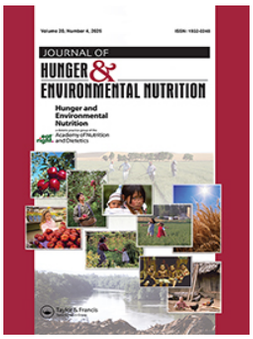

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Household Food Security Status and Diet Diversity Predictors of Mother Child-Dyads from Rural Smallholders in Three Agroecological Zones of Malawi

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ABSTRACT

Data from mother-child dyads ($n = 375$) living in rural smallholder farming households in Malawi was utilized. Households with an average income of >$4.2 US dollars per member had 60% lower odds (OR: 0.40, 95%CI: 0.19–0.82) of food insecurity. Household food insecurity was a predictor of Minimum Dietary Diversity for Women (MDD-W) (OR: 0.43, 95%CI: 0.21–0.89). Children whose female caregivers met MDD-W had 37 times higher odds (OR: 37.6, 95%CI: 13.9–117) of meeting the recommended dietary diversity score. To address food and nutrition security in this population, an approach that encompasses women's empowerment and income diversification is required.

KEYWORDS

Dietary diversity; food insecurity; household food insecurity access scale; minimum dietary diversity for women; minimum dietary diversity for children; nutrition security

Introduction

Malawi, a landlocked nation in southeastern Africa, confronts significant food and nutrition security challenges exacerbated by limited agricultural resources and unstable climatic conditions.[1] The[1] Chronic Food Insecurity (IPC CFI) analysis reported that the Northern and Central regions, including Mzimba and Dedza districts, were classified as moderately food insecure. Conversely, the Southern region, which includes Balaka district, faced severe food insecurity.[1] Furthermore, insights from the 2015–2016 Malawi Demography and Health Survey (2015–16 MDHS) show that only 25.1% of children aged 6–23 months meet the minimum dietary diversity (MDD) requirement. In detail, the Southern and Northern regions recorded 21.6% and 23.7% of children not meeting

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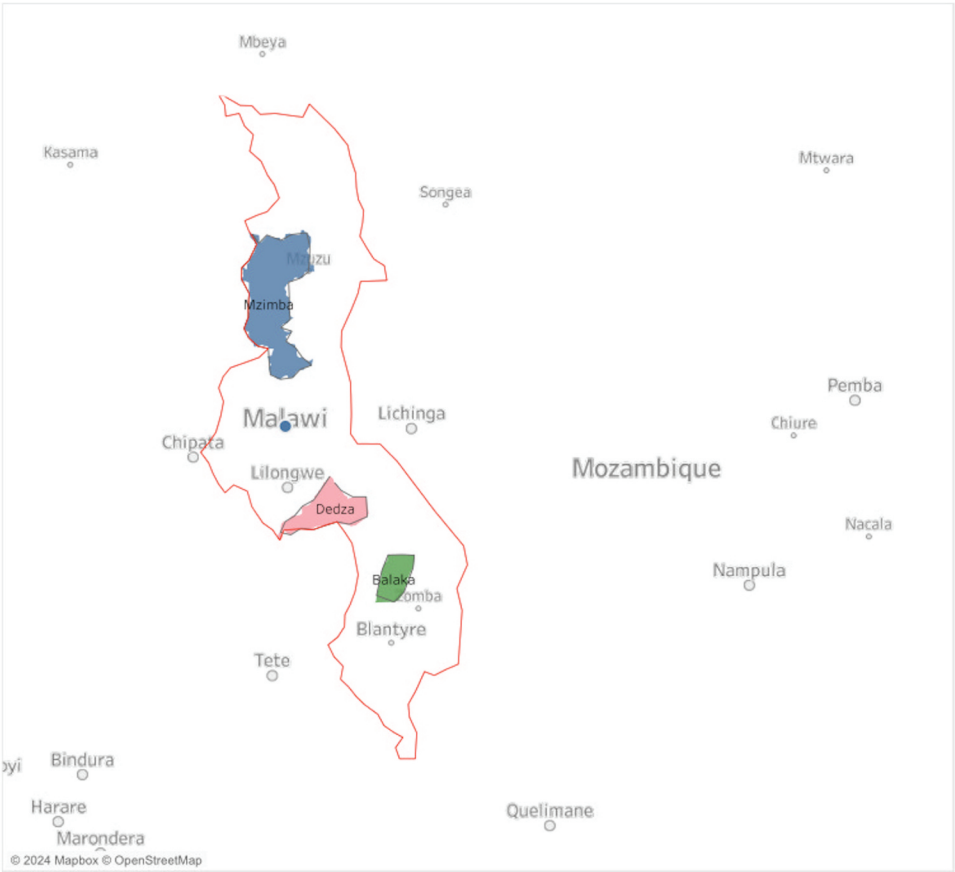

Figure 1. Map of Malawi showing the study districts (Balaka, Dedza, and Mzimba).

the MDD, while the Central region had the highest proportion not meeting the MDD at 29%.[2] When women were considered in the Multiple Indicator Cluster Survey (MICS) and Demographic and Health Surveys (DHS) from 2011 to 2021, over 50% of women of reproductive age fell below the minimum dietary diversity requirement, with even lower estimates (30%) in the Southern region.[1,3,4]

As a result, the prevalence of stunting among children under five years is 37%, which is one of the highest rates of stunting in the Southern Africa region.[2] Similarly, micronutrient deficiencies among women of reproductive age (15–49 years) and preschool children remain a widespread challenge.[2]

Despite the vital role of Malawian smallholder households in food production,[5] they often experience a high prevalence of food and nutrition insecurity.[6] Women in these households typically play a vital role in food preparation and family nutrition,[7] yet they have poor nutrition outcomes.[2] This has negative implications for their agricultural productivity and health.[8]

Similarly, poor children's dietary diversity leads to malnutrition, stunting, and developmental challenges.[9]

This sub-study was nested within a larger study designed to identify the unique drivers of stunting in the three agroecological zones of Malawi. Details of the main study are described elsewhere.[10] There is a paucity of information about food security and dietary predictors among rural smallholder households in Malawi.

Thus, our study's primary objective was to examine food security and dietary diversity predictors among mother-child dyads in rural smallholder households in Malawi. First, we provided an overview of the household food security status and dietary diversity among the surveyed mother-child dyads. Subsequently, we investigated the predictors of food security and dietary diversity. We present the findings on the predictors of food security and dietary diversity, discuss the findings, and conclude by presenting the implications for policy formulation and program design.

Methodology

Ethical Approval and Informed Consent

This study was nested within a larger matched case control study (The Nutrition, Agriculture, Markets, and Gender Study) within the Malawi Seed Industry Development Project Phase II project (MSIDP II) designed to assess the drivers of stunting in the three agro-ecological zones of Malawi, represented by the rural areas of Balaka, Dedza, and Mzimba districts (Figure 1).[10] Prior to the study, the National Health Sciences Research Commission (NHSRC) granted ethical approval (Approval Number: 17/03/1745). Locally, District Health Officers (DHOs') and the respective District Nutrition Coordinating Committee (DNCC) also permitted the research. Additionally, all study participants provided voluntary written informed consent for themselves and/or their children before approving data collection and disseminating results. For participants who could not write, a thumbprint was approved as a means of consent. Study participants were notified of their freedom to decline participation at any point during the questionnaire administration.

Study Design, Sample Size, and Study Area

We sought responses from purposively sampled households ($n = 375$). The required sample size for this study ($n = 292$) was calculated using the Cochran formula,[11] with Z=standard normal deviation at 95% confidence level = 1.96; p=proportion of food insecurity in a prior study = 0.813[12]; q=proportion of alternate outcome (1-p) = 0.187; d=error at 5%; and a 20% non-response. The decision to have a sample size of 375 households, exceeding the required 292,

was intentional and based on strategic considerations. Over-sampling was implemented to account for potential dropouts, incomplete data, or unexpected response variations that could affect the overall robustness and reliability of the study's findings.

For each district, sample sizes were estimated by considering the levels of food insecurity based on the calculated required sample size ($n = 292$). We applied food insecurity prevalence rates of 40%, 40%, and 20% for Balaka, Dedza, and Mzimba, respectively.[13] Consequently, the required sample size for each district was ($n = 117$) for Balaka, ($n = 117$) for Mzimba, and ($n = 58$) for Dedza.

Conceptual Framework

We developed a conceptual framework (Supplementary Figure A1) based on available literature (Supplementary Table A1) that guided the assessment of indicators that could be predictors of food security as well as diet diversity.

Data Collection

Data were collected during the early phase of the COVID-19 pandemic in Malawi, when there were no restriction measures yet (August 2020). All recruited data collection personnel either had a BSc degree or had previous experience administering questionnaires. In addition, the personnel were trained, and their competence in questionnaire administration was assessed based on a pretesting exercise. During the study, interviews were conducted in Chichewa or Tumbuka, the local languages. Questionnaires were checked after each survey day for completeness by the survey team supervisors and principal investigator before data analyses. Our research goals, the characteristics of the study participants, and the specific outcomes under investigation all influenced the choice of assessment methods used in this study.

Assessment of Food Insecurity

Food security was assessed via the Household Food Insecurity Access Scale (HFIAS). The HFIAS module assesses the frequency with which specific aspects of food insecurity are experienced by the household.[14] For this study, we employed the 9-item HFIAS module to evaluate the food security status of the surveyed households over a 30-day period. The responses were transformed into a continuous food security scale, with the total HFIAS score ranging from 0 to 27, signifying the level of food insecurity. As a categorical variable, households were categorized as follows: food secure (0–1), mildly food insecure (2–7), moderately food insecure (8–18), or severely food insecure (19–27). Additionally, we interviewed sampled households to understand

the coping strategies employed in managing food insecurity, utilizing the reduced coping strategy index (rCSI) to assess these strategies.[15]

Assessment of Diet Diversity

Dietary intake was assessed through a 24-hour dietary recall in a one-on-one interview conducted by field personnel.[16] During its administration, the participants were asked to describe food and beverages consumed in the past 24 hours preceding the survey. Recorded meals included breakfast, lunch, dinner, and snacks, considering beverages consumed between each meal and condiments, spices, and accompaniments. Each food was recorded only when the consumed amount was greater than 15 grams; portion sizes were assessed with the aid of a food model.[16] The dietary diversity score related to women was calculated following the guidelines for the Minimum Dietary Diversity for Women of Reproductive Age (MDD-W).[17] The score consists of 10 food groups: all starchy staples, beans and peas, nuts and seeds, dairy, flesh foods, eggs, dark green leafy vegetables, other vitamin A-rich fruits and vegetables, other vegetables, and other fruits. A food group was coded "1" when consumed, and when not consumed, it was coded "0." This was summed to obtain the dietary diversity score. Women of reproductive age were considered to have met the recommended minimum dietary diversity score when they consumed at least 5 of the 10 food groups. The child's diet diversity score was calculated based on the minimum dietary diversity (MDD) guidelines for children aged 6–23 or >23 months old.[18] The MDD questionnaire includes eight food groups: breastmilk, root, grains and tubers, legumes and nuts, flesh foods, eggs, vitamin A-rich fruits and vegetables, and other fruits and vegetables.[18,19] The child's caregiver was asked to recall all the food and drinks the child consumed during the previous 24 hours preceding the survey. The food and drinks were categorized into eight food groups for children aged 6–23 months and seven food groups for children older than 23 months old. Like the MDD-W, a consumed food group was scored as '1' or '0' when it was not consumed. For a child to have achieved the recommended minimum diet diversity score, they had to consume at least five of the eight food groups for children aged 6–23 months and at least four of the seven food groups for children older than 23 months.

Statistical Analyses

The normality of outcome variables was checked using histograms, with all continuous outcomes determined to be normally distributed. Prior to identifying predictors of household food security, women's, and children's dietary diversity, we re-coded the dependent variables to align with the logistic regression assumption of ensuring the outcome variables are in

a binary format. The household food security scale was coded "1" for food secure and "0" for food insecure. We set the threshold at five food groups to categorize women's dietary diversity scores. Women scoring < 5 were labeled as "0," and those with DDS scores ≥ 5 were labeled as "1." For children, the cutoff was ≥ 5 for those aged 6–23 months and ≥ 4 for those older than 24 months. Children meeting the criteria were labeled as "1," while those not meeting it were labeled as "0" We presented continuous variables as means and ranges while categorical variables as proportions (%).

The logistic model addressed multicollinearity among variables through two primary strategies. First, we combined categories to diminish the levels of categorical variables, as exemplified in our treatment of age. Additionally, we reduced the HFIAS categories from four to two, specifically designating them as secure and insecure. Secondly, we employed the Variance Inflation Factor (VIF) to assess the potential impact of multicollinearity. A higher VIF signifies an elevation in standard errors, highlighting potential multicollinearity issues. The obtained VIF value in our study was notably low, indicating a minimal presence of multicollinearity. All statistical analyses were conducted using IBM SPSS Statistics (version 29.0).[20]

Results

The majority (67%) of the households in the study had five or more members, with Balaka district exhibiting the highest proportion (68%) of households in this category. Additionally, 69% of the households were male-headed, and 63% of these household heads were aged between 18 and 35 years. Among these men, 73% were married in a monogamous union, while 56% had received no formal education or did not complete primary education. Similarly, 68% of the sampled child caregivers had either no or incomplete primary education. Farming emerged as the primary occupation for 66% of the surveyed household heads. Regarding household income, 74% of the households reported an average monthly income of ≤ 4.2 United States Dollars (USD) per member (Table 1).

Household Food Security Status and Dietary Diversity

Most of the surveyed households (71%) were severely food insecure, with Mzimba and Dedza having the highest (76%) and lowest (69%) proportions of severely food insecure households, respectively (Table 2). Relying on less preferred food was the most common (85%) coping strategy employed among the households. This was also observed among households classified as severely food insecure, with the highest proportion (92.2%) choosing less preferred foods as a coping strategy (Supplementary Figures 2 and 3).

Table 1. Demographic and socio-economic characteristics of selected rural farming households in Malawi.

Variable	N	Overall	Balaka N = 137	Dedza N = 149	Mzimba N = 89
Household Size, n (%)	348				
1-4 members		116 (33)	44 (32)	47 (39)	25 (28)
5-7 members		174 (50)	71 (52)	62 (51)	41 (46)
>7 members		58 (17)	22 (16)	13 (11)	23 (26)
Gender of HH Head, n (%)	362				
Male		250 (69)	88 (68)	87 (60)	75 (86)
Female		112 (31)	42 (32)	58 (40)	12 (14)
Age of HH Head, (years) n (%)	360				
18-25		56 (16)	19 (15)	30 (21)	7 (8.0)
26-35		168 (47)	49 (38)	76 (53)	43 (49)
36-45		86 (24)	36 (28)	23 (16)	27 (31)
>45		50 (14)	25 (19)	15 (10)	10 (11)
Caregiver Age (Years), n (%)	261				
18-23		39 (15)	13 (13)	18 (20)	8 (11)
24-33		128 (49)	40 (40)	46 (51)	42 (59)
34-43		83 (32)	41 (41)	23 (26)	19 (27)
>43		11 (4.2)	6 (6.0)	3 (3.3)	2 (2.8)
Marital Status of HH Head, n (%)	375				
Married Monogamous		274 (73)	97 (71)	112 (75)	65 (73)
Married Polygamous		34 (9.1)	7 (5.1)	12 (8.1)	15 (17)
Others*		67 (18)	33 (24)	25 (17)	9 (10)
Education Level of HH Head, n (%)	361				
No/Did not complete primary school		202 (56)	67 (52)	102 (70)	33 (38)
Completed Primary School		69 (19)	26 (20)	17 (12)	26 (30)
Secondary/higher education		90 (25)	36 (28)	26 (18)	28 (32)
Level of education of Child Caregiver, n (%)	261				
No/Did not complete primary school		173 (66)	64 (64)	70 (78)	39 (55)
Completed Primary School		45 (17)	17 (17)	10 (11)	18 (25)
Secondary/higher education		43 (16)	19 (19)	10 (11)	14 (20)
Primary Occupation of HH head, n (%)	361				
Farming		239 (66)	72 (56)	105 (72)	62 (71)
No Farming		122 (34)	57 (44)	40 (28)	25 (29)
Primary Occupation of Child Caregiver, n (%)	261				
Farming		190 (73)	68 (68)	69 (77)	53 (75)
No Farming		71 (27)	32 (32)	21 (23)	18 (25)
Household income per member ($), n (%)	348				
<1.4		122 (35)	39 (28)	44 (36)	39 (44)
1.4-4.2		137 (39)	60 (44)	48 (39)	29 (33)
>4.2		89 (26)	38 (28)	30 (25)	21 (24)

Counts do not always add up to 375 due to missing data from individual survey responses; HH=Household head. Monthly household income was converted from Malawian Kwacha (MWK) to United States Dollar (USD) using the 2020 exchange rate as per OANDA (1MWK = $0.0014); * Divorced, separated, Widow/widower, partnered, never married.

The Minimum Dietary Diversity Scores recommended for women and children were not met by 79% of child caregivers, 100% of children aged 6–23 months, and 80.5% of children (>23 months). When stratified across districts, Dedza had the highest proportion (89%) of women not meeting the MDD-W, while Balaka and Dedza had the lowest proportion (74%). On the other hand, when children's dietary diversity was considered, Dedza had the highest (88.5%). In comparison, Balaka and Mzimba had the lowest (75%) proportion of children aged (>23 months) not meeting the recommended MDD for children, respectively (Table 2). Grains, roots, and tubers were the most frequently consumed food group among women and children

Table 2. Household food security status and dietary diversity of caregivers and children from selected small holder farming households in Malawi.

Variable	Overall	Balaka	Dedza	Mzimba
Household Food Insecurity Access Score (HFIAS), n, (%)				
N	375	137	149	89
Food Secure	22 (5.9)	9 (6.6)	9 (6.0)	4 (4.5)
Mildly Food Insecure	26 (6.9)	13 (9.5)	6 (4.0)	7 (7.9)
Moderately Food Insecure	59 (16.0)	18 (13.0)	31 (21.0)	10 (11.0)
Severely Food Insecure	268 (71.0)	97 (71.0)	103 (69.0)	68 (76.0)
Minimum Dietary Diversity for Women				
N	261	103	88	70
Mean (Range)	3.51(9)	3.87(9)	3.05(7)	3.57(8)
Child Dietary Diversity				
N (>23 months)	358	134	139	85
Mean (Range)	2.54(7)	2.84(6)	2.20(5)	2.62(7)
N (6-23 months)	13	2	8	3
Mean (Range)	2.62(3)	3.50(1)	2.38(3)	2.67(3)
Minimum Dietary Diversity for Women, n (%)				
N	261	103	88	70
<5 Groups	206 (79)	76 (74)	78 (89)	52 (74)
≥5 Groups	55 (21)	27 (26)	10 (11)	18 (26)
Child Dietary Diversity, n (%)				
N (>23 months)	358	134	139	85
<4 Groups	288(80.5)	101 (75.4)	123 (88.5)	64 (75.3)
≥4 Groups	70(19.5)	33(24.6)	16(11.5)	21 (24.7)
Child Dietary Diversity, n (%)	13	2	8	3
N (6-23 months)				
<5 Groups	13 (100.0)	2 (100.0)	8 (100.0)	3 (100.0)
≥5 Groups	-	-	-	-

(Supplementary Figures 4 and 5). Additionally, women of reproductive age also commonly consumed dark leafy vegetables and other vegetables, with reported percentages of 76.7%, 84.1%, and 71.4% for dark leafy vegetables and 78.6%, 55.7%, and 64.3% for other vegetables in Balaka, Dedza, and Mzimba, respectively (Supplementary Figure 4). In the assessment of children's dietary diversity across districts, it was observed that other fruits and vegetables were also a commonly consumed food group. This food group accounted for reported percentages of 81.8%, 61. 2%, and 68.2% in Balaka, Dedza, and Mzimba, respectively (Supplementary Figure 5). Conversely, dairy, pulses, eggs, meat, fish, and poultry were the least consumed food groups among the women and children (Supplementary Figures 4 and 5). Animal food sources such as flesh foods, dairy, and eggs were the least consumed by children and women of reproductive age (<40% across all surveyed districts).

Household Food Security Status and Diet Diversity Predictors

Households where the head was unmarried had approximately 2.99 times higher odds (OR = 2.99, 95%CI, 1.06–8.81) of being food insecure compared to households where the head was monogamous. The odds of experiencing food insecurity among households that reported farming as their primary occupation were also 2.61 times greater (OR = 2.61, 95%CI, 1.5–4.59) than households with no farming activities. Conversely, household food insecurity

decreased by 72% in households where the head completed secondary or higher education (OR = 0.28, 95%CI, 0.14–0.54). Households with more than seven members had 66% lower odds of experiencing food insecurity than households with one to four members (OR = 0.34, 95%CI, 0.14–0.85). On the other hand, households whose monthly income was more than 4.2 USD per member per month were 60% less likely to experience food insecurity than households whose income was less than 1.4 USD per member (OR = 0.40, 95%CI, 0.19–0.82) (Table 3).

In identifying the predictors of MDD-W, the odds of meeting MDD-W were 63% lower among women aged between 23 and 33 years than women aged 18–23 (OR = 0.37, 95%CI, 0.14–0.95). Moreover, women in severely food insecure households had 57% lower odds of meeting the MDD-W compared to women in food secure or moderately food insecure households (OR = 0.43, 95%CI, 0.21–0.89) (Table 4).

Table 3. Predictors of severe household food insecurity in rural farming households in Malawi.

		Univariate Model			Multivariate Model		
Variables	N	OR	95% CI	p-value	OR	95% CI	p-value
District	375						
Balaka		Ref	—		Ref	—	
Dedza		0.92	0.56 - 1.53	0.76	0.55	0.29 - 1.04	0.069
Mzimba		1.34	0.73 - 2.49	0.35	1.24	0.61 - 2.56	0.56
Gender of HH Head	362						
Male		Ref	—		Ref	—	
Female		1.10	0.67 - 1.82	0.71	0.57	0.25 - 1.35	0.2
Age of HH Head (Years)	360						
18-25		Ref	—		Ref	—	
26-35		1.31	0.66 - 2.53	0.43	1.66	0.72 - 3.75	0.23
36-45		0.81	0.39 - 1.66	0.58	0.75	0.29 -1.88	0.54
>45		1.12	0.48 - 2.62	0.79	1.11	0.39 - 3.18	0.85
Marital Status of HH Head	375						
Married Monogamous		Ref	—		Ref	—	
Married Polygamous		2.84	1.15 - 8.55	0.037	2.26	0.79 - 7.67	0.15
Others*		2.24	1.18 - 4.58	0.019	2.99	1.06 - 8.81	0.041
level of education of HH Head	361						
No/Did not complete primary school		Ref	—		Ref	—	
Completed Primary School		0.95	0.50 - 1.86	0.88	0.73	0.35 - 1.57	0.41
Secondary/higher education		0.31	0.18 - 0.53	<0.001	0.28	0.14 - 0.54	<0.001
Primary Occupation of HH Head	361						
No Farming		Ref	—		Ref	—	
Farming		2.67	1.67 - 4.30	<0.001	2.61	1.50 - 4.59	<0.001
Household Size	348						
1-4 members		Ref	—		Ref	—	
5-7 members		0.94	0.55 - 1.60	0.83	0.69	0.36 to 1.33	0.28
>7 members		0.61	0.31 - 1.22	0.16	0.34	0.14 to 0.84	0.019
Household income per member ($)	348						
<1.4		Ref	—		Ref	—	
1.4-4-2		0.61	0.33 - 1.08	0.094	0.63	0.32 - 1.22	0.18
>4.2		0.33	0.17 - 0.60	<0.001	0.40	0.19 - 0.82	0.013

HH=Household head.

Monthly household income was converted from Malawian Kwacha (MWK) to United States Dollar (USD) using the 2020 exchange rate as per OANDA (1MWK = $0.0014).

*Married but wife/husband away, Divorced/separated, Widow/widower, never married.

Ref=Reference group; OR = Odds ratio; CI = Confidence interval; P-value <.05.

Table 4. Predictors of dietary diversity among women of reproductive age in rural farming household in Malawi.

		Univariate Model			Multivariable Model		
Variable	N	OR	95% CI	p-value	OR	95% CI	p-value
District	261						
Balaka		Ref	—		Ref	—	
Dedza		0.89	0.44 - 1.78	0.7	0.79	0.36 - 1.68	0.5
Mzimba		1.03	0.49 - 2.13	>0.9	1.03	0.45 - 2.34	>0.9
WRA Age	261						
18-23		Ref	—		Ref	—	
24-33		0.44	0.19 - 1.06	0.061	0.37	0.14 - 0.95	0.038
34-43		0.98	0.42 - 2.33	>0.9	0.79	0.29 - 2.16	0.6
>43		0.95	0.18 - 4.03	>0.9	0.57	0.09 - 2.91	0.5
WRA Marital Status	261						
Married Monogamous		Ref	—		Ref	—	
Married Polygamous		2.06	0.82 - 4.92	0.11	1.99	0.74 - 5.15	0.2
Others		0.52	0.17 - 1.31	0.2	0.57	0.17 - 1.55	0.3
Household Size	261						
1-4 members		Ref	—		Ref	—	
5-7 members		1.44	0.72 - 2.98	0.3	1.18	0.51 - 2.80	0.7
>7 members		1.51	0.63 - 3.61	0.4	0.78	0.27 - 2.26	0.7
Household income per member ($)	261						
<1.4		Ref	—		Ref	—	
1.4-4.2		0.61	0.31 - 1.22	0.2	0.55	0.26 - 1.16	0.12
>4.2		0.57	0.26 - 1.20	0.15	0.47	0.19 - 1.12	0.094
WRA Level of education	261						
No/Did not complete primary school		Ref	—		Ref	—	
Completed Primary School		0.56	0.21 - 1.27	0.2	0.51	0.19 - 1.25	0.2
Secondary/higher education		0.49	0.18 - 1.17	0.13	0.49	0.16 - 1.30	0.2
WRA Primary Occupation	261						
No Farming		Ref	—		Ref	—	
Farming		0.74	0.39 - 1.42	0.3	0.73	0.36 - 1.50	0.4
Household Food Security	261						
Food Secure-Moderately Food Insecure		Ref	—		Ref	—	
Severely Food Insecure		0.57	0.30 - 1.07	0.075	0.43	0.21 - 0.89	0.022

Monthly household income was collected in Malawian Kwacha (MWK) and was converted to United States Dollar (USD) using the 2020 exchange rate (1MWK = $0.0014); * Married but wife/husband away, Divorced/separated, Widow/widower, never married.; Ref=Reference group; OR = Odds ratio CI = Confidence interval; P-value <.05.

Children living in Dedza had 83% lower odds of meeting the recommended MDD compared to those residing in Balaka households (OR = 0.17, 95%CI, 0.04–0.65). On the other hand, children of older caregivers (above 43 years of age) had approximately 14 times greater odds of meeting the MDD than children of caregivers aged 18–23 years old (OR = 15.1, 95% CI, 1.29–192). Furthermore, children whose mothers met the MDD-W had 37.6 times higher odds of meeting the MDD than those whose mothers did not meet the MDD-W (OR = 37.6, 95%CI, 13.9–117) (Table 5).

Discussion

Overall, our results suggested a high prevalence of severe food insecurity (71%) among smallholder households in the study areas. Moreover, most smallholder households relied on less preferred and less expensive foods as the most common coping strategy (85.1%). According to the fifth integrated

Table 5. Predictors of dietary diversity among children in rural farming households in Malawi.

		Univariate			Multivariable		
Variable	N	OR	95% CI	p-value	OR	95% CI	p-value
District	261						
Balaka		Ref	—		Ref	—	
Dedza		0.17	0.05 - 0.45	0.001	0.17	0.04 - 0.65	0.015
Mzimba		1.2	0.59 - 2.44	0.6	1.72	0.56 - 5.40	0.3
Caregiver Age (Years)	261						
18-23		Ref	—		Ref	—	
26-33		1.57	0.60 - 4.90	0.4	3.03	0.67 - 15.7	0.2
36-43		1.57	0.53 - 5.28	0.4	4.74	0.77 - 32.7	0.1
>43		2.16	0.39 - 10.5	0.3	15.1	1.29 – 192	0.031
Caregiver Marital Status	261						
Married Monogamous		Ref	—		Ref	—	
Married Polygamous		0.24	0.01 - 1.21	0.2	0.35	0.01 - 3.29	0.4
Others		1.91	0.84 - 4.12	0.11	2.14	0.65 - 6.99	0.2
Caregiver level of education	261						
No/Did not complete primary school		Ref	—		Ref	—	
Completed Primary School		1.47	0.54 - 3.56	0.4	1.97	0.51 - 7.19	0.3
Secondary/higher education		4.32	1.97 - 9.43	<0.001	2.03	0.59 - 6.97	0.3
Caregiver Primary Occupation	261						
No Farming		Ref	—		Ref	—	
Farming		0.91	0.44 - 1.99	0.8	2.32	0.75 - 8.02	0.2
Household Size	261						
1-4 members		Ref	—		Ref	—	
5-7 members		0.98	0.50 - 1.97	>0.9	0.72	0.21 - 2.55	0.6
>7 members		0.53	0.15 - 1.58	0.3	0.23	0.03 - 1.66	0.2
Household income per member ($)	261						
<1.4		Ref	—		Ref	—	
1.4 - 4.2		2.36	0.92 - 6.85	0.089	1.61	0.39 - 7.29	0.5
>4.2		5.4	2.18 - 15.4	<0.001	1.51	0.36 - 6.68	0.6
Household Food Security Status	261						
Food Secure -Moderately Food Secure		Ref	—		Ref	—	
Severely Food Insecure		0.48	0.24 - 0.94	0.03	0.57	0.21, 1.62	0.3
Minimum Women Dietary Diversity	261						
<5 Food groups		Ref	—		Ref	—	
≥5 Food groups		34.3	15.3 - 83.2	<0.001	37.6	13.9 - 117	<0.001

Monthly household income was collected in Malawian Kwacha (MWK) and was converted to United States Dollar (USD) using the 2020 exchange rate (1MWK = $0.0014).
Married but wife/husband away, Divorced/separated, Widow/widower, never married.
Ref=Reference group; OR = Odds ratio; CI = Confidence interval; P-value <.05.

household food survey (IHS5) conducted between April 2019 and March 2020, 68% of surveyed households reported experiencing very low food security. At the regional level, the southern region had the highest prevalence, with 68.4% of households facing very low food security. In comparison, the Central and Northern regions reported lower percentages of 60.8% and 50.3%, respectively.[21] Our study had higher overall rates of food insecurity (87%) as well as differences in regional trends compared to IHS5, with the highest food insecurity in Mzimba in the Northern region (76.0%) versus 69.0% and 71% among households in Dedza (Central region) and Balaka (Southern region). The survey period in our study coincided with Malawi's post-harvest period when most rural households usually consume food from their own production. Therefore, the observed food insecurity prevalence was expected to be lower than IHS5. The differing findings could be explained by the fact that in

the lean season, parts of the Northern region experienced flooding in the 2019/2020 rainfall season, parts of the Central region experienced early cessation of rainfall, and parts of the Southern region experienced localized dry spells and erratic rainfall, thus affecting food production.[22] Although we did not assess this, we hypothesized that the impacts of COVID-19 mitigation measures may have also affected remittance-dependent households, as observed in other studies.[23,24] However, a panel data survey conducted in Malawi within a similar period observed that COVID-19 restrictions did not drastically change food security as their impacts depended on market integration levels.[25] Our findings were, therefore, due to climate-related challenges and are helpful when considering food insecurity due to the impacts of climate change.

Research findings suggest that alcohol consumption can increase vulnerability to food insecurity by diverting financial resources from essential food expenditures.[26–28] In Malawi, data from the 2017 STEPS nationwide survey indicates that 17.3% of respondents aged 18–69 years (male and female) reported consuming alcohol.[29] Furthermore, insights from the fourth integrated household survey (IHS4) reveal that 6.8% of sampled households dedicated 7.8% of their total budget to alcohol.[30] Our study did not, however, explore alcohol consumption as a possible contributor to food insecurity in the investigated districts. This would be an area of future investigation.

Higher income was observed to be protective against food insecurity. These results are consistent with those reported from studies in Malawi, Kenya, and Uganda, where an increase in household income was associated with a low prevalence of household food insecurity.[31,32] Also, we observed that larger household sizes were protective against food security. Larger households may have more income-earning adults and, therefore, are cushioned from food insecurity, as previously observed by Oluwatayo.[33] This is equally true in our study population, as the adult-to-dependent ratio tended to be lower as household size increased. This allows for a higher number of earners within the household, contributing to increased financial stability and, consequently, a reduced risk of food insecurity. Larger households also likely have greater social networks, which can offer additional support during difficult times, such as periods of economic hardship or food insecurity.[34]

Interestingly, the regional trends in food insecurity were not replicated in the MDD-W and MDD of children. Prior to this study, we hypothesized that the most food-insecure region would also have the poorest dietary diversity indices. Contrary to this, households in the Central region reported the lowest mean dietary diversity scores and the highest proportion of women and children not meeting the recommended dietary diversity scores. These findings contradict the 2015–2016 Malawi Demography and Health Survey (MDHS) results, which indicated that central Malawi had the highest proportion of children aged 6–23 months meeting the recommended dietary

diversity.[2] Notably, most children included in our study were older than 23 months and from rural areas, which may explain the disparity between our findings and those of the latest MDHS. Moreover, our findings align with the 2012 Malawi Comprehensive Food Security and Vulnerability Analysis (CFSVA) and Nutrition Assessment, with a reported lower mean dietary diversity score in rural Central Malawi than in rural North and South regions.[35]

We anticipated high dietary diversity among the studied population, considering that our study data were collected during the post-harvest season. Contrary to expectations, the low dietary diversity scores for women and children in our study may be attributed to the climate challenges experienced in various regions of Malawi. These challenges may have disrupted local food production and contributed to the elevated levels of food insecurity identified in our study. Consequently, the dietary diversity of women and children may have been compromised due to potential limitations in accessing a variety of nutritious foods. Furthermore, our study uncovered a significant association between severe food insecurity and MDD-W, which subsequently serves as a predictor for children's MDD.

Previous studies have observed a similar relationship between food insecurity and MDD-W.[36–38] Household food insecurity can restrict women's access to diverse and nutritious foods, leading to a monotonous diet lacking essential nutrients.[39,40] Also, women from food-insecure households may prioritize quantity over quality, leading to a noticeable disparity in diet diversity between women and other household members.[41,42] In our sample population, one key strategy for increasing women's dietary diversity is investment in improving food security and empowering women to access diverse diets. In return, addressing dietary diversity for women could have the added benefit of improving children's dietary diversity.[43,44]

There is a paucity of dietary assessment studies in Malawi that would allow for comparisons with our study findings. Despite this, we suggest several possible reasons for the study results. In our study, we observed differences in regional trends in women's and children's dietary diversity, which could be attributed to household heads or caregivers' levels of education. Dedza had the highest percentage of household heads (70%) and caregivers (78%) with no or incomplete primary education. This observation was consistent with the 2016–2017 Malawi demography and health survey, which reported central Malawi to be the region with the lowest adult literacy.[2] Low literacy levels may limit a person's ability to understand and apply nutrition information, which can impact their dietary choices and diversity.[45–49] Moreover, literacy levels may also impact income and purchasing power, which may impact dietary diversity. Adults with low literacy levels may have limited access to higher-paying jobs, which can limit their ability to afford a diverse diet.[50] Similarly, Muthini et al. reported that mother's education level was significantly

associated with children's dietary diversity in rural Kenya.[47] Our study findings corroborate these observations: households with women who had a secondary school education or higher had 72% lower odds of being food insecure. Another reason Dedza may have the poorest dietary diversity indices is the household's dependence on farming as the main economic activity. Previous studies have consistently shown that farming households face a higher risk of food insecurity, which can be attributed to several factors, including limited access to agricultural inputs, land constraints, market access, and environmental elements like climate variations.[51–54] Diversifying income streams can play a crucial role in mitigating these challenges. By diversifying income, households can spread risk and reduce the impact of any one activity failing.

Furthermore, having multiple sources of income can enhance household resilience to economic and environmental shocks. One crucial outcome of diversifying income is improved nutrition. Households with diversified incomes can afford a wider variety of foods, thus promoting better nutrition within the family.[55] We also observed that women of reproductive age between 24–33 years were less likely to meet the MDD-W compared to their younger counterparts aged between 18 and 23 years. In rural households, older women are more likely to prioritize the nutritional needs of other family members, particularly children, an observation also made by Fox et al.,[56] in a comprehensive narrative review. We observed that children of women in higher age categories have higher mean dietary diversity scores than those of women in the 18–23 years group. Over time, their experience in child-feeding practices might also contribute to better child-feeding practices.[57] These findings emphasize the complex interplay of cultural norms, maternal age, and caregiving practices in shaping dietary diversity outcomes for women and children in rural households.

Strengths and Limitations of the Study

The strength of our study lies in the collection of data from households in diverse agro-ecological settings. Additionally, our study highlights the interconnectedness of food security, diet quality, and other socio-economic factors that need to be addressed to improve food and nutrition security.

There are limitations worth noting. Firstly, because we utilized cross-sectional data, this study only establishes associations, not causality. Secondly, there may have been instances of over-reporting food insecurity experiences by respondents who expected to receive assistance. Furthermore, it is worth acknowledging that a 24-hour dietary recall questionnaire can overestimate or underestimate dietary intake, as it depends on the caregivers' ability to recall their or their children's dietary intake. However, we are confident in the dietary assessment results, as the study

was sufficiently powerful to address any under- or over-reporting cases. The trends reported in the consumption of food groups also align with previous observations.

Conclusions and Recommendations

To address food insecurity and poor maternal and child dietary diversity among rural smallholder farmers, we suggest: first, investing in adult education and literacy programs, including nutrition education, to empower both women and men, enabling them to make informed decisions about their dietary habits; Second, extension service providers may promote climate-resilient practices and crop diversification among smallholder farming households. These include providing relevant information and resources to help farmers adapt to changing weather patterns and ensure agricultural production and food security sustainability. Investing in agriculture remains a key lever in addressing food and nutrition security, as Malawi is highly dependent on this sector. Lastly, social support programs, such as conditional cash transfers or food assistance, should be implemented to offer temporary relief to vulnerable households, ensuring access to nutritious foods and contributing to improved food security and dietary diversity. These programs should consider strategies to empower women, as their food and nutrition security have an impact on that of their children as well.

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Author Contributions

Conceptualization, W.N.G-W.; Data collection, W.N.G-W and N.C.K, methodology, W.N.G.-W.; data analysis, K.A. and W.N.G-W; writing – original draft preparation, K.A.; writing – review and editing, W.G.N.-W. and W.O.-T; visualization, K.A., and W.N.G.-W; supervision, W.N.G.-W, and W.O.-T. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author (Wanjiku N Gichohi-Wainaina). The data are not publicly available due to their containing information that could compromise the privacy of research participants.

References

1. IPC. IPC Malawi chronic food insecurity *Report May 2022*. 2022. https://malawi.un.org/sites/default/files/2022-05/IPC%20Malawi%20Chronic%20Food%20Insecurity%20Report%20May%202022.pdf.
2. National Statistical Office (NSO) [Malawi] and ICF. *Malawi Demographic and Health Survey 2015-16*. Zomba, Malawi, and Rockville, Maryland, USA: NSO and ICF; 2017.
3. National Statistical Office (NSO)). Malawi multiple indicator cluster survey 2019-20, survey findings report. Zomba, Malawi: National Statistical Office; 2021.
4. National Statistical Office (NSO) and ICF Macro. *Malawi Demographic and Health Survey 2010*. Zomba, Malawi and Calverton, Maryland, USA: NSO and ICF Macro; 2011.
5. Tuni A, Rentizelas A, Chipula G. Barriers to commercialise produce for smallholder farmers in Malawi: an interpretive structural modelling approach. *J Rural Stud*. 2022;93:1–17. doi:10.1016/j.jrurstud.2022.05.003.
6. Mango N, Makate C, Mapemba L, Sopo M. The role of crop diversification in improving household food security in central Malawi. *Agriculture And Food Secur*. 2018;7(1). doi:10.1186/s40066-018-0160-x.
7. Mkandawire E, Bisai C, Dyke E, et al. A qualitative assessment of gender roles in child nutrition in central Malawi. *BMC Public Health*. 2022;22(1). doi:10.1186/s12889-022-13749-x.
8. Workneh F, Tsegaye S, Amanuel H, et al. Dietary perspectives and practices during pregnancy in rural Amhara region of Ethiopia: an exploratory qualitative study. *Curr Dev Nutr*. 2023;7(6):100079. doi:10.1016/j.cdnut.2023.100079.
9. Aboagye RG, Seidu AA, Ahinkorah BO, et al. Dietary diversity and undernutrition in children aged 6–23 months in sub-saharan Africa. *Nutrients*. 2021;13(10):3431. doi:10.3390/nu13103431.
10. Zulu R, Gichohi-Wainaina W, Fungo R, et al. *Malawi Seed Industry Development Project Phase II (MSIDP II) Malawi Seed Industry Development Project Phase II (MSIDP II) Nutrition, Agriculture, Market, and Gender Analysis an Integrated Approach Towards Alleviating Malnutrition Among Vulnerable Populations in Malawi*. 2021. https://www.researchgate.net/publication/354311541.
11. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? *Indian J Psychol Med*. 2013;35(2):121–126. doi:10.4103/0253-7176.116232.

12. World Bank. Prevalence of moderate or severe food insecurity in the population - Malawi. *The World Bank*. 2020. https://data.worldbank.org/indicator/SN.ITK.MSFI.ZS?end=2020&locations=MW&start=2015&view=chart.
13. Malawi Vulnerability Assessment Committee. Bulletin No. 14/17 volume 1: the integrated food security phase classification (IPC) in Malawi: findings of the 2017 assessment and analysis. 2017. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/1_IPC_Malawi_AcuteFI_MVAC_2017Oct2018Mar.pdf.
14. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide (v. 3). Washington, D.C: USAID Food and Nutrition Technical Assistance Project; 2007. https://www.fantaproject.org/sites/default/files/resources/HFIAS_ENG_v3_Aug07.pdf.
15. Subedi M, Kent S. *Measuring Household Stress: The Development of a Contextualized Multi-Sector Coping Strategy Index for Afghanistan*. 2018. doi:10.21201/2018.2517.
16. Gibson RS, Ferguson EL. An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries. Opportunities for Micronutrient Interventions (OMNI) program of the United States Agency for International Development (USAID). Harvest Plus; 2008. file:///C:/Users/WGichohi/Downloads/p15738coll2_128218.pdf.
17. FAO. *Minimum Dietary Diversity for Women*. Rome; 2021. doi:10.4060/cb3434en.
18. Food and Nutrition Technical Assistance III Project (FANTA). *Developing Tools to Measure Progress on Infant and Young Child Feeding*. Washington, DC: FHI360/FANTA; 2014.
19. WHO/UNICEF. *Global Nutrition Monitoring Framework: Operational Guidance for Tracking Progress in Meeting Targets for 2025*. 2017. https://www.who.int/publications/i/item/9789241513609.
20. IBM Corp. *Released 2023. IBM SPSS Statistics for Windows, Version 29.0.2.0*. Armonk, NY: IBM Corp. https://www.ibm.com/products/spss-statistics.
21. National Statistical Office (NSO). The fifth integrated household survey (IHS5) 2019-2020 report. 2020. https://microdata.worldbank.org/index.php/catalog/3818/related-materials.
22. Integrated Food Security Phase Classification (IPC)). IPC Malawi acute food insecurity 2020. 2021. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Malawi_Acute_Food_Insecurity_2020Nov2021Mar_Report.pdf.
23. Murakami E, Shimizutani S, Yamada E. Projection of the effects of the COVID-19 pandemic on the welfare of remittance-dependent households in the Philippines. *Econ Of Disasters And Clim Change*. 2021;5(1):97–110. doi:10.1007/s41885-020-00078-9.
24. Shimizutani S, Yamada E, Gherghina SC. Resilience against the pandemic: the impact of COVID-19 on migration and household welfare in Tajikistan. *PLOS ONE*. 2021;16(9):e0257469. doi:10.1371/journal.pone.0257469.
25. Aggarwal S, Jeong D, Kumar N, et al. COVID-19 market disruptions and food security: evidence from households in rural Liberia and Malawi. *PLOS ONE*. 2022;17(8):e0271488. doi:10.1371/journal.pone.0271488.
26. Jolex A, Kaluwa B, Paraje G. Crowding out effects of alcohol consumption expenditure on household resource allocation in Malawi. *PLOS ONE*. 2022;17(2):e0263330. doi:10.1371/journal.pone.0263330.
27. Jumrani J, Birthal PS. Does consumption of tobacco and alcohol affect household food security? Evidence from rural India. *Food Secur*. 2017;9(2):255–279. doi:10.1007/s12571-017-0660-8.
28. Pu CY, Lan V, Chou YJ, Lan CF. The crowding-out effects of tobacco and alcohol where expenditure shares are low: analyzing expenditure data for Taiwan. *Soc Sci Med*. 2008;66(9):1979–1989. doi:10.1016/j.socscimed.2008.01.007.

29. World Health Organization, & Government of Malawi. Malawi national STEPS survey for chronic non-communicable diseases and their risk factors final report. 2017. https://www.who.int/publications/m/item/2017-steps-country-report-malawi.
30. National Statistical Office of Malawi. Fourth Integrated Household Survey 2016-2017. Malawi; 2017. https://microdata.worldbank.org/index.php/catalog/2936.
31. Dunga HM, Dunga SH. Coping strategies among the food-insecure household in Malawi, a case of female and male-headed household in South-East of Malawi. *Int J Soc Sci And Humanity Stud*. 2017;9(1):91–107.
32. Kansiime MK, Tambo JA, Mugambi I, Bundi M, Kara A, Owuor C. COVID-19 implications on household income and food security in Kenya and Uganda: findings from a rapid assessment. *World Devel*. 2021;137:105199. doi:10.1016/j.worlddev.2020.105199.
33. Oluwatayo IB. Towards assuring households' food security in rural Nigeria: have cooperatives got any place? *Int J Agric Econ and Rural Devel*. 2009;2(1):52–61.
34. Niles MT, Rudnick J, Lubell M, Cramer L. Household and community social capital links to smallholder food security. *Front Sustain Food Syst*. 2021;5:5. doi:10.3389/fsufs.2021.583353.
35. World Food Programme (WFP). *Comprehensive Food Security and Vulnerability Analysis (CFSVA) and Nutrition Assessment Malawi*. 2012. https://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp203208.pdf.
36. Arlinghaus R, & Laska MN. Parent feeding practices in the context of food insecurity Katherine. *Int J Environ Res Public Health*. 2021;18(2):366. doi:10.3390/ijerph18020366.
37. Johnson ME, Edelman B, Kazembe C. A farm-level perspective of the policy challenges for export diversification in Malawi: example of the oilseeds and maize sectors. *IFPRI Discussion Paper,1549*. 2016.
38. Roy D, Zulfiqar F, Tsusaka TW, Datta A. Household food insecurity and dietary diversity of women of reproductive age among smallholder farming households in northwest Bangladesh. *Ecol Food Nutr*. 2022;61(4):460–483. doi:10.1080/03670244.2021.2024176.
39. McIntyre L, Glanville NT, Raine KD, Dayle JB, Anderson B, Battaglia N. Do low-income lone mothers compromise their nutrition to feed their children? *Can Med Assoc J*. 2003;168(6):686–691.
40. Tarasuk VS. Household food insecurity with hunger is associated with women's food intakes, health, and household circumstances. *J Nutr*. 2001;131(10):2670–2676. doi:10.1093/jn/131.10.2670.
41. Asesefa Kisi M, Tamiru D, Teshome MS, Tamiru M, Feyissa GT. Household food insecurity and coping strategies among pensioners in Jimma Town, Southwest Ethiopia. *BMC Public Health*. 2018;18(1). doi:10.1186/s12889-018-6291-y.
42. Gupta S, Sunder N, Pingali PL. Are women in rural India really consuming a less diverse diet? *Food Nutr Bull*. 2020;41(3):318–331. doi:10.1177/0379572120943780.
43. Amugsi DA, Mittelmark MB, Oduro A, Gillison F. Association between maternal and child dietary diversity: an analysis of the Ghana demographic and health survey. *PLOS ONE*. 2015;10(8):e0136748. doi:10.1371/journal.pone.0136748.
44. Nguyen PH, Avula R, Ruel MT, et al. Maternal and child dietary diversity are associated in Bangladesh, Vietnam, and Ethiopia. *J Nutr*. 2013;143(7):1176–1183. doi:10.3945/jn.112.172247.
45. Frempong RB, Annim SK. Dietary diversity and child malnutrition in Ghana. *Heliyon*. 2017;3(5):e00298. doi:10.1016/j.heliyon.2017.e00298.
46. Kolliesuah NP, Olum S, Ongeng D. Status of household dietary diversity and associated factors among rural and urban households of Northern Uganda. *BMC Nutr*. 2023;9(1):83. doi:10.1186/s40795-023-00739-4.

47. Muthini D, Nzuma J, Nyikal R. Farm production diversity and its association with dietary diversity in Kenya. *Food Secur*. 2020;12(5):1107–1120. doi:10.1007/s12571-020-01030-1.
48. Ochieng J, Afari-Sefa V, Lukumay PJ, Dubois T, van Wouwe JP. Determinants of dietary diversity and the potential role of men in improving household nutrition in Tanzania. *PLOS ONE*. 2017;12(12):e0189022. doi:10.1371/journal.pone.0189022.
49. Rajendran S, Afari-Sefa V, Shee A, et al. Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems. *Agriculture Food Secur*. 2017;6(1). doi:10.1186/s40066-017-0127-3.
50. Obayelu OA, Osho FR. How diverse are the diets of low-income urban households in Nigeria? *J Agric Food Res*. 2020;2:100018. doi:10.1016/j.jafr.2019.100018.
51. Ahmed UI, Ying L, Bashir MK, Abid M, Zulfiqar F, Mertens F. Status and determinants of small farming households' food security and role of market access in enhancing food security in rural Pakistan. *PLOS ONE*. 2017;12(10):e0185466. doi:10.1371/journal.pone.0185466.
52. Ifad FAO, Unicef WFP, WHO. *The State of Food Security and Nutrition in the World 2023*. FAO; IFAD; UNICEF; WFP; WHO; 2023. doi:10.4060/cc3017en.
53. Herrera JP, Rabezara JY, Ravelomanantsoa NAF, et al. Food insecurity related to agricultural practices and household characteristics in rural communities of northeast Madagascar. *Food Secur*. 2021;13(6):1393–1405. doi:10.1007/s12571-021-01179-3.
54. Nuvey FS, Nortey PA, Addo KK, et al. Farm-related determinants of food insecurity among livestock dependent households in two agrarian districts with varying rainfall patterns in Ghana. *Front Sustain Food Syst*. 2022;6:6. doi:10.3389/fsufs.2022.743600.
55. Stephanie Wouterse F. *The Returns to Empowerment in Diversified Rural Household: Evidence from Niger (1611)*. 2017. http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/131076.
56. Fox EL, Davis C, Downs SM, Schultink W, Fanzo J. Who is the woman in women's nutrition? A narrative review of evidence and actions to support women's nutrition throughout life. *Curr Dev Nutr*. 2019;3(1). doi:10.1093/cdn/nzy076.
57. Weerasekara PC, Withanachchi CR, Ginigaddara GAS, Ploeger A. Food and nutrition-related knowledge, attitudes, and practices among reproductive-age women in marginalized areas in Sri Lanka. *Int J Environ Res Public Health*. 2020;17(11):3985. doi:10.3390/ijerph17113985.