

RESEARCH

Open Access



Food production diversity based on food groups is associated with minimum dietary diversity and dietary diversity among lactating mothers residing in subsistence farming households in rural Kyankwanzi district, Uganda

Edward Buzigi^{1,2,3*} , Kirthee Pillay² , Muthulisi Siwela², Blessing Mkhwanazi² and Mjabuliseni Ngidi²

Abstract

Background Consuming a variety of food groups is a proxy indicator of micronutrient adequacy among women of reproductive age (WRA). This study examined the association between minimum food group production diversity (MFGPD) and minimum dietary diversity for women (MDD-W); and the correlation between food group production diversity (FGPD) and women's dietary diversity (WDD) among lactating mothers in rural Kyankwanzi district, central Uganda.

Method Lactating mothers residing in subsistence farming households (HH) were recruited by systematic sampling. The outcome variables were WDD and MDD-W. A respondent scored either "1" or "0" if she consumed or did not consume any of the 10 food groups in the previous 24 h, respectively. The WDD was calculated as the total of all food group scores. The respondent was considered to have achieved MDD-W if she consumed ≥ 5 out of the 10 food groups. The main exposure variables were FGPD and MFGPD. The food groups used to classify foods on the farm were the same as the 10 food group classifications used in the MDD-W. The FGPD was calculated as the total of all food group scores on the farm. The MFGPD was achieved if the farm had ≥ 5 of the 10 food groups. The association between FGPD and WDD was tested by Poisson regression analysis. The association between MFGPD and MDD-W was tested by logistic regression analysis. A test was significant at 95% confidence interval (CI) and P value < 0.05 .

Results There was a positive correlation between WDD and FGPD, adjusted β : 0.15 (95% CI 0.13–0.16, $P < 0.0001$). Lactating mothers who achieved MFGPD were more likely to achieve MDD-W, adjusted odds ratio (AOR): of 8.6 (95% CI: 5.6–13.0, $P < 0.0001$).

*Correspondence:

Edward Buzigi
ebuzigi@musph.ac.ug

Full list of author information is available at the end of the article



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

Conclusion The MFGPD is positively associated with MDD-W, while WDD increases as FGPD increases among lactating mothers in the study area. Promoting food production diversity based on food groups has the potential to improve WDD and achieve MDD-W among lactating mothers in the study area.

Keywords Food production diversity, Food groups, Lactating mothers, Women's dietary diversity, Minimum dietary diversity

Introduction

Promoting food production diversity (FPD) is a nutrition-sensitive agriculture outcome that encourages the farming of a variety of plant-source foods (PSFs) and animal-source foods (ASFs) to increase access to diversified food groups and improve dietary diversity for subsistence farming households in resource-limited settings [1, 2]. Globally, women of reproductive age (WRA), 15–49 years of age are more vulnerable to major micronutrient deficiencies such as iron, vitamin A, and zinc deficiencies compared to their male counterparts because of the increased physiological demands of these micronutrients among WRA during menstruation, pregnancy, and lactation [3–7]. However, the highest burden of these micronutrient deficiencies is on WRA who reside in rural resource-limited settings of low and middle-income countries (LMICs) because they continuously consume less diversified and monotonous diets predominantly prepared from staple food groups such as cereals, tubers, and legumes [8–10]. These micronutrient deficiencies occur because cereal or tubers and legumes are either low in micronutrients or contain mineral micronutrient absorption inhibitors such as phytates and polyphenols [11, 12].

Dietary diversity for WRA is defined as consuming a variety of food groups from 10 main different food groups including (i) cereals/grains, white roots and tubers, and plantains; (ii) Pulses (beans, peas, and lentils); (iii) nuts and seeds; (iv) Milk and milk products; (v) Meat, poultry, and fish; (vi) Eggs; (vii) Dark green leafy vegetables; (viii) Other vitamin A-rich fruits and vegetables; (ix) Other vegetables and (x) other fruits [13]. There is convincing evidence that consuming at least 5 of these 10 food groups is a proxy indicator of micronutrient adequacy among WRA [8, 13, 14]. Women are considered to have achieved the minimum dietary diversity (MDD-W) if they consume at least 5 out of the above 10 food groups in the previous 24 h [13].

Most WRA residing in rural settings of Africa access food for either their own or household (HH) consumption through subsistence farming [15]. To this end, FPD has been suggested as a nutrition-sensitive agricultural approach to improve WDD and MDD-W residing in the subsistence-farming households (HHs) of LMICs [13]. The FPD can be measured by counting either the number of food species or food groups on the farm. For example, consider a HH that has a farm with white cassava, maize,

and rice. Based on the count of food species, this HH farm will have three food species. However, the same HH farm will have one food group if FPD is based on the count of food groups. This is plausible because white cassava, rice, and maize belong to one food group called cereals, tubers, and plantains [13]. Studies that have tested the association between FPD and WDD in LMICs are scarce [16]. Moreover, the majority that have measured FPD used a simple count of food species [16–18].

It is important to note that the use of a simple count of food species to measure FPD has been questioned because it does not necessarily reflect diversity from a dietary point of view [19]. This is because the WDD score for WRA is counted as the number of food groups consumed, not the number of food species consumed [13]. Therefore, it is likely that measuring the association between FPD based on a simple count of food species and dietary diversity based on food groups does not match if the food species belong to the same food group and, therefore, may produce weaker associations between FPD and WDD [19, 20]. For example, assume that one HH has a farm that grows only maize and so has a FPD score of (1) Another HH farm that grows maize and cassava has a FPD score of (2) A third HH farm that grows maize, cassava, and white-fleshed sweet potato has a FPD score of (3). If a WRA from each of these HH farms ate only the foods they produced (maize; maize and cassava; or maize, cassava, and white-fleshed potato), then the WDD score would be 1 in all cases because all of the food is from the “Grains, white roots and tubers, and plantains group” [13].

There are limited studies that have taken a step to understand the association between minimum FPD based on food group count, minimum food group production diversity (MFGPD), and MDD-W among lactating mothers [21, 22]. The available studies have either tested the association of household dietary diversity and FPD based on food species or have neglected to assess the association between FPD and WDD [21, 22]. These studies revealed that crop species count, and animal species count are differently associated with dietary diversity [21, 22].

Neglecting to test the association between FPD based on food groups and dietary diversity among population groups at risk of inadequate dietary diversity, such as WRA including lactating mothers, may undermine efforts to generate evidence that may inform policy and

programs that aim to promote and support FPD based on food groups and WDD in Uganda [23]. To this end, we constructed a minimum farm production diversity index, called MFGPD, based on the 10 food groups used to assess MDD-W [13] and then determined the association between MFGPD and MDD-W among lactating mothers residing in subsistence farming HHs in rural Kyankwanzi district, Uganda. We hypothesized that (i) achieving MFGPD is associated with achieving MDD-W and (ii) farm production diversity based on counting food groups, food group production diversity (FGPD) is associated with WDD.

Methods

Study design and setting

This HH cross-sectional quantitative study was conducted in the rural Kyankwanzi district, central Uganda, an area where over 90% of food for HH consumption is produced through subsistence farming [24, 25]. Moreover, 50% of the WRA are either pregnant or lactating mothers [24]. Data collection was done during the crop harvesting season between December 2019 and March 2020.

Study participants, inclusion, and exclusion criteria

The study participants were all mothers who had infants and young children (IYC) aged 0 to 23 months in the study area during the data collection period. A woman was eligible for inclusion in the study if she was a WRA (15–49 years old) and breastfeeding. Study participants who resided in HHs without a subsistence farm, those who had mental disorders, were unable to hear or speak, and were not willing to participate in the study were excluded from the study.

Pilot study

A pilot study was conducted to inform the sample size calculation for the main study [26]. This was necessary because we found no previous studies that determined the prevalence of MFGPD and its association with MDD-W. The pilot study was conducted in the rural Kiboga district, a neighboring district to Kyankwanzi, where the main study was conducted [27]. The pilot study recruited 123 lactating mothers with infants and young children, 0–23 months old. The lactating mothers were residing in HHs with subsistence farms. The FGPD score is a sum of the number of different food groups produced by each farm. Therefore, the food groups used to classify foods on the farm were the same as those of the 10 food group classifications used in the MDD-W indicator [13]. To this end, a lactating mother was considered to have achieved MFGPD if she resided in a HH that had a farm with at least 5 out of the 10 food groups. A lactating mother was considered to have achieved MDD-W if

she had consumed at least 5 out of the 10 food groups in the previous 24 h. Results from the pilot study showed that the proportion of lactating mothers who achieved MDD-W in a group that had achieved MFGPD was 19%. In contrast, the proportion of mothers who achieved MDD-W in a group that did not achieve MFGPD was 11%. These proportions were used to calculate the sample size of the main study. This pilot study was also used to train four enumerators on how to collect data concerning FPD, MFGPD, MDD-W, and WDD. The enumerators had obtained a Bachelor of Science in Human Nutrition and were experienced in collecting dietary diversity data.

Sample size determination

We used a two proportion formula,

$$N = \frac{P_0(1 - P_0) + P_1(1 - P_1)(z_\alpha + z_\beta)^2}{(P_0 - P_1)}$$

to calculate sample size because this study tested associations between exposure variables and a binary outcome, and proportions were determined by a pilot study conducted in a neighboring district [28].

Where N = required minimum sample size.

P_0 = Proportion of mothers who achieved MDD in a group that has MFGPD = 19%.

P_1 = Proportion of mothers who achieve MDD in a group that does not achieve MFGPD = 11%.

Z_α is a standard normal value corresponding to a level of significance of 5% = 1.96.

Z_β is the standard normal value corresponding to the power of the study (80%) = 0.84. Values for P_0 and P_1 were based on the pilot study results.

$$\text{Therefore, } N = \frac{0.19(1 - 0.19) + 0.11(1 - 0.11) \times (1.96 + 0.84)^2}{(0.19 - 0.11)^2} = 308 \text{ participants}$$

After multiplying this by a design effect of 2, the final sample size was 616. Considering a non-response rate of 8.4%, 668 participants were required in the study. We calculated the design effect based on the pilot study data as the ratio of the variance of an estimate under a sampling plan to the variance of the same estimate from a simple random sample with the same number of observations. The non-response rate was also calculated based on the pilot study.

Sampling procedure for study participants

The lactating mothers were recruited by systematic sampling method. The district was divided into its administrative units of 15 sub-counties and six town councils to give a total of 21 administrative units (strata). The village health team members (VHTs) listed all HHs in each

administrative unit with a subsistence farm and mothers having IYC, 0 to 23 months old. The number of lactating mothers recruited per administrative unit was based on the proportion to the size of the administrative unit. On average, 30 lactating mothers were listed per day per administrative unit. Therefore, we systematically recruited 10 of 30 lactating mothers per day per administrative unit. The following procedure was followed: Every morning, a list of all the first 30 participants was obtained. To this end, $30/10=3$. Therefore, every third lactating mother was recruited. A number from 1 to 3 was chosen at random as a starting point for the recruitment of study participants. In this case, number 1 was chosen at random. Therefore, every 3rd participant was recruited into the study per administrative unit until the calculated sample size was achieved. That is to say, participants 1,4,7, 10, 13,16,19,22,25, and 28 were selected from the list to participate in the study. In cases where the HH had more than one lactating mother, then one lactating mother was picked by computer-generated simple random sampling to participate in the study.

Measurement of outcome variables

The outcome variables of this study were women's dietary diversity (WDD) and minimum dietary diversity for women (MDD-W). A 24-hour dietary recall questionnaire was completed for each participant in a face-to-face interview. This was guided by the Food and Agriculture Organization of the United Nations (FAO) non-quantitative open 24-hour recall method used to collect data on WDD and MDD-W [13]. The trained enumerators asked a series of standard probing questions to help the lactating mothers recall all foods and beverages consumed the previous day and night and to probe for the main ingredients in mixed dishes. Thereafter, the enumerator determined to which food groups these foods belonged. According to the FAO guideline, all the food items were categorized into 10 food groups, including (i) Grains, white roots and tubers, and plantains; (ii) Pulses (beans, peas, and lentils); (iii) Nuts and seeds; (iv) Milk and milk products; (v) Meat, poultry, and fish; (vi) Eggs; (vii) Dark green leafy vegetables; (viii) Vitamin A-rich fruits and vegetables; (ix) Other vegetables; (x) Other fruits. A participant was scored either "1" if she consumed the food group or "0" if she did not consume the food group in the previous 24 h. The lactating mothers' WDD was calculated as the total of all food group scores. The lactating mother was considered to have achieved MDD-W if she consumed at least 5 out of the 10 food groups in the previous 24 h [13].

Measurement of exposure variables

The main exposure variables were minimum farm group production diversity (MFGPD) and food group

production diversity (FGPD). This study opted to use the count of "food groups" and not "food species" because, as noted above, nutritionists are expected to promote achieving MDD-W based on food groups, not food species [13, 19]. During the survey, lactating mothers were asked to report details of their current farm production. This was confirmed by the enumerators through observation of the farms. The FGPD score was a sum of the number of different food groups produced by each farm. Therefore, the food groups used to classify foods on the farm were the same as those of the 10 food group classifications used in the MDD-W indicator [13]. The lactating mother was considered to have achieved MFGPD if her farm HH had at least 5 out of the 10 food groups. The FGPD score did not take into account condiments and seasonings such as garlic, onions, and hot pepper, among others, because they are not part of the food groups for assessing either WDD or MDD-W among WRA [13].

Assessment of confounding variables

A structured questionnaire was used to collect data on confounding variables. The lactating mothers were asked to report on the socio-economic and demographic confounders such as the sex of the HH head, the mother's age, the mother's education, off-farm income, nutrition education to the mother, purchase of food for consumption, and sale of food produced from the HH farm because previous studies have demonstrated that they have a potential to influence dietary diversity [20–22, 29–32]. Categorization for: Sex of HH head was into male and female; education into no formal education, primary, secondary and tertiary education; off-farm income into yes and no; nutrition education on either WDD and MDD-W into yes and no; sale of food into yes and no; purchase of food into yes and no; lactating mothers age was categorized into adolescent (yes and no). The lactating mother was considered an adolescent and non-adolescent if she was aged 15–19 and 20–49 years, respectively [33]. Because of their higher growth spurt, adolescent mothers have higher nutritional demands compared to older non-adolescent mothers [34]; therefore, it was important to control for the age of respondents based on adolescence. Furthermore, the age of the breastfeeding child was considered as a cofounder because the infant and young child feeding guidelines recommend mothers breastfeed their children 0 to 23 months old [35]. The 0 to 23 age range was further categorized into the period of exclusive breastfeeding and complementary feeding, which target mothers with children 0 to 5 months old and 6 to 23 months old, respectively [35].

Statistical data analysis

We analyzed the data using STATA, version 15.0. A statistical test was considered significant at 95% confidence interval (CI) and probability value, P less than 0.05 ($P < 0.05$). The association between the WDD score and FGP score was analyzed by bivariate and multivariable Poisson regression analysis [36]. The unadjusted and adjusted correlation coefficients (β) were reported in the former and latter, respectively.

Table 1 Background characteristics of study participants ($n = 668$)

Variable	Frequency	Percentage (%)
Adolescent mother		
Yes (15–19 years old)	164	24.5
No (20–49 years old)	504	75.5
Age of breastfed child		
0–5 months	261	39.1
6–23	407	60.9
Mother education		
None	190	28.5
Primary	192	28.7
Secondary	91	13.6
Tertiary	195	29.2
HH head		
Female	104	15.6
Male	564	84.4
Sell		
Yes	306	45.8
No	362	54.2
Off-farm income		
Yes	265	39.7
No	403	60.3
Purchase		
Yes	279	41.8
No	389	58.2
Farm size (> 1 acre)		
Yes	276	41.3
No	392	58.7
Number of HH members		
1–5	262	39.2
>5	406	60.8
Nutrition education on WDD or MDD-W		
Yes	268	40.1
No	400	59.9
MFGPD		
Yes	148	22.2
No	520	77.8
MDD-W		
Yes	183	27.4
No	485	72.6

HH: Household head; WDD: Women dietary diversity; MDD-W: minimum dietary diversity for women

MFGPD: Minimum food group production diversity

We created a binary outcome for MDD-W (yes and no). The association between MDD-W and independent variables was analyzed by bivariate and multivariable logistic regression analysis. Crude odds ratios (COR) and adjusted odds ratios (AOR) were reported in the former and latter, respectively. Differences in the prevalence of MFGPD and MDD-W among HHs where lactating mothers resided were analyzed using McNemar's test.

Ethical approval

This study is part of the caregiver acceptability study of a complementary food prepared from pumpkin and common bean in Uganda [37]. Permission to conduct the study was granted by the District Health Office, Kyankwanzi district, Uganda. Ethical approval was granted by The AIDS Support Organisation Research Ethical Committee (Reference number: TASO-REC/066/19-UG-REC-009) under the study "Nutrition and sensory properties of a complementary food prepared from pumpkin and common bean in Uganda." Written and signed consent were obtained individually from the lactating mothers who participated in the study. Written/signed consent was taken from legally authorized representatives and/or guardians of all lactating mothers who were below 18 years old and those without formal education.

Results

Background characteristics of study participants

Out of the 668 lactating mothers who participated in the study, 24.5% were adolescents (15–19 years old), while 75.5% were non-adolescents (≥ 20 years); 60.9% had children in the age range of complementary feeding (6–23 months old), while 39.1% had children in the age range of exclusive breastfeeding (0–5 months old). The mean WDD and FGP score (\pm standard deviation) were $3.9(\pm 1.1)$ and $3.7(\pm 1.1)$. The proportion of lactating mothers who achieved MDD-W and MFGPD is 27.4% and 78% MDD-W, respectively. Table 1 shows the background characteristics of the 688 lactating mothers who participated in the study.

Out of the 668 participants, 28.5% ($n = 190$) never had any form of formal education, and 15.6% ($n = 104$) resided in HHs headed by females. About 46% ($n = 306$) had sold at least one food group produced on their farm in the previous 24 h, and 41.8% had purchased at least one food group for consumption in the previous 24 h. About 40% ($n = 265$) had an off-farm income source, 41.3% had a farm size of greater than 1 acre, 60.8% resided in HH with more than five members, and 40.1% had some nutrition education on either WDD or MDD-W (Table 1).

Prevalence of minimum farm production diversity and minimum dietary diversity among lactating mothers

The prevalence of MDD-W and MFGPD was 27.4% (95% CI: 24.1–30.9) and 22.2% (95% CI: 19.2–25.5), respectively. Moreover, the proportion of lactating mothers who achieved MDD-W was significantly higher than those who resided in HHs that achieved MFGPD ($P=0.005$). Figure 1 shows the proportion of lactating mothers' households and lactating mothers that produced and consumed the 10 food groups, respectively.

The proportion of lactating mothers' HHs that produced pulses (91.8%) was significantly higher than their consumption of pulses (59.9%) ($P<0.00001$); nuts and seeds were significantly lower (19.8%) than those that consumed them (30.7) ($P<0.00001$); milk and milk products was significantly higher (38%) than its consumption (21.0%); dark green leafy vegetables was significantly lower(45.8%) than its consumption (54.9%), $P=0.0007$; other vegetables was significantly lower (23.2%) than those HHs that consumed it (69.8%), $P<0.00001$; Vitamin A rich fruits and vegetables were significantly higher (27.5%) than those HHs that consumed them (16.3%), $P<0.00001$. There was no significant difference between HH farm production and lactating mothers' consumption among the other food groups, including grains, white roots, and tubers; meat poultry and fish; Eggs; and other fruits.

Association between food group production diversity score and women's dietary diversity score

Using bivariate Poisson regression analysis, there was a positive correlation between WDD and FGPD, $\beta: 0.15(95\%CI: 0.14-0.17, P<0.0001)$. The confounder that had a significant negative correlation with WDD was attaining tertiary education, $\beta:-0.09(95\%CI:-0.14 - -0.03, P=0.003)$. The other cofounders, including maternal age, head of household, teenage age, and sale of food produced from the farm, were not correlated with WDD (Table 2).

After adjusting for potential confounders (multivariable Poisson regression analysis), the positive correlation between WDD and FGPD remained highly significant, $\beta:0.15(95\%CI 0.13-0.16, P<0.0001)$, Furthermore, the negative correlation between WDD and attaining tertiary education, $\beta:0.05(95\% CI:-0.095- -0.0005)$ remained significant after running a multivariable analysis (Table 2).

Association between minimum dietary diversity and minimum farm production diversity

Table 3 shows the bivariate and multivariable logistic regression analysis between MDD-W and minimum food production diversity based on food groups.

On using bivariate logistic regression analysis, households that produced five or more food groups (achieved MFGPD) were more likely to have lactating mothers who achieved MDD-W, COR 3.6 (95% CI: 2.2–4.8, $P<0.0001$). The confounding variables that were positively associated with MDD-W among lactating mothers were off-farm income, household size, any purchase of

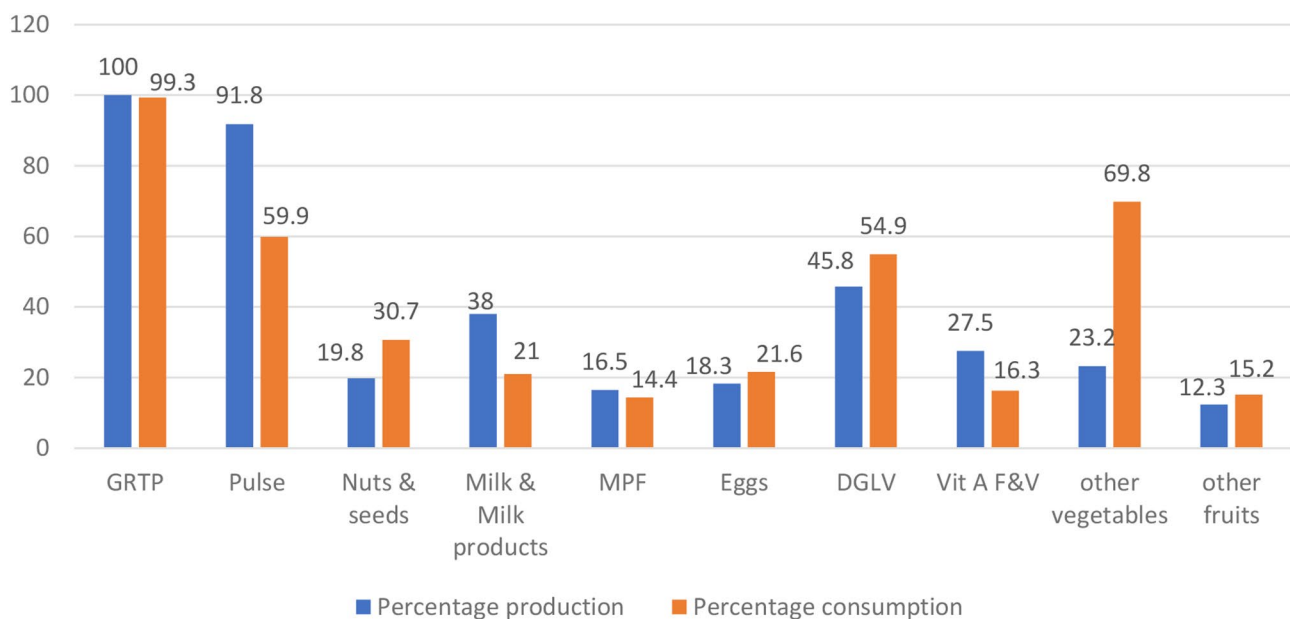


Fig. 1 Proportion of lactating mothers' households and lactating mothers that produced and consumed the 10 food groups, respectively. GRTP: Grains, white roots, and tubers; MPF: Meat, poultry, and fish; DGLV: Dark green leafy vegetables; Vit A F&V: Vitamin A rich fruits and vegetables

Table 2 Unadjusted and adjusted coefficient, B between food group production diversity score and women dietary diversity score for lactating mothers in Kyankwanzi district, Uganda

Predictor variable	Unadjusted		Adjusted	
	β (95%CI)	P value	β (95%CI)	P value
FGPDS	0.15(0.14–0.17)*	<0.0001	0.15(0.13–0.16)*	<0.0001
Adolescent mother				
Yes	0.01(-0.04-0.06)	0.586	0.0008(-0.04-0.40)	0.970
No	Reference		Reference	
Head of HH				
Male	-0.01(-0.07-0.05)	0.703	-0.02(-0.05-0.05)	0.939
Female	Reference		Reference	
Education status				
None	Reference		Reference	
Primary	-0.03(-0.09-0.02)	0.241	-0.03(-0.07-0.19)	0.254
Secondary	-0.009(-0.075-0.056)	0.779	0.02(-0.035-0.66)	0.55
Tertiary	-0.09(-0.14- -0.03)*	0.003	-0.048(-0.095- -0.0005)*	0.048
Off-farm income				
Yes	0.06(-0.02-0.14)	0.134	0.07 (-0.08-0.21)	0.35
No	Reference		Reference	
Farm size (> 1 acre)				
Yes	0.05(-0.02-0.13)	0.178	-0.05(-0.18-0.079)	0.442
No	Reference		Reference	
HH size				
1–5	0.05(-0.02-0.13)	0.172	-0.01(-0.14-0.11)	0.815
> 5	Reference		Reference	
Sell farm food ^a				
Yes	0.02(-0.06-0.10)	0.622	-0.008(-0.004-0.03)	0.665
No	Reference		Reference	
Food purchase ^b				
Yes	0.05(-0.02-0.13)	0.174	-0.07(-0.18-0.04)	0.192
No	Reference		Reference	
Nutrition Education ^c				
Yes	0.06 (-0.02-0.14)	0.152	0.10(-0.08-0.28)	0.265
No	Reference		Reference	
Age of breastfed child				
0–5 months	0.02(-0.06-0.10)	0.634	0.02(-0.02-0.05)	0.376
6–23 months	Reference		Reference	

^a Sold food group produced on their farm in the previous 24 h; ^b Purchased any food group consumed in the previous 24 h; ^c Have ever received nutrition education on women's dietary diversity; HH: Household; FGPDS: Food group production diversity score; *Significant association at $p < 0.05$

food consumed in the last 24 h, and nutrition education on WDD. Women who had off-farm income, COR 1.47 (95% CI:1.04–2.07, $P = 0.03$); residing in HHs having less than six members, COR:1.42 (95% CI: 1.0–2.0, $P = 0.03$); purchased any food group consumed in previous 24 h, COR:1.4 (95% CI: 1.0–2.0, $P = 0.04$); and those who had received nutrition education on MDD-W, COR: 1.5 (95%CI:1.1–2.1, $P = 0.02$) were likely to achieve MDD-W (Table 3).

After controlling for potential confounders, the association between MFGPD and MDD-W remained significant, with AOR 3.2(95% CI: 1.8–4.1, $P < 0.0001$). Also, the association between MDD-W and nutrition education on WDD remained significant, AOR 5.1 (95% CI:1.2–3.2, $P = 0.02$) and MDD-W. In contrast, there were no

significant associations between MDD-W and off-farm income, AOR 2.4 (95% CI: 0.4–5.9, $P = 0.38$); household size of less than 6 members, AOR 0.7(95% CI: 0.1–4.3, $P = 0.66$); and food purchase, AOR: 0.3(95% CI: 0.1–1.5, $P = 0.43$) (Table 3).

Discussion

To the best of our knowledge, this is the first study to construct a MFGPD and test its association with MDD-W among lactating mothers in Uganda. Previous studies conducted in Uganda measured food production diversity based on food species [2, 21]. Our study is unique in the way that it created a minimum food production diversity score based on food groups that are used to construct MDD-W. Moreover, those studies conducted

Table 3 Bivariate and multivariable logistic regression analysis between minimum dietary diversity for lactating women and minimum farm production diversity in rural Kyankwanzi, Uganda

Variable	MDD-W		COR (95%CI)	P value	AOR (95%CI)	P value
	Yes n (%)	No n (%)				
MFGPD						
Yes	93(62.8)	55(37.2)	3.6(2.2–4.8)*	< 0.00001	3.2(1.8–4.1)*	< 0.0001
No	90(17.3)	430(82.7)	Reference		Reference	
Adolescent mother						
Yes	41(25)	123(75)	0.8(0.6–1.2)	0.43	0.7(0.4–1.1)	0.11
No	142(28.2)	362 (71.8)	Reference		Reference	
Sex of HH head						
Female	30(28.9)	74(71.2)	Reference	0.67	Reference	0.92
Male	153(27.2)	411(72.8)	0.9(0.6–1.5)		1.0(0.6–1.7)	
Mother education						
None	55(28.9)	135(71.1)	Reference		Reference	
Primary	59(30.7)	133 (69.3)	1.1 (0.7–1.7)	0.70	1.1(0.7–1.9)	0.60
Secondary	28(30.8)	63(69.2)	1.1(0.6–1.9)	0.75	1.3 (0.7–2.5)	0.35
Tertiary	41(21.0)	154 (79.0)	0.7(0.4-1.0)	0.07	0.8 (0.5–1.4)	0.41
Off-farm income						
Yes	85 (32.1)	180(67.9)	1.47(1.04–2.07)	0.03	2.4 (0.4–5.9)	0.38
No	98(24.3)	305(75.7)	Reference		Reference	
Farm size (> 1 acre)						
Yes	86(31.2)	190(68.8)	1.4(0.98–1.94)	0.07	0.2(0.02–1.2)	0.06
No	97(24.7)	295(75.3)	Reference		Reference	
HH size						
1–5	83(31.7)	179(68.3)	1.42(1.0–2.0)*	0.03	0.7(0.1–4.3)	0.66
> 5	100(24.6)	306(75.4)	Reference		Reference	
Sell farm food ^a						
Yes	92(30.1)	214(69.9)	1.3(0.9–1.8)	0.16	1.2(0.8–1.7)	0.42
No	91(25.4)	271(74.9)	Reference		Reference	
Food purchase ^b						
Yes	88(35.5)	191(68.5)	1.4(1.0–2.0)*	0.04	0.3(0.1–1.5)	0.13
No	95(24.4)	294 (75.6)	Reference		Reference	
Nutrition Education ^c						
Yes	87(32.5)	181(67.5)	1.5(1.1–2.1)*	0.02	5.1(1.2–3.2)*	0.03
No	96(24.0)	304 (76.0)	Reference		Reference	
Age of breastfed children (months)						
0–5	76(29.1)	185(70.9)	1.2 (0.8–1.6)	0.42	1.1(0.8–1.6)	0.44
6–23	107(26.3)	300(73.7)	Reference		Reference	

^a Sold food produced from their farm in the previous 24 h; ^b Purchased any food group consumed in the previous 24 h

^c Have received nutrition education on women's dietary diversity

AOR: Adjusted odds ratio; COR: crude odds ratio; MDD-W: Minimum dietary diversity for women; MFGPD: Minimum food group production diversity; HH: Household; *Significant association at $p < 0.05$

in Africa that measured FPD either by using food species or food groups did not create a minimum FPD that is compatible with the MDD-W [8, 16, 18, 38–41].

The prevalence of achieving MDD-W observed in this present study is nearly in agreement with similar populations in other African countries [31, 38]. The significantly higher prevalence of MDD-W compared to MFGPD observed in this study likely indicates that the mothers could have accessed food groups for their consumption from other sources, such as the market, other than from

their HH farm. This is supported by the fact that any form of food purchase and off-farm income were predictors of MDD-W during bivariate analysis. Moreover, previous studies have demonstrated that rural household members, including women, who have any source of income access food from nearby markets to improve their dietary diversity [22, 42]. Furthermore, our study revealed that HHs that achieved MFGPD were most likely to have a lactating mother who achieved MDD-W. Our findings indicate that promoting achieving minimum FPD based

on food groups may contribute towards achieving MDD-W, an indicator of micronutrient adequacy among WRA [43]. Our study informs that it is possible to construct a minimum FPD based on food groups used to construct MDD-W and test the association between MFGPD and MDD-W. It is worth noting that previous studies that measured FPD based on either food groups or food species did not construct a minimum FPD based on food groups used to measure MDD-W [8, 18, 20, 38, 40].

This present study showed that FPD was positively associated with WDD. These findings may suggest that practicing FPD based on food groups should not be undermined in improving dietary diversity for vulnerable populations, including WRA [20]. This is plausible because, from a nutrition point of view, nutrition-sensitive agriculture should be based on food groups, not food species to enable it to match with dietary diversity of consumers, which is measured based on food groups [13, 38, 44]. Previous studies have questioned testing the association between dietary diversity and FPD based on food species because the former is not compatible with the latter since their measurements are based on food groups and food species, respectively [40, 42]. These studies confirm that by replacing the measurement of FPD using the count of food groups with a simple count of food species, the association between FPD and dietary diversity either becomes insignificant or weaker [38, 40, 42]. Such studies inform that findings generated from testing associations between FPD based on food species and dietary diversity, which is based on food groups, should be interpreted with caution because the relationship between FPD and dietary diversity depends on how the number of foods on the farm is counted [19]. This is plausible because FPD doesn't reflect true farm diversity if the food species on the farm belong to the same food group [19].

Study strengths and limitations

Several strengths are inherent in this study. Instead of using crop and animal species count, this study measured FPD and MFGPD using the same food groups used to measure WDD and MDD-W, respectively. From a nutrition-sensitive agriculture point of view, when FAO promotes achieving MDDW, they explicitly intend for it to produce foods from various food groups, not food species [13, 44]. Therefore, testing the association between either FPGD and WDD or MFGPD and MDD-W would match compared to other studies that tested the association between food production diversity based on the count of food species and dietary diversity [8, 16, 29, 40].

This study collected dietary diversity data using a single 24-hour recall method. A limitation of a single 24-hour dietary assessment recall method is that it cannot capture data that may explain individual day-to-day variations in dietary diversity [45]. However, this present study

conducted a single 24-hour recall per lactating mother in the harvest season with a focus on analyzing group-level associations, for which the limitation of not capturing habitual intake from a single 24-hour recall is less problematic [45].

One may argue that the variation in the seasonality of food production between lean and harvest seasons was not ruled out as an alternative explanation of the study outcomes. To address the variation in seasonality, future studies should consider panel data analysis of the same sample in the lean season (non-harvesting season) to check if the association still holds [14, 46, 47]. In addition, the MDD-W indicator was developed as a proxy indicator to reflect the micronutrient adequacy of diets for WRA, including lactating mothers [13, 43]. Therefore one may argue that while data were collected from individual lactating mothers, the indicator cannot be used to conclude about a habitual adequate micronutrient intake as it is based on a single 24-hour recall period and, therefore does not reflect day-to-day variability for individual adequate micronutrient intake. However, at a population level, for example, lactating mothers under study, the MDD-W generated from a single 24-hour recall reflects adequate micronutrient intake [13, 43]. One other weakness is that our study findings cannot be generalized to the whole country. Lastly, being a cross-sectional study, it was difficult to establish the causal relationship between either MFGPD and MDD-W or FPGD and WDD.

Conclusion

In conclusion, there was a significant association between MFGPD and MDD-W for lactating mothers, and we can accept the hypothesis that MFGPD is positively associated with MDD-W among lactating mothers in the study area. Besides, there is a significant positive correlation between lactating mothers' WDDS and FPGDS, and the hypothesis that WDD for lactating mothers in the study area increases as FPGD increases can be accepted. Therefore, nutrition programs and agricultural policymakers should consider promoting food production diversity based on food groups to improve WDD and achieve MDD-W among lactating mothers in the study area.

Acknowledgements

The authors would like to thank the lactating mothers who participated in the study and the community health workers who helped in the mobilization of the study participants.

Author contributions

Conceptualization: EB, KP, and MS; Data curation: EB; Formal analysis: EB; Funding acquisition: EB, KP, MS, MN, and BM; Investigation: EB; Methodology: EB, KP, MS, MN, and BM; Project administration: EB; Resources: EB; Supervision: EB, KP, MS, MN, and BM; Validation: EB, KP, MS, MN, and BM; Visualization: EB, KP, MS, MN, and BM; Writing original draft: EB; Writing, review and editing: All authors reviewed and edited the published version of the manuscript.

Funding

This research was funded through the postdoctoral scholarship awarded to Edward Buzigi in the School of Agricultural, Earth, and Environmental Science within the College of Agriculture, Engineering, and Science at the University of Kwa-Zulu Natal, South Africa.

Data availability

The datasets used and/or analyzed in the present study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study was performed following the ethical standards as laid down in the 1964 Declaration of Helsinki. Ethical approval was granted by the Research Ethical Committee at The AIDS Support Organisation Research Ethical Committee (Reference number: TASO-REC/066/19-UG-REC-009). Informed and signed consent were obtained individually from the pregnant women in the antenatal clinic. Informed consent was taken from legally authorized representatives and/or guardians of all participants who were below 18 years old and those without formal education.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

¹Department of Community Health & Behavioral Sciences, School of Public Health, Makerere University, P.O. Box 7062, Kampala, Uganda

²Department of Dietetics and Human Nutrition, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, 3201, South Africa

³Department of Public Health & Nutrition, Faculty of Health Sciences, Victoria University, P.O. Box 30866 Kampala, Uganda

Received: 10 August 2024 / Accepted: 7 March 2025

Published online: 17 March 2025

References

- Ecker O. Agricultural transformation and food and nutrition security in Ghana: does farm production diversity (still) matter for household dietary diversity? *Food Policy*. 2018;79:271–82.
- Khonje MG, Ricker-Gilbert J, Muyanga M, Qaim M. Farm-level production diversity and child and adolescent nutrition in rural sub-Saharan Africa: a multicountry, longitudinal study. *Lancet Planet Heal*. 2022;6:e391–9.
- Khayat S, Fanaei H, Ghanbarzahi A. Minerals in pregnancy and lactation: A review Article. *J Clin Diagn Res*. 2017;11:QE01–5.
- Gannon BM, Jones C, Mehta S. Vitamin A requirements in pregnancy and lactation. *Curr Dev Nutr*. 2020;4:1–18.
- Abbafti C, Abbas KM, Abbasi-Kangevari M, Abd-Allah F, Abdelalim A, Abdolahi M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *Lancet*. 2020;396:1204–22.
- Mawani M, Aziz Ali S. Iron deficiency Anemia among women of reproductive age, an important public health problem: situation analysis. *Reprod Syst Sex Disord*. 2016;5:1–6.
- Gardner W, Kassebaum N. Global, regional, and National prevalence of Anemia and its causes in 204 countries and territories, 1990–2019. *Curr Dev Nutr*. 2020;4(Supplement 2):830–830.
- Arimond M, Wiesmann D, Becquey E, Carriquiry A, Daniels MC, Deitchler M, et al. Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. *J Nutr*. 2010;140:2059–69.
- Arimond M, Deitchler M. Measuring Diet Quality for Women of Reproductive Age in Low-and Middle-Income Countries: Towards new metrics for changing diets. Washington D.C.; 2019.
- Torheim LE, Ferguson EL, Penrose K, Arimond M. Women in Resource-Poor settings are at risk of inadequate intakes of multiple micronutrients. *J Nutr*. 2010;140:S2051–8.
- Samtiya M, Aluko RE, Dhewa T. Plant food anti-nutritional factors and their reduction strategies: an overview. *Food Prod Process Nutr*. 2020;2:1–14.
- Petry N, Egli I, Zeder C, Walczyk T, Hurrell R. Polyphenols and phytic acid contribute to the low iron bioavailability from common beans in young women. *J Nutr*. 2010;140:1977–82.
- Food and Agriculture Organization of the United Nations. Minimum dietary diversity for women. An updated guide for measurement: from collection to action. Rome; 2021.
- Chakona G, Shackleton C. Minimum dietary diversity scores for women indicate micronutrient adequacy and food insecurity status in South African towns. *Nutrients*. 2017;9:2–16.
- Christiaens L, Demery L. Agriculture in Africa: telling Myths from facts. Directions in development. Washington DC: World Bank; 2018.
- Bellon MR, Ntandou-Bouzitou GD, Caracciolo F. On-farm diversity and market participation are positively associated with dietary diversity of rural mothers in Southern Benin, West Africa. *PLoS ONE*. 2016;11:1–20.
- Verger EO, Gaillard C, Jones AD, Remans R, Kennedy G. Construction and interpretation of production and market metrics used to understand relationships with dietary diversity of rural smallholder farming households. *Agriculture*. 2021;11:1–21.
- Bellows AL, Canavan CR, Blakstad MM, Moshia D, Noor RA, Webb P, et al. The relationship between dietary diversity among women of reproductive age and agricultural diversity in rural Tanzania. *Food Nutr Bull*. 2020;41:50–60.
- Berti PR. Relationship between production diversity and dietary diversity depends on how number of foods is counted. *Proc Natl Acad Sci U S A*. 2015;112:E5656.
- Sibhatu KT, Krishna VV, Qaim M. Production diversity and dietary diversity in smallholder farm households. *Proc Natl Acad Sci U S A*. 2015;112:10657–62.
- Sekabira H, Nansubuga Z, Ddungu SP, Nazziwa L. Farm production diversity, household dietary diversity, and nutrition: evidence from Uganda's National panel survey. *PLoS ONE*. 2022;17(12 December):1–23.
- Jordan I, Röhlrig A, Glas MG, Waswa LM, Mugisha J, Krawinkel MB et al. Dietary diversity of women across agricultural seasons in the Kapchorwa district, Uganda: results from a cohort study. *Foods*. 2022;11.
- Ministry of Agriculture Animal Industry and Fisheries. Uganda Multi-Sector Food Security and Nutrition project– Ministry of Agriculture, Animal Industry and Fisheries. 2019. <https://www.agriculture.go.ug/uganda-multi-sector-food-security-and-nutrition-project/>. Accessed 17 Nov 2019.
- Uganda Bureau of Statistics. National Population and Housing Census 2014 Area Specific Profiles Kyankwanzi District. Kampala; 2017.
- Uganda Bureau of Statistics, Inner City Fund. Uganda demographic and health survey 2016. Maryland, USA: Kampala, Uganda and Rockville; 2018.
- Thabane L, Ma J, Chu R, Cheng J, Ismaila A, Rios LP, et al. A tutorial on pilot studies: the what, why and how. *BMC Med Res Methodol*. 2010;10:1–10.
- Uganda Bureau of Statistics, Inner City Fund. Uganda demographic and health survey 2016: key indicators report. Kampala, Uganda and Maryland, USA; 2017.
- Ahmad WMAW, Amin WAAWM, Aleng NA, Mohamed N. Some practical guidelines for effective sample-size determination in observational studies. *Aceh Int J Sci Technol*. 2012;1:51–3.
- Melby CL, Orozco F, Averett J, Muñoz F, Romero MJ, Barahona A. Agricultural food production diversity and dietary diversity among female small holder farmers in a region of the Ecuadorian Andes experiencing nutrition transition. *Nutrients*. 2020;12:1–15.
- Boedecker J, Odhiambo Odour F, Lachat C, Van Damme P, Kennedy G, Termote C. Participatory farm diversification and nutrition education increase dietary diversity in Western Kenya. *Matern Child Nutr*. 2019;15:1–12.
- Geta TG, Gebremedhin S, Omigbodun AO. Dietary diversity among pregnant women in garage zone, South central Ethiopia: assessment based on longitudinal repeated measurement. *Int J Womens Health*. 2022;14:599–615.
- Gitagia MW, Ramkat RC, Mituki DM, Termote C, Covic N, Cheserek MJ. Determinants of dietary diversity among women of reproductive age in two different agro-ecological zones of Rongai sub-county, Nakuru, Kenya. *Food Nutr Res*. 2019;63:1–12.
- Singh JA, Siddiqi M, Parameshwar P, Chandra-Mouli V. World health organization guidance on ethical considerations in planning and reviewing research studies on sexual and reproductive health in adolescents. *J Adolesc Heal*. 2019;64:427–9.

34. Black RE, Laxminarayan R, Temmerman M, Walker N, editors. Reproductive, maternal, newborn, and child health 2 VOLUME DISEASE CONTROL PRIORITIES • THIRD EDITION. Third edit. Washington DC: The World bank; 2016.
35. World Health Organization. United Nations Children's Fund. Indicators for assessing infant and young child feeding practices Definitions and measurement methods. Geneva; 2021.
36. Muñoz-Pichardo JM, Pino-Mejías R, García-Heras J, Ruiz-Muñoz F, Luz González-Regalado M. A multivariate Poisson regression model for count data. *J Appl Stat.* 2021;48:2525–41.
37. Buzigi E, Pillay K, Siwela M. Caregiver perceptions and acceptability of a provitamin A carotenoid, iron and zinc rich complementary food blend prepared from common bean and pumpkin in rural Uganda. *Nutrients.* 2020;12:906.
38. Adubra L, Savy M, Fortin S, Kameli Y, Kodjo NE, Fainke K, et al. The minimum dietary diversity for women of reproductive age (MDD-W) indicator is related to household food insecurity and farm production diversity: evidence from rural Mali. *Curr Dev Nutr.* 2019;3:1–9.
39. Custodio E, Kayikati F, Fortin S, Thomas AC, Kameli Y, Nkuzimana T, et al. Minimum dietary diversity among women of reproductive age in urban Burkina Faso. *Matern Child Nutr.* 2020;16:1–12.
40. Gaillard C, Verger EO, Dury S, Dop MC, Ati J, El. Farm production diversity and women's dietary diversity: evidence from central Tunisia. *PLoS ONE.* 2022;17(2 February):1–22.
41. Jones AD, Shrinivas A, Bezner-Kerr R. Farm production diversity is associated with greater household dietary diversity in Malawi: findings from nationally representative data. *Food Policy.* 2014;46:1–12.
42. Koppmair S, Kassie M, Qaim M. Farm production, market access and dietary diversity in Malawi. *Public Health Nutr.* 2017;20:325–35.
43. Islam MH, Nayan MM, Jubayer A, Amin MR. A review of the dietary diversity and micronutrient adequacy among the women of reproductive age in low- and middle-income countries. *Food Sci Nutr.* 2024;12:1367–79.
44. Food and Agriculture Organization of the United Nations. Compendium of indicators for nutrition-sensitive agriculture. Rome: FAO; 2016.
45. Food, Agriculture Organization of the United Nations. Dietary assessment: A resource guide to method selection and application in low resource settings. Rome: FAO; 2018.
46. Baye K, Mekonnen D, Choufani J, Yimam S, Bryan E, Griffiths JK et al. Seasonal variation in maternal dietary diversity is reduced by small-scale irrigation practices: A longitudinal study. *Matern Child Nutr.* 2022;18.
47. Henjum S, Torheim LE, Thorne-Lyman AL, Chandyo R, Fawzi WW, Shrestha PS, et al. Low dietary diversity and micronutrient adequacy among lactating women in a peri-urban area of Nepal. *Public Health Nutr.* 2015;18:3201–10.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.