deduct whether the composition or the level of household income matters for consumption.

4.2. Econometric results

Table 6 describes the regression results for annual food expenditures

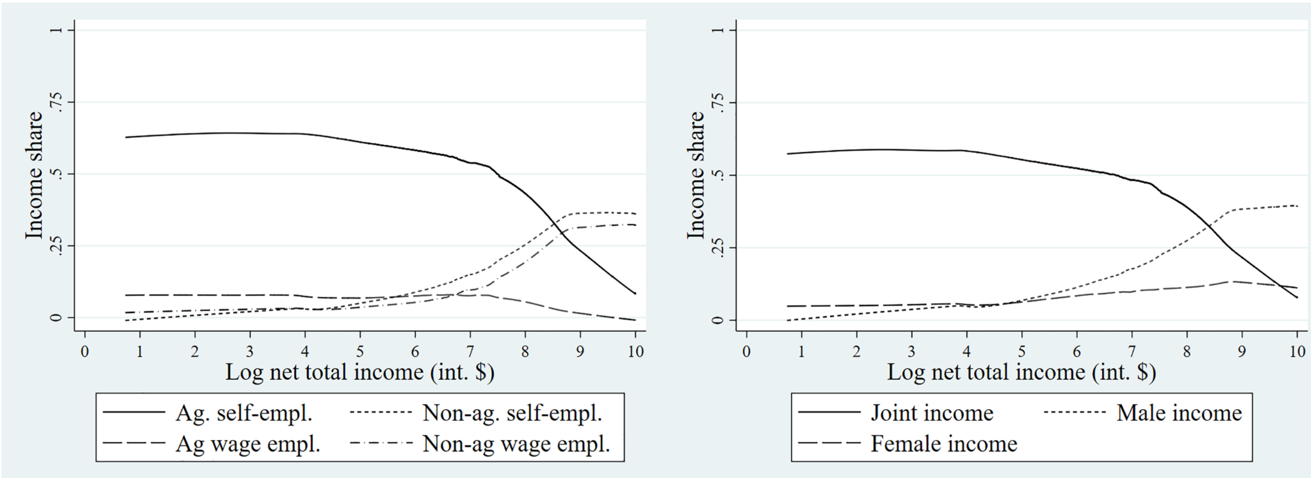

Fig. 1. Income shares by sector and by gender in function of total income.

Table 4
Summary statistics of food expenditures and nutrition for two survey rounds.

	2010–2011 (2,277 obs)		2012–2013 (2,277 obs)	
	Mean	*St. Dev.*	*Mean*	*St. Dev.*
Food expenditures (int. $)	777.50	488.22	849.92	547.24
Daily energy intake (kcal)	2,396.43	1,012.13	2,368.58	1,056.04
Daily vitamin A intake (µg)	742.88	710.99	852.68	913.03
Daily iron intake (mg)	16.02	7.67	16.22	8.32
Daily zinc intake (mg)	9.80	4.72	9.80	5.17
Energy deficiency	0.44	0.50	0.46	0.50
Vitamin A deficiency	0.58	0.49	0.54	0.50
Iron deficiency	0.65	0.48	0.63	0.48
Zink deficiency	0.87	0.33	0.85	0.35

Notes: Sample includes rural households that are observed in the two waves. All values are converted to per adult equivalent intake.

Table 5
Summary statistics of food group consumption and own production.

	Share of HHs that consumed at least once during past 7 days	Share of HHs that derive (part of) their consumption from own production
Cereals	0.93	0.55
Roots & tubers	0.76	0.61
Legumes, nuts & beans	0.85	0.46
Vegetables	0.95	0.48
Fruits	0.52	0.37
Meat	0.46	0.30
Eggs	0.13	0.65
Fish & seafood	0.67	0.04
Dairy	0.29	0.40

Notes: Sample includes only rural households that are observed in the two waves. Data are pooled for the two survey waves (N = 4,554).

per AE. The estimated coefficient for total income is highly significant both in the RE and FE models with a value of 0.10 and 0.08 respectively. This means that an increase in income across households as well as an increase in income over time within a given household, are both associated with higher food expenditures. Which specific sector the income comes from or who earns it, seems to matter less. Only in the RE models we observe significantly negative coefficients for the share of agricultural wage employment and for the share of male and female income, but the significance of these effects disappears in the FE model. Other factors that are related with higher food expenditures are the literacy level of the household head, total landholdings, livestock units and non-agricultural assets. Factors that are related with lower food expenditures are the number of men, women and children, household head's age, and the share of literate men – with the latter effect being somewhat surprising. Most of these factors are only significant in the RE models.

Table 7 summarizes the results for caloric and micronutrient intake. Again, we observe very large coefficients for total income that are significant in both RE and FE models, and across the various nutritional outcomes. Coefficients from FE estimations are 102 for kcal, 24 for vit A, and 0.5 for Fe and Zn. Also various coefficients for different income sources are significant in the regressions, which implies that the composition of income, and not only the level of income, matters for caloric and micronutrient intake. We find that the more income is derived from agricultural self-employment, the more kcal, Fe and Zn are consumed. In contrast, the more income is derived from non-agricultural wage employment, the lower the daily intake of vit A, iron and kcal. Moreover, we find that the more households rely on jointly earned income, the more kcal, vit A, Fe and Zn are consumed. In contrast, households who rely more on male earned income, consume less kcal. The share of female earned income is not significantly correlated with energy and micronutrient intake. Most coefficients for different income sources are only statistically significant in the RE models. This is largely due to smaller within-variation than between-variation, resulting in larger standard errors for all coefficients from FE estimations. Our results are rather inconclusive on how nutrition varies with within-household changes in income composition but do reveal that differences in income composition across households are strongly associated with differences in nutrition.

Table 8 summarizes the results for energy and micronutrient deficiencies. In line with the previous regressions, we observe large coefficients for total income, which are statistically significant both in RE and FE models. In addition, we find similar results from RE estimations for nutrient deficiencies as for nutritional intake: a higher income share of agricultural self-employment and jointly earned income across households is associated with a lower probability of undernourishment and micronutrient deficiencies (including vit A, Fe and Zn). Results from FE models are again less conclusive.

5. Discussion

We find a very strong correlation between income and food consumption, indicating that income growth is important for improving household nutrition in rural Tanzania. This correlation is valid across households as well as within households, and for all the monetary and

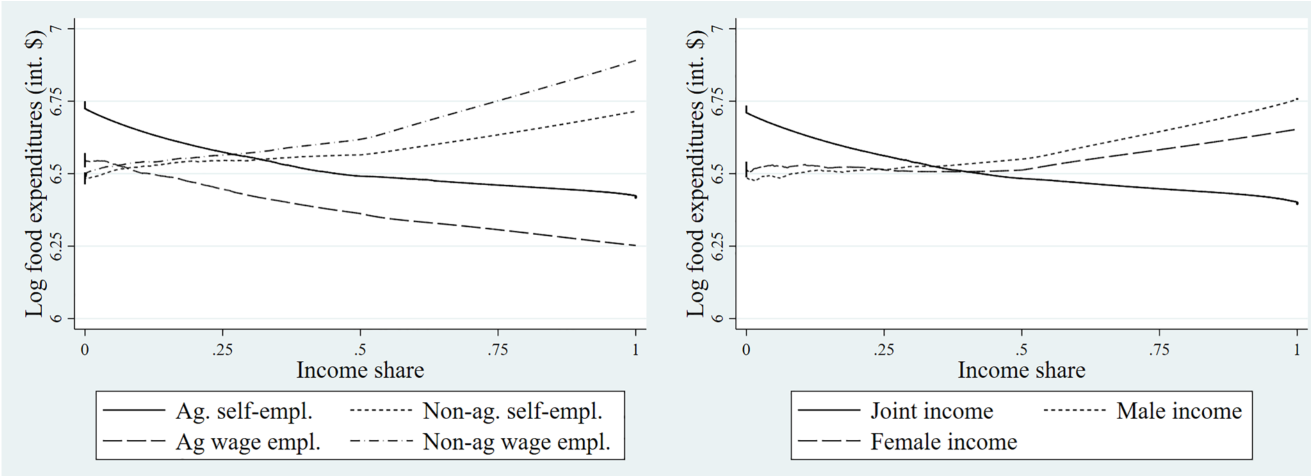

Fig. 2. Food expenditures in function of income shares by sector and by gender.

non-monetary food consumption measures used in the analysis. Even when controlling for agricultural and non-agricultural assets, a higher income leads to the consumption of more and more nutritious food. We find an income elasticity of food demand of 0.08 to 0.10, implying that a 10% increase in income leads to a 0.8% to 1% increase in food expenditures. If income increases with 10% within households, average daily energy intake per AE increases with 10 kcal, vit A intake with 2 μg, Fe intake with 0.05 mg and Zn intake with 0.05 mg; which comes down to income elasticities of 0.03–0.05. This means that food expenditures as well as caloric and micronutrient intake are income inelastic, implying that rural households in Tanzania have ways to smooth food consumption. The size of estimated elasticities is in line with those reported in other studies (Ogundari and Abdulai, 2013; Colen et al., 2018). Moreover, we find that a 10% income increase within households is sufficient to reduce the probability of undernourishment with 0.32 percentage points (pp), vit A deficiency with 0.22 pp, Fe deficiency with 0.37 pp and Zn deficiency with 0.29 pp. Given the high undernourishment and micronutrient deficiencies in rural Tanzania, these results are economically significant.

We find that also the composition of income, and not only the income level, matters for nutrition. A higher share of income from agricultural self-employment (i.e. crop and livestock production on the household farm) across households, is positively correlated with a higher intake of calories, Fe and Zn, and with a reduced probability of undernourishment and deficiency in vit A, Fe and Zn. A 10 pp higher income share from agricultural self-employment across households is associated with a daily per capita energy intake that is 18 kcal higher, an Fe intake that is 0.14 mg higher, a Zn intake that is 0.09 mg higher, and with a 0.58–0.97 pp reduced probability of energy and micronutrient deficiencies. Contrarily, specializing in non-agricultural employment (particularly wage employment) is negatively associated with caloric and Vit A intake and positively with the likelihood of nutrient deficiencies. This contradicts other studies that find a positive correlation between non-farm income and nutrition (Villa et al., 2010; Kirk et al., 2018). The negative correlation might relate to the specific setting of rural Tanzania, where households live quite remotely, face large market imperfections and are subsistence oriented. Switching from farm to non-farm activities in this setting might entail a decrease in direct access to food that is not compensated by an increase in indirect access to food. Cropping and livestock-rearing is the most important sector of employment in rural Tanzania, and poorer households derive relatively more income from this sector. Therefore, our findings imply that income growth in agricultural self-employment is more effective in reducing malnutrition than income diversification and income growth from other activities. This view is largely supported by other studies that investigate agriculture-nutrition pathways (Carletto et al., 2015; Pingali and Sunder, 2017; Gillespie et al., 2019). Analyzing different income sources, we find significant correlations with non-monetary nutrition outcomes but not with food expenditures, which points to the complementarity of monetary food consumption measures and non-monetary nutrition measures for a comprehensive understanding of income-nutrition pathways, and justifies our approach.

Unlike other studies and common assertions, we do not find a positive correlation between the importance of income earned solely by women and nutrition. As female employment is lowly paid, the gains from time spent on income generating labor might not outweigh a possibly reduced time spent on meal preparation. The insignificant correlation might also be due to differences in methods, as most studies do not control for total household income level. However, an important nuance is that we do find a positive correlation between nutrition and the importance of jointly earned income, which also captures women's contribution to these activities. This raises the question of how women's economic empowerment should be measured, as women who make income decisions alone are not necessarily more empowered than women who make decisions jointly with spouses. On the other hand, we find a higher share of male earned income to be negatively correlated with kcal and Zn intake, and with a higher probability of being undernourished. This might suggest that men prefer to spend their income on other goods and services than food, or that income earned by men is *de facto* spent on other goods and services (i.e. mental accounting). These findings reflect the complex nature of intra-household responsibilities for nutrition and urge caution when oversimplified nutrition policies solely target the economic empowerment of women, such as off-farm job creation (Doss et al., 2018).

6. Conclusion and policy implications

In this paper, we investigate the link between the level and composition of household income and nutrition in rural Tanzania. We find that income growth is important for improving household nutrition, both in terms of quantity and quality. The income elasticity of food expenditures is estimated to be 0.08–0.1, while a 10% income increase is sufficient to reduce undernourishment rates with 0.3 pp, vit A deficiency with 0.2 pp, Fe deficiency with 0.4 pp and Zn deficiency with 0.3 pp. In addition, we show that a higher share of income from agricultural self-employment across households is strongly positively correlated with caloric and micronutrient intake while a higher share of non-agricultural wage employment is negatively correlated with various nutrition outcomes. Furthermore, we find that a higher share of jointly earned income is positively correlated with nutrition while the

Table 6
Full regression results for log food expenditures (int. $).

	Income by sector				Income by gender			
	RE		*FE*		*RE*		*FE*	
Income share								
Ag. self-empl.	−0.015		0.039					
	(0.039)		(0.050)					
Non-ag. self-empl.	−0.021		0.024					
	(0.041)		(0.057)					
Ag. wage empl.	−0.171	***	−0.006					
	(0.063)		(0.081)					
Non-ag. wage empl.	0.023		0.098					
	(0.044)		(0.062)					
Jointly earned					−0.019		0.003	
					(0.032)		(0.044)	
Male earned					−0.054	*	−0.016	
					(0.031)		(0.037)	
Female earned					−0.096	*	−0.075	
					(0.051)		(0.063)	
Log total income	0.100	***	0.075	***	0.106	***	0.079	***
	(0.009)		(0.012)		(0.009)		(0.012)	
Number of male adults (19+)	−0.057	***	−0.078	***	−0.059	***	−0.080	***
	(0.018)		(0.025)		(0.018)		(0.025)	
Number of female adults (19+)	−0.046	***	−0.035		−0.045	***	−0.031	
	(0.017)		(0.024)		(0.017)		(0.024)	
Number of children (19−)	−0.080	***	−0.081	***	−0.081	***	−0.080	***
	(0.006)		(0.012)		(0.006)		(0.012)	
Share of literate male adults	−0.071	***	−0.005		−0.072	***	−0.006	
	(0.026)		(0.042)		(0.026)		(0.042)	
Share of literate female adults	−0.008		−0.018		−0.007		−0.017	
	(0.020)		(0.040)		(0.020)		(0.040)	
Head's age (years)	−0.001	**	−0.002		−0.001	**	−0.002	
	(0.001)		(0.003)		(0.001)		(0.002)	
Male head	0.016		0.062		0.010		0.064	
	(0.025)		(0.072)		(0.026)		(0.073)	
Literate head	0.069	**	0.002		0.072	***	0.002	
	(0.027)		(0.047)		(0.028)		(0.047)	
Landholdings (ha)	0.013	***	0.008		0.013	***	0.008	
	(0.003)		(0.008)		(0.003)		(0.008)	
Tropical livestock units	0.009	***	0.003	***	0.009	***	0.003	***
	(0.003)		(0.001)		(0.003)		(0.001)	
Asset index	0.189	***	0.148	***	0.197	***	0.148	***
	(0.014)		(0.037)		(0.014)		(0.037)	
Distance to nearest road (km)	0.000		−0.004		0.000		−0.004	
	(0.001)		(0.003)		(0.001)		(0.003)	
Distance to nearest town (km)	0.000		0.002		0.000		0.002	
	(0.000)		(0.002)		(0.000)		(0.002)	
Constant	6.220	***	6.554	***	6.200	***	6.589	***
	(0.090)		(0.256)		(0.090)		(0.253)	
Year FE	Y		Y		Y		Y	
Region FE	Y		Y		Y		Y	
Month of interview FE	Y		Y		Y		Y	
Number of observations	4,554		4,554		4,554		4,554	
R^2 within	0.076		0.090		0.077		0.090	
R^2 between	0.368		0.133		0.366		0.127	

All variables are described in Table 1. Standard errors are presented in parentheses. Significant coefficients are indicated with $p < 0.1$ *, $p < 0.05$* and $p < 0.01$ ***.

importance of male earned income is negatively correlated with some nutrition outcomes.

Our results imply that a focus on raising labor productivity and household income would benefit nutrition policies in rural Tanzania. Closing the labor productivity gap between agriculture and rural non-farm sectors is a more effective strategy to improve nutrition and reach SDG2 than diversifying income away from agriculture. Income diversification is associated with higher income levels but reaching these higher income levels from within agriculture is in rural Tanzania more effective to combat malnutrition. Our results on gender go against a common perception in the scientific and policy debate that shifting income towards women has superior nutritional outcomes. Joint control over income can achieve beneficial outcomes as well. We urge for caution with oversimplified policies that solely target the economic empowerment of women without taking other intra-household relations and responsibilities into account.

Other important effects may emerge in nutritional intake at the individual level, which our study does not address. Future research could therefore focus on how nutritional impacts vary across different household members, thereby further unravelling the various income-nutrition pathways. Additional research is also needed on how to capture income generation at the individual level to better understand gender effects. Specific attention should be paid on how cooperation between men and women may contribute to improved nutrition. Moreover, our inconclusive results on within-household linkages between income composition and nutrition from fixed effects estimations reveal that longer panel periods are needed to understand within-household dynamics in income-nutrition pathways.

Table 7
Summarized results for nutrition and income by a) sector and b) gender.

	Daily energy intake (kcal)		Daily vitamin A intake (μg)		Daily iron intake (mg)		Daily zinc intake (mg)	
	RE	*FE*	*RE*	*FE*	*RE*	*FE*	*RE*	*FE*
Income share by sector								
Ag. self-empl.	175.882 **	49.963	74.394	94.319	1.351 ***	0.166	0.913 ***	0.370
	(74.766)	(103.596)	(51.694)	(69.184)	(0.524)	(0.705)	(0.347)	(0.494)
Non-ag. self-empl.	−95.543	−52.679	−100.842 **	75.623	0.095	−0.459	−0.127	−0.037
	(79.534)	(117.191)	(51.080)	(74.864)	(0.525)	(0.795)	(0.337)	(0.520)
Ag. wage empl.	−75.678	−68.425	34.094	−17.021	0.964	0.246	−0.152	0.055
	(105.482)	(143.416)	(94.815)	(117.561)	(0.809)	(1.091)	(0.494)	(0.640)
Non-ag. wage empl.	−166.070 **	−145.544	−111.199 **	79.631	−0.838	−1.631 **	−0.495	−0.701
	(78.726)	(113.831)	(54.155)	(79.464)	(0.543)	(0.798)	(0.360)	(0.516)
Log total income	130.399 ***	101.526 ***	50.779 ***	23.706 *	0.433 ***	0.482 ***	0.572 ***	0.457 ***
	(16.208)	(23.323)	(9.909)	(13.691)	(0.111)	(0.162)	(0.074)	(0.110)
Number of observations	4,554	4,554	4,554	4,554	4,554	4,554	4,554	4,554
R^2 within	0.040	0.052	0.048	0.075	0.035	0.045	0.040	0.052
R^2 between	0.222	0.053	0.261	0.122	0.409	0.055	0.309	0.070
Income share by gender								
Jointly earned	166.496 ***	39.025	109.188 **	77.375	1.011 **	0.213	0.732 ***	0.287
	(61.577)	(81.076)	(44.706)	(61.935)	(0.424)	(0.576)	(0.279)	(0.378)
Male earned	−122.055 *	−104.246	−46.083	11.743	−0.141	−0.317	−0.392	−0.355
	(62.670)	(74.978)	(47.930)	(59.772)	(0.435)	(0.537)	(0.280)	(0.344)
Female earned	−103.924	−97.702	16.967	−3.644	−0.520	−0.853	−0.351	−0.536
	(89.059)	(113.700)	(65.722)	(73.622)	(0.610)	(0.776)	(0.385)	(0.506)
Log total income	124.488 ***	100.174 ***	42.628 ***	28.884 **	0.382 ***	0.437 ***	0.554 ***	0.456 ***
	(15.328)	(22.562)	(9.521)	(13.185)	(0.107)	(0.159)	(0.070)	(0.107)
Number of observations	4,554	4,554	4,554	4,554	4,554	4,554	4,554	4,554
R^2 within	0.040	0.052	0.050	0.075	0.033	0.044	0.040	0.052
R^2 between	0.219	0.052	0.257	0.121	0.407	0.049	0.306	0.069

Standard errors are presented in parentheses. Significant coefficients are indicated with $p < 0.1$ *, $p < 0.05$* and $p < 0.01$ ***. These are summarized results; the full regressions control for all control variables described in Table 1 and fixed effects for year, region and month of interview.

Table 8
Summarized results for nutrition deficiencies and income by (a) sector and (b) gender.

	Energy deficiency		Vitamin A deficiency		Iron deficiency		Zinc deficiency	
	RE	*FE*	*RE*	*FE*	*RE*	*FE*	*RE*	*FE*
Income share by sector								
Ag. self-empl.	−0.067 *	0.018	−0.058 *	−0.070	−0.097 ***	−0.046	−0.058 **	−0.050
	(0.035)	(0.055)	(0.034)	(0.050)	(0.031)	(0.048)	(0.024)	(0.037)
Non-ag. self-empl.	0.023	0.011	0.045	−0.048	−0.010	0.046	0.008	−0.025
	(0.039)	(0.061)	(0.037)	(0.058)	(0.035)	(0.055)	(0.025)	(0.038)
Ag. wage empl.	0.019	0.037	0.007	−0.002	−0.061	−0.029	0.009	−0.048
	(0.054)	(0.085)	(0.052)	(0.077)	(0.050)	(0.074)	(0.033)	(0.046)
Non-ag. wage empl.	0.115 ***	0.058	0.090 **	0.014	0.056	0.159 ***	0.025	0.036
	(0.038)	(0.066)	(0.037)	(0.062)	(0.036)	(0.059)	(0.025)	(0.037)
Log total income	−0.050 ***	−0.032 ***	−0.032 ***	−0.022 **	−0.025 ***	−0.037 ***	−0.036 ***	−0.029 ***
	(0.007)	(0.011)	(0.007)	(0.011)	(0.007)	(0.011)	(0.005)	(0.008)
Number of observations	4,554	4,554	4,554	4,554	4,554	4,554	4,554	4,554
R^2 within	0.027	0.040	0.025	0.036	0.030	0.038	0.021	0.030
R^2 between	0.173	0.014	0.210	0.027	0.236	0.034	0.157	0.051
Income share by gender								
Jointly earned	−0.070 **	0.027	−0.097 ***	−0.088 **	−0.058 **	−0.025	−0.042 **	−0.024
	(0.028)	(0.044)	(0.029)	(0.040)	(0.026)	(0.040)	(0.021)	(0.029)
Male earned	0.069 **	0.050	0.028	0.000	0.017	0.043	0.007	0.005
	(0.031)	(0.040)	(0.027)	(0.034)	(0.027)	(0.033)	(0.021)	(0.028)
Female earned	0.027	0.036	−0.001	0.010	0.047	0.071	0.022	0.002
	(0.040)	(0.054)	(0.041)	(0.052)	(0.038)	(0.049)	(0.027)	(0.034)
Log total income	−0.048 ***	−0.033 ***	−0.029 ***	−0.026 **	−0.021 ***	−0.031 ***	−0.033 ***	−0.028 ***
	(0.007)	(0.011)	(0.007)	(0.010)	(0.007)	(0.011)	(0.005)	(0.008)
Number of observations	4,554	4,554	4,554	4,554	4,554	4,554	4,554	4,554
R^2 within	0.027	0.041	0.027	0.037	0.027	0.034	0.020	0.028
R^2 between	0.169	0.014	0.207	0.022	0.234	0.024	0.154	0.052

Standard errors are presented in parentheses. Significant coefficients are indicated with $p < 0.1$ *, $p < 0.05$* and $p < 0.01$ ***. These are summarized results; the full regressions control for all control variables described in Table 1 and fixed effects for year, region and month of interview.

CRediT authorship contribution statement

Goedele Van den Broeck: Conceptualization, Formal analysis, Writing - original draft. **Myrthe Mardulier:** Formal analysis. **Miet Maertens:** Conceptualization, Writing - review & editing.

Declaration of Competing Interest

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.

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Appendix

See Table A1.

Table A1
Probability of attrition between two survey rounds.

Number of male adults (19+)	0.016	**
	(0.007)	
Number of female adults (19+)	−0.001	
	(0.009)	
Number of children < 19yrs	−0.006	**
	(0.002)	
Share of literate male adults	0.001	
	(0.017)	
Share of literate female adults	−0.008	
	(0.011)	
Head's age (years)	−0.001	**
	(0.000)	
Male head	−0.027	**
	(0.014)	
Literate head	0.018	
	(0.019)	
Landholdings (ha)	−0.001	
	(0.002)	
Tropical livestock units	0.001	
	(0.001)	
Asset index	0.027	***
	(0.006)	
Distance to nearest road (km)	0.000	
	(0.000)	
Distance to nearest town (km)	−0.001	***
	(0.000)	
Region dummies	Y	
Month of interview dummies	Y	
N	2,456	
Pseudo R^2	0.1566	

All variables are described in Table 1. Average marginal effects from a logit model are reported and standard errors are presented in parentheses. Significant effects are indicated with $p < 0.1$*, $p < 0.05$* and $p < 0.01$***.

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