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SUPPLEMENT ARTICLE

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Predictors of micronutrient powder sachet coverage and recent intake among children 12–23 months in Eastern Uganda

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Abstract

We evaluated predictors of micronutrient powder (MNP) sachet coverage and recent intake using data from a cross-sectional survey representative of children aged 12–23 months in Amuria district, Uganda. In June/July 2016, caregivers were interviewed 12 months after implementation of an integrated MNP and infant and young child feeding pilot (N = 761). Logistic regression described predictors of (a) high-MNP sachet coverage (received at least 60 sachets/6 months) and (b) recent intake (consumed MNP during the 2 weeks preceding the survey) among children who had ever received MNP and had complete data (N = 683). Fifty-nine percent (95% Confidence Interval [CI] [53.8, 64.2]) of children had high-MNP sachet coverage, and 65.4% (95% CI [61.0, 69.9]) had recent intake. MNP ration cards (Adjusted Odds Ratio [AOR] 2.67, 95% CI [1.15, 6.23]), organoleptic changes to foods cooked with soda ash (AOR 1.52, 95% CI [1.08, 2.14]), having heard of anaemia (AOR 1.59, 95% CI [1.11, 2.26]), knowledge of correct MNP preparation (AOR 1.89, 95% CI [1.11, 3.19]), and current breastfeeding (AOR 2.04, 95% CI [1.36, 3.08]) were positively associated with MNP coverage whereas older child age (18–23 vs. 12–17 months) was inversely associated with coverage (AOR 0.32, 95% CI [0.23, 0.50]). MNP ration cards (AOR 2.86, 95% CI [1.34, 6.09]), having heard an MNP radio jingle (AOR 1.40, 95% CI [1.01, 1.94]), knowledge of correct MNP preparation (AOR 1.88, 95% CI [1.04, 3.39]), and the child not disliking MNP (AOR 1.90, 95% CI [1.13, 3.22]) were positively associated with recent intake. Interventions that increase caregiver knowledge and skills and focus on older children could improve MNP coverage and recent intake.

KEYWORDS

child nutrition, coverage, home fortification, implementation science, micronutrient powders (MNP), Uganda

1 | INTRODUCTION

Micronutrient deficiencies affect an estimated two billion people globally (Investing in the Future, 2009). Children under 5 years are especially vulnerable; at least, half of children 6–59 months suffer from one or more micronutrient deficiencies (Investing in the Future, 2009). In many low-resource settings, complementary feeding practices are insufficient to meet the nutritional needs of young children due to low dietary diversity, low-nutrient density of complementary foods, and low-nutrient bioavailability. The World Health Organization (WHO) recommends home-based fortification as a low-cost intervention to prevent iron deficiency and anaemia in children 6–23 months

(WHO, 2011, 2016). With home-based fortification, caregivers mix a single-serving packet of micronutrients—also known as micronutrient powders (MNP)—into a child's usual soft or semi-solid food.

Because it can be mixed into a child's typical home diet, adding MNP is often seen as an "easy" solution to address micronutrient deficiencies. However, MNP programmes rely on caregivers adopting a complex series of behaviours. According to the Information, Motivation, Behavioural Skills theory, knowledge and skills alone are not sufficient for behaviour change (Fisher & Fisher, 1992). Caregivers must additionally be motivated to initiate, sustain, and ultimately adopt new behaviours. Although sustained behaviour change is a key component of many public health interventions, motivation can be difficult to maintain (WHO, 2003). Identifying effective behaviour change strategies leading to adoption of new health behaviours and maintenance of these behaviours over time is a key component to achieving desired health outcomes. In the context of MNP interventions, it is crucial to identify factors associated with caregivers: (a) obtaining sufficient MNP sachets (MNP coverage) initially and over time and (b) initiating and continuing to prepare and serve their children foods mixed with MNP overtime (sustained intake; Tumilowicz, Schnefke, Neufeld, & Pelto, 2017).

There has been a proliferation of MNP programmes in recent years. As of 2015, 65 countries had implemented MNP programs, reaching more than 10 million children under 5 years (UNICEF, 2017). Despite the multitude of MNP programmes with different strategies and at different stages of the project life cycle, relatively few studies have explored predictors of MNP coverage or adherence (Angdembe, Choudhury, Haque, & Ahmed, 2015; Jefferds et al., 2015; Mirkovic et al., 2016; Kodish, Rah, Kraemer, de Pee, & Gittelsohn, 2015; Locks et al., 2017). Although some evidence has been summarized (Sunley et al., 2017; Olney, Rawat, & Ruel, 2012), a larger evidence base is needed to inform scale-up and sustainability. Specifically, the field needs a better understanding of how programmes achieve sustained coverage and intake not only in the context of well-resourced pilots but also to inform developing lower resource models that are feasible for scale-up in multiple settings.

In 2015, the Uganda Ministry of Health (MoH) in collaboration with the United Nations World Food Programme (WFP) implemented a pilot programme to promote and distribute MNP along with infant and young child feeding (IYCF) counselling in Amuria and Katakwi districts in Eastern Uganda. The aims of the pilot were to reduce the prevalence of anaemia and other micronutrient deficiencies as well as improve IYCF practices among children 6–23 months. The impact evaluation only occurred in Amuria district but not Katakwi district due to limited funding.

Using data from the pilot's end line evaluation survey collected 12 months after programme implementation in Amuria, the objectives of this analysis were to determine predictors of high-MNP coverage and recent intake among children 12–23 months. We examined various factors expected to influence both outcomes, including MNP distribution channels; exposure to intervention package components; IYCF and MNP knowledge, practices, and experiences; and sociocultural and demographic indicators. By identifying modifiable factors associated with MNP coverage and recent intake, lessons learned from the district-level pilot could inform a wider application and implementation of the intervention in other districts or at the national-level while contributing to the global evidence base for MNP programs.

Key messages

- In settings with limited resources and where front-line health workers have heavy workloads, understanding which activities and behaviour change communication channels are critical to influence micronutrient powder (MNP) sustained coverage and use can help programme planners design effective, low resource intervention packages.
- Behaviour change interventions that increase caregiver knowledge, skills, and demand, and focus on older children are modifiable actions that could improve repeat coverage of MNP sachets and recent intake of MNP in Eastern Uganda.
- Future research should explore factors associated with organoleptic changes to foods mixed with MNP, including food preparation and cooking methods, product quality, integrity of MNP packaging, and micronutrient absorption.

2 | METHODS

2.1 | Pilot programme integrating MNP into an infant and IYCF programme in Amuria and Katakwi districts

The 12-month IYCF/MNP pilot project, started in July 2015, in Amuria and Katakwi districts had two major components. The first was to ensure the MNP supply chain from procurement through delivery to caregivers. The second focused on caregiver behaviour change to motivate optimal IYCF practices for children under 2 years and to generate demand for MNP—free of charge—for children 6–23 months of age according to a schedule of one box of 30 sachets every 2 months. To support a behavioural pattern of regular MNP receipt and intake, messaging suggested giving the child one sachet mixed into their food every other day. The pilot also focused on counselling and messages regarding appropriate preparation of food mixed with MNP. As part of the MoH and MNP Technical Working Group, formative data collection (e.g., a situation analysis, MNP package development, and a 20-day MNP acceptability study [UBC et al., 2014]) was carried out to create an evidence-based and tailored intervention prior to the development and implementation of the MNP pilot. This formative research was used to develop a behaviour change strategy for the IYCF/MNP project that was operationalized in multiple Ugandan districts piloting MNPs, including Amuria and Katakwi.

The MNP project implementation in Amuria and Katakwi was supported by Andre Food Consults (AFC; https://andrefoodsinternational.org/), an implementing partner contracted by WFP during the yearlong pilot period. Multiple stakeholders managed the MNP supply chain. WFP procured the MNP (Hexagon Nutrition, Tamil Nadu, India and DSM Nutritional Products, Basel, Switzerland), whereas the MoH managed the storage. Health facility staff and village health teams (VHTs) in Amuria and Katakwi carried out the monthly MNP distribution with support from AFC staff. The MNP, locally branded as *Vitamin and Mineral Powder*, was delivered through two channels: MoH outreach sites (government outposts and health centres) and community-level distribution led by VHTs (central locations in villages or home delivery). AFC produced monthly distribution reports and used the data to monitor implementation and adjust the distribution as necessary to maximize coverage. At the start of the pilot, the IYCF/MNP programme used existing MoH outreach sites for MNP distribution. After the first project quarter, AFC created new outreach sites, and VHTs delivered MNP to caregivers who missed scheduled distribution at outreach sites. During distribution, caregivers received counselling on the proper preparation of food mixed with MNP, the MNP dosing schedule, and locally tailored optimal IYCF practices, including food preparation demonstrations. Caregivers received an MNP sticker, programme brochure, and ration card to document the date(s) MNP was received and the date to return for the next box of MNP. Caregivers also received an MNP adherence card where caregivers could mark checkboxes to help track the days the child consumed MNP.

MoH staff and VHTs received training on the IYCF/MNP intervention package including IYCF and MNP counselling messages to be delivered to caregivers at MNP distribution and elsewhere opportunistically. The pilot used mass media (radio jingles, brochures, stickers, and posters) and partnerships with VHTs, women groups, and others to disseminate messages about IYCF and MNPs.

2.2 | Study population

We used data from a population-based cross-sectional survey representative of children 12–23 months in Amuria district in Eastern Uganda. The survey was the second of two sequential cross-sectional surveys (pre-intervention and post intervention), designed to evaluate programme process indicators and changes in the prevalence of anaemia, iron deficiency, and vitamin A deficiency 12 months after implementing an integrated MNP/IYCF pilot programme in an intervention and a non-intervention (comparison) district. Our analyses used end line data collected in June–July 2016 from the intervention district. The survey was led by Makerere University School of Food Technology, Nutrition and Bio-Engineering with technical assistance from the United States Centers for Disease Control and Prevention (CDC) and oversight of the WFP and the MoH.

Using a multistage cluster sampling design, 38 census enumeration areas were randomly selected using probability proportional to population size. Enumerators completed a census in each selected cluster and then randomly selected 22 children ages 12–23 months from each cluster. There was no replacement of clusters or children for any reason. Of the 806 eligible children in the selected clusters, 761 (94.4%) caregivers consented to participate. Of those, 689 (90.5%) reported having ever received MNP for their child. We excluded six children (<1.0%) due to missing information on the variables of interest, for a final analytic sample of 683 children.

2.3 | Data collection and variable specification

Data were collected from caregivers using a pretested interviewer-administered questionnaire on sociodemographic characteristics, household assets and housing characteristics, food security, child's sex, age, dietary consumption the day preceding the survey (WHO IYCF food groups), and 2-week morbidity (fever, cough, and diarrhoea), frequency of contact with health facilities and VHTs, exposure to the MNP pilot and its behaviour change communication channels, IYCF and MNP knowledge and practices, and perceptions of and experiences with MNP.

Child weight was measured to the nearest 100 g using an electronic SECA 874 digital floor scale (UNICEF Electronic Scale or Uniscale). Recumbent length was measured to the nearest 0.1 cm using a standard length board (Shorr-Board brand). We calculated length-for-age, weight-for-age, and weight-for-length Z using the WHO child growth standards (WHO, 2006). Stunting, underweight, and wasting were classified as length-for-age, weight-for-age, and weight-for-length <−2 *SD*, respectively (WHO, 2006).

2.3.1 | Outcomes: MNP sachet coverage and recent intake

According to the WHO recommendation when the pilot was designed, children should consume at least 60 sachets every six months (WHO, 2011). High-MNP sachet coverage was defined as receiving at least the minimum recommended number of sachets during the pilot year per the WHO guideline based on self-report ("How many times have you ever received MNP [box of 30 sachets] for the child?"). We calculated the expected number of sachets received over the 12-month pilot based on the child's age at the time of data collection, assuming the child began receiving MNP as soon as he was eligible (i.e., at the start of the intervention or at age 6 months, whichever came later) so that children 12–15 months receiving ≥60 sachets, children 15–17 months receiving ≥90 sachets, and children 18–23 months receiving ≥120 sachets during the pilot year were classified as having high-MNP sachet coverage.

We defined MNP recent intake as any reported consumption of MNP during the 2 weeks preceding the survey.

2.3.2 | Predictor variables

We identified potential predictor variables in four categories: (a) sociocultural and demographic factors; (b) IYCF and MNP knowledge; (c)

IYCF behaviours; and (d) exposure to, experience with, and perceptions of the MNP intervention.

1. *Sociocultural and demographic factors:* Child age was categorized as 12–17 months and 18–23 months. Caregiver schooling was defined as completed less than primary school versus other level of schooling. A household asset score was created using principal components analysis of household assets and housing characteristics, and then the score was divided into household wealth tertiles. Severe household food insecurity was defined as households who often cut back on meal size or number of meals and/or ever experienced any of the three most severe conditions (Ballard, Coates, Swindale, & Deitchler, 2011). Improved water source was defined as piped water, tube well borehole, protected well or spring, stone tap, rainwater, or bottled water (WHO and UNICEF, 2017).
2. *IYCF and MNP Knowledge:* Proxy indicators for general IYCF knowledge (yes/no) included the appropriate age to introduce complementary foods, the recommended number of meals per day per the national guidelines, ever heard of anaemia, identification of ≥1 cause of anaemia, identification of ≥1 sign of anaemia, ever heard of iron, and ever heard of vitamin A. Proxy indicators for MNP knowledge (yes/no) included ability to describe MNP and name ≥1 potential benefit of consumption and correctly answering all six questions about MNP preparation.
3. *IYCF and MNP Practices:* Proxy indicators for general IYCF practices (yes/no) included child currently breastfeeding, complementary foods introduced at age 6 months, and the child's dietary consumption in the day preceding the survey (animal flesh/organ foods; vitamin A-rich fruits or vegetables; dark, leafy greens; minimum meal frequency; minimum dietary diversity; and minimum acceptable diet). Minimum meal frequency was defined as ≥3 meals for breastfed children and ≥4 meals including milk feeds for nonbreastfed children (WHO, 2010). Minimum dietary diversity was defined as intake from ≥4 of the seven main food groups (WHO, 2010). Minimally acceptable diet was defined as minimum meal frequency and minimum dietary diversity among breastfed children and at least two milk feeds, minimum dietary diversity not including milk feeds, and minimum meal frequency among nonbreastfed children (WHO, 2010).
4. *Exposure to, experience with, and perceptions of the MNP intervention:* Proxies for caregiver exposure to the MNP program (yes/no) included contact with the VHT ≥1 times in the month preceding the survey, ever received an MNP ration card (documenting the date[s] MNP was received and the date to return for the next box), ever received an MNP adherence card (to track days when child consumed MNP by marking checkboxes), ever received an MNP brochure, ever heard radio jingle about MNP, heard radio jingle in the 7 days preceding the survey, and ever received a call or visit from the VHT as a reminder to collect MNP. Enumerators asked caregivers whether they had received counselling on MNP the first time and the most recent time they retrieved the MNP sachets (yes/no) and who provided the counselling (VHT, health centre staff, or AFC staff).

Data were collected about experiences with the MNP pilot the most recent time caregivers retrieved MNP including who provided the MNP (VHT delivery to home vs. other distribution method), length of journey (<30 min, 30–60 min, 1–2 hr, and ≥2 hr) and wait time at the distribution location (<30 min, 30–60 min, 1–2 hr, and ≥2 hr). Caregiver perceptions of MNP included ease of obtaining MNP for the child (easy or very easy vs. sometimes or very difficult), whether the child likes to consume foods mixed with MNP (yes/no), organoleptic changes in foods mixed with MNP (yes/no), organoleptic changes in foods cooked with soda ash (sodium carbonate) and mixed with MNP (yes/no), whether organoleptic changes stopped the caregiver from serving the food (yes/no), and whether organoleptic changes stopped the child from consuming the food (yes/no). Caregivers were also asked if they observed any positive or negative effects in the child consuming MNP and if they had difficulties and motivations in ensuring the child consumed MNP. We classified these perceptions as ≥1 positive effects in child versus no positive effects in child; ≥1 negative effects in child versus no negative effects in child; ≥1 difficulties in ensuring the child consumed MNP versus no difficulties; and ≥1 motivations in ensuring the child consumed MNP versus no motivations.

2.4 | Statistical analyses

We evaluated differences in sociodemographic and health characteristics, perceptions of and experience with the MNP intervention, and IYCF knowledge and practice by MNP coverage and recent intake using Rao-Scott chi-square tests. For each outcome, we conducted bivariate analyses between candidate predictors and the outcome. For indicators asked to all respondents and where $P < 0.05$, candidate predictors were included in the multivariable logistic regression models. Models additionally controlled for household wealth tertile and caregiver education. To identify potential collinearity, we used eigenvalues <0.01 and conditionality index >30.

In 2016, the WHO updated its suggested intake recommendations to 90 sachets every 6 months (WHO, 2016). We also evaluated differences in sociodemographic and health characteristics, perceptions of and experience with the MNP intervention, and IYCF knowledge and practice by coverage status using the most updated WHO intake recommendations. Because only 155 received the recommended number of sachets per the 2016 guideline, we were unable to use regression modelling to evaluate factors associated with coverage using the updated definition. Results of the bivariate analyses are presented in Table SS1–S3.

We conducted all analyses in SAS v.9.4 using PROC SURVEY procedures (SAS Institute Inc., Cary, North Carolina). The sample was self-weighted, and all analyses accounted for complex sampling design. Statistical significance was set a priori at two-sided $P < 0.05$.

Ethical approval for this survey was obtained from the School of Biomedical Sciences Higher Degrees, Research and Ethics Committee, College of Health Sciences, Makerere University, and research clearance was obtained from Uganda National Council for Science and Technology. Enumerators obtained informed consent from all participating caregivers for their child(ren).

3 | RESULTS

Overall, 59.0% (95% Confidence Interval [CI 53.8, 64.2]) of children received ≥60 sachets every 6 months during the 12-month pilot (the recommended dosing according to the 2011 WHO guidelines), 65.4% (95% CI [61.0, 69.9]) consumed MNP during the 2 weeks preceding the survey, and 43.5% (95% CI [38.5, 48.4]) had both high coverage and recent intake (Table 1). In total, 84.6% (95% CI [81.0, 88.2]) of children had received a box of MNP within 2 months of the survey. Among those for whom MNP receipt was at least 2 months before the survey (i.e., children who should have consumed all 30 sachets), caregivers reported 74.3% (standard error 33.6) of sachets had been consumed. Among children who had recently consumed MNP, average consumption during the 2 weeks preceding the survey was 6.1 (standard error 2.3) sachets. Nearly three quarters of children 12–17 months (73.9%, 95% CI [69.4, 78.5]) had high-MNP coverage relative to 26.1% (95% CI [21.5, 30.6]) of children 18–23 months (Table 2).

Caregivers of children with high coverage had higher knowledge of anaemia compared with caregivers of children with low coverage in bivariate analyses (75.6%, 95% CI [69.1, 82.1] vs. 68.8%, 95% CI [61.3, 76.3] for ever heard of anaemia; 71.0%, 95% CI [63.8, 78.1] vs. 63.2%, 95% [55.7, 70.7] for ability to name at least one cause of anaemia; Table 3). Knowledge of MNP varied significantly by both coverage status and recent intake. Although MNP knowledge was high in both groups, caregivers of children with high coverage also had higher knowledge of MNP compared with caregivers of children with low coverage (97.0%, 95% CI [95.3, 98.8] vs. 92.9%, 95% CI [89.7, 96.0] for ability to describe MNP and name at least one potential benefit of consumption; and 90.6%, 95% CI [86.9, 94.3] vs. 84.6%, 95% CI [79.4, 89.9] for knowledge of correct MNP preparation). Findings for knowledge of MNP were similar for recent intake.

General IYCF practices were better among caregivers of children with high-MNP coverage and recent intake relative to children with low coverage and no recent intake. The prevalence of current breastfeeding was nearly double among children with high-MNP coverage compared with children with low coverage (66.0%, 95% CI [60.4, 71.7] vs. 36.4%, 95% CI [30.3, 42.5]). Further, the percentage of children consuming minimum meal frequency the day preceding the survey was significantly higher among those with high coverage (32.8%, 95% CI [27.3, 38.3] vs. 19.3%, 95% CI [13.4, 25.2]) and recent intake (30.0%, 95% CI [24.7, 35.3] vs. 22.0%, 95% CI [16.6, 27.5]) relative to those with low coverage and no recent intake, respectively. Twenty-three percent (95% CI [17.4, 27.8]) of children with high coverage consumed a minimally acceptable diet the day preceding the survey compared with only 14.6% (95% CI [10.3, 19.0]) of children with low coverage.

Caregiver exposure to, experience with, and perceptions of the MNP pilot are presented in Table 4. Although nearly all caregivers reported having received an MNP ration card, the percentage was significantly higher among caregivers of children with high coverage (97.8, 95% CI [96.2, 99.3] vs. 94.3%, 95% CI [91.5, 97.1]) and among caregivers of children with recent intake (97.8, 95% CI [96.2, 99.4] vs. 93.6%, 95% CI [90.6, 96.6]) compared with those with low coverage and no recent intake, respectively. More than half of caregivers of children with recent intake (53.5%, 95% CI [47.9, 59.0]) had ever heard a radio jingle about MNP compared with 44.1% (95% CI [37.8, 50.3]) of caregivers of children without recent intake. A larger percentage of

TABLE 1 Micronutrient powder coverage and recent intake characteristics, micronutrient powder and infant and young child feeding intervention end line survey, Amuria District, Uganda 2016 (*N* = 683)

	n	% (95% CI) or mean (SE)
MNP coverage [a]		
Low	280	41.0 (35.8, 46.2)
High	403	59.0 (53.8, 64.2)
Recent MNP intake [b]		
No	236	34.5 (30.1, 39.0)
Yes	447	65.4 (61.0, 69.9)
High coverage and recent intake	683	43.5 (38.5, 48.4)
Received last box of MNP within 2 months of the survey	539	84.6 (81.0, 88.2)
% of last box of MNP consumed [c]	150	74.3 (33.6)
No. of MNP sachet consumed in 2 weeks preceding survey [d]	447	6.1 (2.3)

Note. Values presented are percent (95% confidence interval) or mean (SE). All estimates account for complex sampling design.

[a]High MNP sachet coverage was defined as reported receiving at least 60 sachets (two boxes) every 6 months during the 12-month pilot—the minimum recommended dose per the 2011 WHO guideline (WHO, 2011).

[b]Recent MNP intake defined as reporting any consumption of MNP during the two weeks preceding the survey.

[c]Among children whose caregivers reported receiving their last box of MNP (30 sachets) at least 2 months preceding the survey.

[d]Among children whose caregivers reported any MNP intake during the 2 weeks preceding the survey.

TABLE 2 Sociodemographic and health characteristics, by micronutrient powder sachet coverage and recent micronutrient powder intake, micronutrient powder and infant and young child feeding intervention end line survey, Amuria District, Uganda 2016 (N = 683)

Sociodemographic or health characteristic	Low MNP sachet coverage (<60 sachets every 6 months) [a] (n = 280)		High MNP sachet coverage (≥60 sachets every 6 months) [a] (n = 403)			No recent MNP intake (no MNP intake last 14 days) [b] (n = 236)		Recent MNP intake (any MNP intake last 14 days) [b] (n = 447)		
	n	% (95% CI)	n	% (95% CI)	P value	n	% (95% CI)	n	% (95% CI)	P value
Child sex					0.4					0.7
Male	142	50.7 [45.0, 56.5]	216	53.6 [49.1, 58.1]		126	53.4 [47.7, 59.0]	232	51.9 [47.2, 56.6]	
Female	138	49.3 [43.5, 55.0]	187	46.4 [41.9, 50.9]		110	46.6 [41.0, 52.3]	215	48.1 [43.4, 52.8]	
Age group					<0.0001					0.1
12–17 months	116	41.4 [36.5, 46.4]	298	73.9 [69.4, 78.5]		134	56.8 [51.1, 62.5]	280	62.6 [58, 67.3]	
18–23 months	164	58.6 [53.6, 63.5]	105	26.1 [21.5, 30.6]		102	43.2 [37.5, 48.9]	167	37.4 [32.7, 42.0]	
Anthropometry [c]										
Stunting	62	22.1 [16.0, 28.2]	64	16.0 [12.2, 19.8]	0.06	41	17.4 [12.0, 22.8]	85	19.1 [15.4, 22.8]	0.5
Underweight	22	7.9 [4.7, 11.1]	27	6.7 [4.2, 9.2]	0.5	17	7.2 [3.9, 10.5]	32	7.2 [4.6, 9.7]	1.0
Wasting	9	3.2 [1.4, 5.1]	10	2.5 [1.0, 4.0]	0.5	8	3.4 [1.0, 5.8]	11	2.5 [1.2, 3.7]	0.5
Caregiver reported 2-week morbidity										
Fever	221	78.9 [73.5, 84.4]	309	76.7 [71.7, 81.6]	0.5	179	75.8 [68.6, 83.1]	351	78.5 [74.6, 82.4]	0.5
Cough	141	50.4 [43.7, 57.0]	208	51.6 [46.4, 56.9]	0.8	128	54.2 [47.3, 61.2]	221	49.4 [44.0, 54.9]	0.3
Diarrhoea	110	39.3 [33.0, 45.6]	180	44.8 [39.7, 49.8]	0.2	102	43.2 [37.4, 49.0]	188	42.2 [37.4, 46.9]	0.8
Caregiver less than primary education	201	71.8 [65.8, 77.8]	285	70.7 [65.7, 75.8]	0.8	174	73.7 [66.8, 80.6]	312	69.8 [64.3, 75.3]	0.4
Household characteristics										
Improved water source [d]	258	93.5 [89.6, 97.3]	373	93.7 [88.7, 98.8]	0.9	215	93.1 [87.0, 99.1]	416	93.9 [90.2, 97.6]	0.6
Severe food insecurity [e]	31	11.1 [6.3, 15.9]	58	14.4 [10.8, 18.0]	0.2	26	11.0 [6.9, 15.1]	63	14.1 [10.2, 18.0]	0.3
Household wealth tertile					0.1					0.3
Poorest	86	30.7 [24.4, 37.1]	157	39.0 [31.7, 46.3]		81	34.3 [27.3, 41.4]	162	36.2 [30.1, 42.4]	
Middle	107	38.2 [31.2, 45.3]	133	33.0 [28.0, 38.0]		78	33.1 [26.4, 39.7]	162	36.2 [32.1, 40.4]	
Richest	87	31.1 [23.7, 38.4]	113	28.0 [21.8, 34.3]		77	32.6 [25.2, 40.0]	123	27.5 [21.8, 33.3]	

Note. Values presented are percent (95% confidence interval). P values calculated for Rao-Scott chi-square tests. All estimates account for complex sampling design.

[a]High MNP sachet coverage was defined as having reported receiving at least 60 sachets (2 boxes) every 6 months during the 12-month pilot—the minimum recommended dose per the 2011 WHO guideline (WHO, 2011).

[b]Recent MNP intake defined as reporting any consumption of MNP during the 2 weeks preceding the survey.

[c]Stunting defined as length-for-age Z < −2 SD. Underweight defined as weight-for-age Z < −2SD. Wasting defined as weight-for-length Z < −2SD (WHO, 2006).

[d]Improved water source defined as piped water, tube well borehole, protected well or spring, stone tap, rainwater, or bottled water (WHO and UNICEF, 2017).

[e]Severe household food insecurity was defined as households who often cut back on meal size or number of meals and/or ever experienced any of the three most severe conditions (Ballard, 2011).

TABLE 3 Caregiver infant and young child feeding and micronutrient powder (MNP) knowledge and infant and young child feeding practices, by MNP sachet coverage and recent MNP intake, MNP and infant and young child feeding intervention end line survey, Amuria District, Uganda 2016 (*N* = 683)

	Low MNP sachet coverage (<60 sachets every 6 months) [a] (*n* = 280)		High MNP sachet coverage (≥60 sachets every 6 months) [a] (*n* = 403)			No recent MNP intake (no MNP intake last 14 days) [b] (*n* = 236)		Recent MNP intake (any MNP intake last 14 days) [b] (*n* = 447)		
	n	% (95% CI) or mean (SE)	*n*	% (95% CI) or mean (SE)	*P* value	*n*	% (95% CI) or mean (SE)	*n*	% (95% CI) or mean (SE)	*P* value
IYCF knowledge indicators										
Knows age to introduce complementary feeding	206	73.6 [67.0, 80.1]	305	75.7 [69.4, 82.0]	0.6	169	71.6 [65.7, 77.6]	342	76.5 [70.7, 82.3]	0.1
Knows suggested number of meals/day [c]	70	25.0 [18.8, 31.2]	105	26.1 [20.9, 31.2]	0.8	59	25.0 [18.5, 31.5]	116	26.0 [21.2, 30.7]	0.8
Ever heard of iron	155	56.0 [46.7, 65.3]	223	56.5 [48.2, 64.8]	0.9	134	57.5 [48.6, 66.4]	244	55.6 [47.4, 63.8]	0.6
Ever heard of vitamin A	258	92.1 [88.6, 95.7]	374	92.8 [89.6, 96.0]	0.8	218	92.4 [87.9, 96.8]	414	92.6 [89.9, 95.4]	0.9
Ever heard of anaemia	192	68.8 [61.3, 76.3]	304	75.6 [69.1, 82.1]	0.04	172	72.9 [65.3, 80.4]	324	72.8 [65.7, 79.9]	1.0
Can identify ≥1 sign of anaemia [d]	186	66.4 [59.1, 73.7]	283	70.2 [63.5, 76.9]	0.3	162	68.6 [61.0, 76.3]	307	68.7 [61.4, 75.9]	1.0
Can identify ≥1 cause of anaemia [e]	177	63.2 [55.7, 70.7]	286	71.0 [63.8, 78.1]	0.05	160	67.8 [60.0, 75.5]	303	67.8 [60.4, 75.2]	1.0
MNP knowledge indicators										
Can describe MNP and name ≥1 potential benefit of consumption	260	92.9 [89.7, 96.0]	391	97.0 [95.3, 98.8]	0.005	217	91.9 [88.3, 95.6]	434	97.1 [95.3, 98.8]	0.002
Correctly answers question on how to prepare MNP [f]	237	84.6 [79.4, 89.9]	365	90.6 [86.9, 94.3]	0.03	193	81.8 [75.5, 88.0]	409	91.5 [88.5, 94.5]	0.0002
IYCF practices										
Currently breastfeeding child	102	36.4 [30.3, 42.5]	266	66.0 [60.4, 71.7]	<0.0001	120	50.8 [42.8, 58.9]	248	55.5 [49.7, 61.3]	0.3
Introduced complementary foods at age 6 months	182	65.0 [58.1, 71.9]	277	68.7 [62.9, 74.6]	0.3	160	67.8 [60.8, 74.8]	299	66.9 [61.6, 72.2]	0.8

(Continues)

TABLE 3 (Continued)

	Low MNP sachet coverage (<60 sachets every 6 months) [a] (*n* = 280)		High MNP sachet coverage (≥60 sachets every 6 months) [a] (*n* = 403)			No recent MNP intake (no MNP intake last 14 days) [b] (*n* = 236)		Recent MNP intake (any MNP intake last 14 days) [b] (*n* = 447)		
	n	% (95% CI) or mean (SE)	*n*	% (95% CI) or mean (SE)	*P* value	*n*	% (95% CI) or mean (SE)	*n*	% (95% CI) or mean (SE)	*P* value
Child's food consumption the day preceding the survey										
Animal flesh foods	72	25.7 [20.5, 30.9]	98	24.3 [19.2, 29.4]	0.7	53	22.5 [16.6, 28.3]	117	26.2 [21.1, 31.2]	0.3
Vitamin A-rich fruits or vegetables	252	90.0 [83.8, 96.2]	349	86.6 [80.6, 92.6]	0.3	206	87.3 [79.8, 94.7]	395	88.4 [83.5, 93.2]	0.7
Dark, leafy greens	162	57.9 [49.8, 65.9]	206	51.1 [43.6, 58.7]	0.09	127	53.8 [44.6, 63.1]	241	53.9 [47.3, 60.5]	1.0
Minimum meal frequency [g]	54	19.3 [13.4, 25.2]	132	32.8 [27.3, 38.3]	0.002	52	22.0 [16.6, 27.5]	134	30.0 [24.7, 35.3]	0.04
Minimum dietary diversity [h]	170	60.7 [54.6, 66.8]	240	59.7 [53.9, 65.6]	0.8	134	56.8 [50.4, 63.2]	276	61.9 [57.0, 66.8]	0.1
Minimally acceptable diet [i]	41	14.6 [10.3, 19.0]	91	22.6 [17.4, 27.8]	0.02	39	16.5 [11.3, 21.8]	93	20.8 [16.0, 25.6]	0.3

Note. Values presented are percent (95% confidence interval) or mean (SE). *P* values calculated for Rao-Scott chi-square tests. All estimates account for complex sampling design.

[a]High MNP sachet coverage was defined as having reported receiving at least 60 sachets (2 boxes) every 6 months during the 12-month pilot—the minimum recommended dose per the 2011 WHO guideline (WHO, 2011).

[b]Recent MNP intake defined as reporting any consumption of MNP during the 2 weeks preceding the survey.

[c]The Uganda National Infant and Young Feeding Guidelines (2007) recommend three meals and two snacks per day for children 12–24 months of age.

[d]Signs of anaemia included pale palms, skin, eye conjunctiva, and/or tongue, body weakness, and/or dark urine.

[e]Causes of anaemia included recent malaria or fever, sickle cell or other genetic causes, worm infestation, recent illness, poor quality diet, malnutrition (marasmus/kwashiorkor), excessive bleeding, and/or lack of sufficient food.

[f]Knowledge of preparation of MNP defined as caregiver correctly answering all questions about MNP preparation including dosing, mixing MNP in soft, semi-solid, or solid foods, not adding MNP to hot or cooking food, and serving food mixed with MNP within 30 minutes of preparation.

[g]Minimum meal frequency: child received solid, semi-solid, or soft foods the minimum number of times or more the previous day (≥3 times for breastfed children 9–23 months and ≥4 times including milk feeds for nonbreastfed children 6–23 months; WHO, 2010).

[h]Minimum dietary diversity: child received foods from ≥4 food groups the previous day. The seven food groups were grains, roots, and tubers; legumes and nuts; dairy products; flesh foods; eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables (WHO, 2010).

[i]Minimally acceptable diet: Among breastfed children, the child had at least minimum dietary diversity and the minimum meal frequency the previous day. Among nonbreastfed child, the child had at least two milk feeds, the minimum dietary diversity not including milk feeds, and the minimum meal frequency the previous day (WHO, 2010).

TABLE 4 Caregiver exposure to and experience with and perceptions of micronutrient powder (MNP), by MNP sachet coverage and recent MNP intake, MNP and infant and young child feeding intervention end line survey, Amuria District, Uganda 2016 (N = 683)

	Low MNP sachet coverage (<60 sachets every 6 months) [a] (n = 280)		High MNP sachet coverage (≥60 sachets every 6 months) [a] (n = 403)			No recent MNP intake (no MNP intake last 14 days) [b] (n = 236)		Recent MNP intake (any MNP intake last 14 days) [b] (n = 447)		
	n	% (95% CI)	*n*	% (95% CI)	*P* value	*n*	% (95% CI)	*n*	% (95% CI)	*P* value
Caregiver exposure to the MNP programme										
Contacted VHT ≥1 times during previous month	184	65.7 [59.3, 72.1]	263	65.3 [59.1, 71.4]	0.9	155	65.7 [59.4, 71.9]	292	65.3 [59.3, 71.3]	0.9
Ever received MNP ration card	264	94.3 [91.5, 97.1]	394	97.8 [96.2, 99.3]	0.003	221	93.6 [90.6, 96.6]	437	97.8 [96.2, 99.4]	0.002
Ever received MNP adherence card	273	97.5 [95.8, 99.2]	397	98.5 [97.4, 99.6]	0.3	228	96.6 [94.4, 98.8]	442	98.9 [97.7, 100.0]	0.07
Ever received brochure about MNP	206	73.6 [67.3, 79.9]	313	77.7 [73.7, 81.6]	0.2	173	73.3 [67.6, 79.0]	346	77.4 [72.7, 82.1]	0.2
Ever heard radio jingle about MNP	129	46.1 [40.2, 52.0]	214	53.1 [47.5, 58.7]	0.06	104	44.1 [37.8, 50.3]	239	53.5 [47.9, 59.0]	0.02
Heard radio jingle in previous 7 days	23	17.8 [10.0, 25.7]	38	17.8 [11.7, 23.8]	1.0	15	14.4 [7.5, 21.4]	46	19.2 [12.4, 26.1]	0.3
Received call or visit as a reminder to collect MNP	180	64.3 [55.7, 72.9]	270	67.0 [58.6, 75.4]	0.5	151	64.0 [55.4, 72.6]	299	66.9 [58.6, 75.2]	0.5
Caregiver experience with the MNP programme										
The most recent time, who provided MNP					0.1					0.1
The most recent time, wait time at location to receive MNP [c]					0.9					0.8
<30 min	41	22.5 [16.9, 28.2]	62	25.2 [19.3, 31.1]		35	22.4 [16.0, 28.9]	68	25.0 [19.5, 30.5]	
30–60 min	47	25.8 [19.4, 32.2]	56	22.8 [17.9, 27.6]		41	26.3 [19.4, 33.2]	62	22.8 [18.0, 27.6]	
1–2 hr	48	26.4 [19.6, 33.1]	63	25.6 [18.9, 32.3]		42	26.9 [21.2, 32.7]	69	25.4 [19.0, 31.7]	
>2 hr	46	25.3 [18.6, 32.0]	65	26.4 [21.2, 31.7]		38	24.4 [18.0, 30.7]	73	26.8 [21.4, 32.2]	
The first time received MNP, received counselling	272	97.1 [95.3, 99.0]	394	97.8 [96.1, 99.5]	0.6	231	97.9 [96.1, 99.7]	435	97.3 [95.9, 98.8]	0.6
If yes, who provided the counselling [d]										
VHT	248	89.9 [86.2, 93.5]	371	92.1 [88.7, 95.4]	0.3	210	89.7 [85.2, 94.2]	409	91.9 [88.8, 95.0]	0.3
Health centre staff	127	46.4 [37.3, 55.4]	208	52.0 [46.4, 57.6]	0.1	105	45.3 [35.7, 54.9]	230	52.0 [46.0, 58.0]	0.1
AFC staff	112	41.9 [35.2, 48.7]	174	44.7 [39.5, 50.0]	0.5	90	40.5 [33.7, 47.4]	196	45.2 [40.6, 49.7]	0.2
The most recent time received MNP, received additional counselling	135	48.2 [39.6, 56.8]	196	48.6 [41.8, 55.5]	0.9	119	50.4 [42.3, 58.6]	212	47.4 [41.0, 53.9]	0.4
If yes, who provided the counselling [d]										
VHT	185	66.5 [60.1, 73.0]	292	72.5 [66.3, 78.6]	0.07	157	67.1 [59.6, 74.6]	320	71.6 [66.0, 77.1]	0.2
Health centre staff	74	27.0 [19.7, 34.4]	127	31.7 [26.0, 37.3]	0.2	60	26.1 [18.2, 33.9]	141	31.7 [25.6, 37.8]	0.2
AFC staff	57	21.0 [16.4, 25.5]	102	25.8 [21.6, 29.9]	0.1	40	17.6 [12.5, 22.8]	119	27.0 [23.1, 30.9]	0.007
Caregiver perceptions of MNP										
Ease of obtaining MNP					0.004					0.0002
Easy or very easy	231	82.5 [78.4, 86.6]	360	89.3 [85.8, 92.8]		191	80.9 [76.5, 85.4]	400	89.5 [86.3, 92.7]	
Sometimes or very difficult	49	17.5 [13.4, 21.6]	43	10.7 [7.2, 14.2]		45	19.1 [14.6, 23.5]	47	10.5 [7.3, 13.7]	

(Continues)

TABLE 4 (Continued)

	Low MNP sachet coverage (<60 sachets every 6 months) [a] (*n* = 280)		High MNP sachet coverage (≥60 sachets every 6 months) [a] (*n* = 403)			No recent MNP intake (no MNP intake last 14 days) [b] (*n* = 236)		Recent MNP intake (any MNP intake last 14 days) [b] (*n* = 447)		
	n	% (95% CI)	*n*	% (95% CI)	*P* value	*n*	% (95% CI)	*n*	% (95% CI)	*P* value
Child likes to consume foods mixed with MNP					0.01					<0.0001
Yes or neutral	222	79.3 [73.7, 84.9]	348	86.4 [82.3, 90.4]		176	74.6 [67.8, 81.3]	394	88.1 [84.5, 91.8]	
No	58	20.7 [15.1, 26.3]	55	13.6 [9.6, 17.7]		60	25.4 [18.7, 32.2]	53	11.9 [8.2, 15.5]	
Observed ≥1 positive effect in child from consuming MNP	259	92.5 [88.4, 96.6]	386	95.8 [94.2, 97.3]	0.06	210	89.0 [83.8, 94.2]	435	97.3 [95.8, 98.9]	<0.0001
Observed ≥1 negative effect in child from consuming MNP	109	38.9 [32.3, 45.6]	169	41.9 [36.3, 47.6]	0.4	96	40.7 [32.5, 48.8]	182	40.7 [36.1, 45.4]	1.0
Reported ever noticing changes in colour, taste, or odour of foods mixed with MNP	140	51.5 [46.1, 56.9]	200	50.4 [44.3, 56.5]	0.8	118	51.5 [44.7, 58.3]	222	50.5 [45.1, 55.8]	0.8
Type of change(s) reported [d]										
Colour	108	77.1 [70.4, 83.9]	161	80.9 [75.6, 86.2]	0.3	90	77.6 [69.9, 85.3]	179	80.3 [74.0, 86.5]	0.6
Taste	29	20.7 [14.3, 27.1]	36	18.1 [12.5, 23.6]	0.4	28	24.1 [14.8, 33.5]	37	16.6 [11.0, 22.2]	0.1
Odour	26	18.6 [12.4, 24.8]	32	16.1 [10.4, 21.8]	0.5	20	17.2 [9.1, 25.4]	38	17.0 [11.2, 22.9]	1.0
Reported changes to foods cooked with soda ash and mixed with MNP	133	47.5 [40.3, 54.7]	236	58.6 [52.6, 64.5]	0.001	121	51.3 [43.1, 59.5]	248	55.5 [48.2, 62.8]	0.4
Type of change(s) reported [d]										
Colour	131	97.8 [95.1, 100.0]	234	99.6 [98.7, 100.0]	0.1	121	99.2 [97.5, 100.0]	244	98.8 [97.4, 100.0]	0.7
Taste	4	3.0 [0.1, 5.9]	4	1.7 [0.0, 3.4]	0.4	3	2.5 [0.0, 5.3]	5	2.0 [0.3, 3.7]	0.8
Changes stopped caregiver from serving the food	55	41.4 [33.0, 49.7]	70	29.7 [22.6, 36.8]	0.03	53	43.8 [35.0, 52.6]	72	29.0 [23.1, 35.0]	0.001
Changes made the child refuse the food	30	22.6 [13.7, 31.4]	28	11.9 [7.5, 16.3]	0.004	25	20.7 [11.8, 29.5]	33	13.3 [8.8, 17.9]	0.05
Reported ≥1 difficulties in ensuring child consumed MNP	132	47.1 [41.8, 52.5]	185	45.9 [40.9, 50.9]	0.7	125	53.0 [46.7, 59.2]	192	43.0 [38.1, 47.8]	0.01
Reported ≥1 supports/motivations in ensuring child consumed MNP	184	65.7 [58.1, 73.3]	265	65.8 [59.4, 72.1]	1.0	165	69.9 [63.0, 76.8]	284	63.5 [57.3, 69.8]	0.07
VHT delivered to home	91	32.5 [26.0, 39.0]	155	38.5 [31.5, 45.4]		75	31.8 [24.5, 39.0]	171	38.3 [31.6, 44.9]	
Other	189	67.5 [61.0, 74.0]	248	61.5 [54.6, 68.5]		161	68.2 [61.0, 75.5]	276	61.7 [55.1, 68.4]	
The most recent time, length of journey [c]					0.3					0.9
<30 min	34	18.7 [11.3, 26.1]	58	23.6 [16.7, 30.5]		34	21.8 [13.1, 30.5]	58	21.3 [15.2, 27.4]	
30–60 min	51	28.0 [19.9, 36.2]	58	23.6 [18.1, 29.1]		41	26.3 [17.0, 35.6]	68	25.0 [20.5, 29.5]	
1–2 hr	63	34.6 [25.5, 43.8]	72	29.3 [23.5, 35.0]		45	28.8 [19.1, 38.6]	90	33.1 [27.1, 39.0]	
>2 hr	34	18.7 [12.9, 24.4]	58	23.6 [18.2, 29.0]		36	23.1 [14.5, 31.6]	56	20.6 [15.2, 25.9]	

Note. Values presented are percent (95% confidence interval). *P* values calculated for Rao-Scott chi-square tests. All estimates account for complex sampling design. AFC, Andre Food Consults; VHT, village health team.

[a]High MNP sachet coverage was defined as having reported receiving at least 60 sachets (2 boxes) every 6 months during the 12-month pilot—the minimum recommended dose per the 2011 WHO guideline (WHO, 2011).

[b]Recent MNP intake defined as reporting any consumption of MNP during the two weeks preceding the survey.

[c]Among caregivers who did not have MNP delivered to them by the VHT.

[d]Multiple options apply.

children whose caregivers received counselling from AFC staff the most recent time they received MNP had recent intake (27.0%, 95% CI [23.1, 30.9]) compared with children whose caregivers did not receive counselling from AFC staff (17.6%, 95% CI [12.5, 22.8]).

The percentage of caregivers reporting they perceived MNP was easy or very easy to obtain was significantly higher among children with high coverage (89.3%, 95% CI [85.8, 92.8] vs. 82.5%, 95% CI [78.4, 86.6]) and recent intake (89.5%, 95% CI [86.3, 92.7] vs. 80.9%, 95% CI [76.5, 85.4]) relative to those with low coverage and no recent intake, respectively. The percentage of caregivers reporting that their child was neutral about or liked foods mixed with MNP was higher among children with high coverage (86.4%, 95% CI [82.3, 90.4] vs. 79.3, 95% CI [73.7, 84.9]) and recent intake (88.1%, 95% CI [84.5, 91.8] vs. 74.6%, 95% CI [67.8, 81.3]) compared with those with low coverage and no recent intake, respectively.

Nearly all caregivers reported at least one positive effect in the child from consuming MNP (94.4%, 95% CI [92.4, 96.4]), including decreased sickness and improved growth (data not shown); however, the percentage was significantly higher among caregivers of children with recent intake relative to those without (97.3%, 95% CI [95.8, 98.9] vs. 89.0, 95% CI [83.8, 94.2]).

Half of caregivers reported organoleptic changes to food mixed with MNP (50.8%, 95% CI [46.4, 55.2])—most commonly changes in colour (79.4%, 95% CI [74.4, 84.2]), and a similar percentage of caregivers also reported organoleptic changes to foods cooked with soda ash mixed with MNP (54.0%, 95% CI [48.5, 59.6]; data not shown). Among those who reported organoleptic changes to foods cooked with soda ash mixed with MNP, the percentage of caregivers reporting that these changes stopped them from serving the food was significantly lower among children with high coverage (29.7%, 95% CI [22.6, 36.8] vs. 41.4%, 95% CI [33.0, 49.7]) and recent intake (29.0%, 95% CI [23.1, 35.0] vs. 43.8%, 95% CI [35.0, 52.6]) relative to those with low coverage and no recent intake, respectively. Likewise, the percentage of caregivers reporting that these changes stopped their child from consuming the food was significantly lower among children with high coverage (11.9%, 95% CI [7.5, 16.3] vs. 22.6%, 95% CI [13.7, 31.4]) and recent intake (13.3%, 95% CI [8.8, 17.9] vs. 20.7%, 95% CI [11.8, 29.5]) relative to those with low coverage and no recent intake, respectively.

Nearly half of all caregivers reported at least one difficulty in ensuring their child consumed MNP (46.4%, 95% CI [42.5, 50.3]), with difficulties ranging from negative side effects to organoleptic changes to foods cooked with soda ash mixed with MNP, to child's rejection of foods mixed with MNP (data not shown). A lower percentage of caregivers of children with recent intake reported experiencing one or more difficulties compared with caregivers of children without recent intake (43.0%, 95% CI [38.1, 47.8] vs. 53.0%, 95% CI [46.7, 59.2]). The majority of caregivers also reported at least one motivation in ensuring that their child consumed MNP (65.7%, 95% CI [60.2, 71.3]), with motivations ranging from observing positive effects of MNP in their child to knowing how to get information about how to resolve side effects (data not shown). Motivations did not vary by coverage or recent intake in bivariate analyses.

In multivariable models controlling for household wealth and caregiver education, children of caregivers who received an MNP ration card had 2.67 times increased odds of having high-MNP coverage relative to children whose caregivers did not receive a ration card (95% CI [1.15, 6.23]; Table 5). Caregivers who reported organoleptic changes to foods cooked with soda ash and mixed with MNP had 52% higher odds of having received the recommended number of MNP sachets for their child compared with caregivers who did not report these organoleptic changes (Adjusted Odds Ratio [OR]1.52, 95% CI [1.08, 2.14]).

Children of caregivers who reported having ever heard of anaemia had nearly 60% higher odds of having high-MNP coverage relative to children of women who had not heard of anaemia (AOR 1.59, 95% CI [1.11, 2.26]). Children whose caregivers knew how to correctly prepare and serve MNP was associated with 1.89 times increased odds of high-MNP coverage compared with children whose caregivers answered one or more MNP preparation questions incorrectly (95% CI [1.11, 3.19]). For general IYCF practices, current breastfeeding was positively associated with high-MNP coverage (OR 2.04, 95% CI [1.36, 3.08]). Child age was the only sociocultural or demographic factor associated with MNP coverage. Older children (18–23 months) had lower odds of high-MNP coverage compared with younger children (12–17 months; AOR 0.32, 95% CI [0.23, 0.50]).

In multivariable models controlling for household wealth and caregiver education, children of caregivers who received an MNP ration card had 2.86 times increased odds of having recent intake relative to children whose caregivers did not receive a ration card (95% CI [1.34, 6.09]; Table 6). Children whose caregivers reported having ever heard a radio jingle about MNP had 40% increased odds of recent intake compared with children whose caregivers had not heard an MNP radio jingle (95% CI [1.01, 1.94]).

Proxy indicators representing experience with the MNP intervention were associated with recent intake. Children whose caregivers reported the child liked or was neutral about consuming foods mixed with MNP had nearly two-times higher odds of recent intake relative to children whose caregivers reported the child disliked foods mixed with MNP (AOR 1.90, 95% CI [1.13, 3.22]). Although only marginally statistically significant (P = 0.05), children whose caregivers reported that MNP was easy or very easy to obtain had 1.55 times increased odds of recent intake compared with children whose caregivers reported that MNP was sometimes or very difficult to obtain (AOR 1.55, 95% CI [1.00, 2.42]). Children of caregivers with correct knowledge about how to prepare and serve MNP had 1.88 times increased odds of recent intake compared with children whose caregivers answered one or more MNP preparation questions incorrectly (95% CI [1.04, 3.39]).

4 | DISCUSSION

We found high-MNP sachet coverage and recent intake among children 12–23 months in a yearlong pilot of an integrated MNP-IYCF programme in Eastern Uganda. In total, 59.0% of children received

TABLE 5 Predictors of high micronutrient powder sachet coverage (≥60 sachets every 6 months) among children 12–23 months, micronutrient powder and infant and young child feeding intervention Endline survey, Amuria District, Uganda 2016 (N = 683) [a]

	Adjusted odds ratio	95% CI	*P* value
Child age group (18–23 months vs. 12–17 months)	0.32	[0.23, 0.50]	<0.0001
Received MNP ration card	2.67	[1.15, 6.23]	0.02
Easy or very easy to obtain MNP	1.54	[0.96, 2.45]	0.07
Child likes to consume foods mixed with MNP or is neutral	1.45	[0.91, 2.29]	0.1
Organoleptic changes to foods cooked with soda ash	1.52	[1.08, 2.14]	0.02
Ever heard of anaemia	1.59	[1.11, 2.26]	0.01
Can describe MNP and name ≥1 potential benefit of consumption	1.94	[0.91, 4.11]	0.08
Knows how to correctly prepare and serve MNP [b]	1.89	[1.11, 3.19]	0.02
Currently breastfeeding the child	2.04	[1.36, 3.08]	0.001
Child consumed minimum meal frequency [c]	1.50	[0.61, 3.69]	0.4
Child consumed minimum acceptable diet [d]	0.78	[0.32, 1.89]	0.6
Poorest household wealth tertile (vs. richest)	0.69	[0.42, 1.13]	0.1
Middle household wealth tertile (vs. richest)	0.75	[0.48, 1.17]	0.1
Caregiver education (less than primary vs. higher)	0.91	[0.61, 1.37]	0.3

[a]Estimates are adjusted odds ratios and 95% confidence intervals from logistic regression, accounting for complex sampling design. High-MNP sachet coverage defined as having reported receiving at least 60 sachets (2 boxes) every 6 months during the 12-month pilot—the minimum recommended dose per the 2011 WHO guideline (WHO, 2011). Models included all predictor variables where $P < 0.05$ in bivariate analyses and additionally controlled for household wealth tertile and caregiver education.

[b]Knowledge of preparation of MNP defined as caregiver correctly answering all questions about MNP preparation including dosing, mixing MNP in soft, semi-solid, or solid foods, not adding MNP to hot or cooking food, and serving food mixed with MNP within 30 min of preparation.

[c]Minimum meal frequency: child received solid, semi-solid, or soft foods the minimum number of times or more the previous day (≥3 times for breastfed children 9–23 months and ≥4 times including milk feeds for nonbreastfed children 6–23 months; WHO, 2010).

[d]Minimally acceptable diet: For breastfed children, the percentage who had at least the minimum dietary diversity and the minimum meal frequency in the day preceding the survey. For nonbreastfed children, the percentage who had at least two milk feeds and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency in the day preceding the survey (WHO, 2010).

the recommended dose of MNP (≥60 sachets every 6 months) during the pilot year, 65.4% consumed MNP during the 2 weeks preceding the survey, and 43.5% had both high coverage and recent intake. Children with recent intake consumed an average of six sachets during the 2 weeks preceding the survey—in accordance with intake recommendations. These findings are consistent with the intervention strategy process indicators showing high exposure to many components of the intervention programme package, including receipt of programme materials and counselling. MNP ration cards and knowledge of correct MNP preparation were important for both MNP sachet coverage and recent intake. Additionally, having ever heard of anaemia, current breastfeeding, and younger child age were all associated with increased odds of high-MNP coverage whereas hearing a radio jingle about MNP, ease of obtaining sachets, and child liking foods mixed with MNP were all positively associated with odds of recent intake. With the exception of child age, all significant factors were potentially modifiable, suggesting that MNP programmes could be designed to leverage factors shown to contribute to high coverage and recent intake. The finding that an older child age was associated with lower MNP coverage might imply that additional resources and behaviour change communication strategies targeted towards maintaining demand for older children may be warranted.

Although there is no agreed upon threshold for effective MNP programme performance, the Uganda pilot programme had high coverage relative to some MNP programmes. In the Micronutrient Powders Consultation's review of free health sector MNP interventions, the Consultation selected a threshold of >70% coverage based on the experiences of vitamin A supplementation and IYCF programmes (Reerink et al., 2017). The Consultation did not define coverage, which could be based on receipt, consumption, or purchasing, per the evaluators' discretion. Thus, programme success is in part determined by how coverage is operationalized. Because definitions in the review varied considerably, comparing across programmes is difficult. Coverage—most frequently defined as "received MNP"—ranged from 32% to 83% (Dhillon et al., 2017). Of the 761 children included in this pilot end line study, 90.5% of children had received MNP (data not presented). Because *any* receipt of MNP was high in our study, we used a more stringent definition of coverage based on reported receipt of the WHO recommended number of MNP sachets (≥60 sachets every 6 months) during the pilot year. Among those who reported ever receiving MNP, 59.0% received the recommended number of MNP sachets.

Strong supply chain management and a dynamic distribution strategy likely contributed to high coverage in the Uganda pilot programme. Based on programme post-distribution monitoring reports from AFC, the implementing partner, we found no evidence of stock outs. Further, only two caregivers reported limited supply as a difficulty. In an effort to increase coverage and sustained intake, the MNP delivery mechanisms evolved during the pilot. At the start, the IYCF/MNP programme used existing MoH outreach sites for MNP

TABLE 6 Predictors of recent micronutrient powder intake (any micronutrient powder intake during the 2 weeks preceding the survey) among children 12–23 months, micronutrient powder and infant and young child feeding intervention Endline survey, Amuria District, Uganda 2016 (N = 683) [a]

	Adjusted odds ratio	95% CI	*P* value
Received MNP ration card	2.86	[1.34, 6.09]	0.008
Ever heard radio jingle about MNP	1.40	[1.01, 1.94]	0.04
Easy or very easy to obtain MNP	1.55	[1.00, 2.42]	0.05
Child likes to consume foods mixed with MNP or is neutral	1.90	[1.13, 3.22]	0.02
Observed ≥1 positive effect of MNP in child	2.18	[0.79, 6.03]	0.1
Reported ≥difficulties in ensuring child consumed MNP	0.88	[0.61, 1.27]	0.5
Can describe MNP and name ≥1 potential benefit of consumption	1.38	[0.50, 3.82]	0.5
Knows how to correctly prepare and serve MNP [b]	1.88	[1.04, 3.39]	0.04
Child consumed minimum meal frequency [c]	1.40	[0.93, 2.09]	0.1
Poorest household wealth tertile (vs. richest)	0.91	[0.66, 1.24]	0.5
Middle household wealth tertile (vs. richest)	0.70	[0.51, 0.95]	0.02
Caregiver education (less than primary vs. higher)	0.85	[0.53, 1.38]	0.5

[a]Estimates are adjusted odds ratios and 95% confidence intervals from logistic regression, accounting for complex sampling design. Recent MNP intake defined as reporting any consumption of MNP during the 2 weeks preceding the survey. Models included all predictor variables where $P < 0.05$ in bivariate analyses and additionally controlled for household wealth tertile and caregiver education.

[b]Knowledge of preparation of MNP defined as caregiver correctly answering all questions about MNP preparation including dosing, mixing MNP in soft, semi-solid, or solid foods, not adding MNP to hot or cooking food, and serving food mixed with MNP within 30 min of preparation.

[c]Minimum meal frequency: child received solid, semi-solid, or soft foods the minimum number of times or more the previous day (≥3 times for breastfed children 9–23 months and ≥4 times including milk feeds for nonbreastfed children 6–23 months; WHO, 2010).

distribution. After the first project quarter, AFC created new outreach sites, and VHTs delivered MNP to caregivers who missed scheduled distribution at outreach sites. Although research has shown that community-based distribution generally leads to higher coverage (Reerink et al., 2017), given that the pilot was supported by an implementing partner, it is unclear if additional outreach sites and home delivery by VHT would be financially sustainable without additional resources, especially at increasing scale. Cost-effectiveness studies may provide evidence to help decision makers evaluate whether additional outreach sites, home delivery, or other distribution strategies are worth considering.

Caregiver perception of ease of obtaining MNP appeared to be more important to recent intake than measures of delivery channel, journey length, or wait time. Thirty-six percent (95% CI [30.5, 41.5]) of caregivers had MNP delivered to their home by a VHT the most recent time they received MNP, and among those who did not have MNP delivered, 78.5% (95% CI [72.7, 84.3]) had to travel longer than 30 min to retrieve MNP, and 75.9% (95% CI [71.8, 80.1]) had to wait longer than 30 min at the distribution point (data not shown). Surprisingly, in multivariable models, MNP distribution method, length of journey to retrieve MNP, and length of wait at distribution point were not associated with either coverage or recent intake; however, perceived ease of obtaining MNP was marginally associated with increased odds of recent intake.

Among the variety of behaviour change communication channels employed in the pilot, only two were significantly associated with the study outcomes in multivariable models. Ration cards were positively associated with odds of both high coverage and recent intake; although it is important to note that coverage of ration cards was high across all groups. Having ever heard a radio jingle about MNP was positively associated with recent intake only. Theoretically, prompts such as stickers, brochures, posters, radio ads, and reminders from health care workers might serve as reminders to get and give MNP to children, combat intervention fatigue, and support permanent adoption of this routine practice. Promotional materials including calendars, brochures, cups, stickers, and T-shirts were positively associated with recent MNP use in a study on sustainability after 3 years of sales in western Kenya (Suchdev et al., 2013). A study of an MNP programme in Nepal found that receiving a reminder card was positively associated with high intake (Mirkovic et al., 2016). In our analyses, frequent contact with the VHT (≥1 per month), receiving adherence card, reminder calls/visits, and recently hearing radio jingle about MNP were not associated with MNP coverage or recent intake.

Surprisingly, organoleptic changes to foods cooked with soda ash were positively associated with MNP coverage. Previous studies have shown that organoleptic changes can reduce coverage/adherence (Bilukha, Howard, Wilkinson, Bamrah, & Husain, 2011; Kounnavong et al., 2011). When prepared correctly, MNP should not alter the colour, taste, odour, or texture of food (WHO, 2011; WHO, 2016); however, more than half of caregivers reported ever noticing changes organoleptic changes to foods mixed with MNP (50.8% 95% CI [46.4, 55.2] and 54.0% 95% CI [48.5, 59.6] reported changes specifically to foods cooked with soda ash; data not presented). Although organoleptic changes could be a sign that food was prepared incorrectly—for example, if MNP are added when a dish is very hot—88.1% (95% CI [84.8, 91.5]) of caregivers correctly answered all MNP preparation questions (data not shown), suggesting they understood how to properly prepare and serve foods mixed with MNP.

Further, reporting having ever noticed organoleptic changes and reporting organoleptic changes specifically to foods cooked with soda ash did not vary by knowledge of correct MNP preparation (P = 0.1 and P = 0.09, respectively).

Organoleptic changes to foods cooked with soda ash could serve as a proxy indicator for the quality of IYCF/MNP counselling. Findings from the formative research prior to the pilot suggested that mixing MNP into certain foods, such as greens, caused food to immediately change colour (UBC et al., 2014). This was interpreted by the technical advisory group as a problem with improper MNP preparation, so guidance emphasized not adding MNP to food while too hot. After starting the pilot project, intervention staff noted that families were saying they experienced food colour changes when mixing MNP into foods prepared with soda ash. In eastern Uganda, foods such as greens and legumes are commonly cooked with soda ash to reduce cooking time (Bergeson, Opio, & MacMillan, 2016). This prompted the staff to mix MNP into food cooked with soda ash, and they confirmed the colour changes. Thereafter, the IYCF/MNP counselling sessions in Amuria warned caregivers about potential changes to foods cooked with soda ash and encouraged them to continue feeding their children these foods despite colour changes. Accordingly, among those reporting organoleptic changes to foods cooked with soda ash mixed with MNP, 29.7% (95% CI [22.6, 36.8]) of caregivers whose children had high-MNP coverage refused to serve their child the food compared with 41.4% (95% CI [33.0, 49.7]) of caregivers whose children had low coverage. Given that organoleptic changes are frequently reported across studies and programme contexts (Bilukha et al., 2011; Inayati et al., 2012; Kounnavong et al., 2011; MoH of the Kyrgyz Republic, 2014; Rosado et al., 2010), future research should explore factors associated with changes, including food preparation and cooking methods, product quality, integrity of MNP packaging, and micronutrient absorption.

Similar to findings from MNP studies in Nepal and Madagascar (Mirkovic et al., 2016; Locks et al., 2017), children's perceptions of foods mixed with MNP were associated with coverage and recent intake. Children whose caregivers reported the child liked or was neutral about consuming foods mixed with MNP had nearly two-times higher odds of recent intake relative to children whose caregivers reported the child disliked foods mixed with MNP. In the study from Nepal, Mirkovic et al. found that child disliking food with MNP was negatively associated with intake (Mirkovic et al., 2016). Dislike of food could be a result of organoleptic changes due to mixing MNP into foods cooked with soda ash, and among caregivers reporting changes to foods cooked with soda ash, 33.9% (95% CI [28.4, 39.3]) of children refused to eat the food (data not shown).

Context-specific differences in knowledge, attitudes and practices around complementary feeding, and understanding of anaemia and micronutrient deficiencies may be relevant to behaviour change. In our study population, caregiver knowledge was positively associated with both MNP outcomes. Knowing how to correctly prepare and serve MNP was positively associated with both high-MNP coverage and with recent intake. Having ever heard of anaemia was associated with increased odds of high-MNP coverage. Despite differences in knowledge, we found no difference in the prevalence of counselling either the first or most recent times caregivers received MNP by either coverage or recent intake. Finally, some improved IYCF practices were positively associated with MNP outcomes in the study population. Current breastfeeding was associated with greater odds of MNP sachet coverage—suggesting that MNP did not negatively affect breastfeeding practices.

Child age was the only sociocultural or demographic factor associated with MNP coverage. We found that older children had lower odds of high-MNP coverage relative to younger children. Differences in coverage by age in our analyses might be explained by caregiver perception of reduced risk of micronutrient malnutrition among older children and/or need for micronutrient supplementation in the Ugandan context. Our findings are contrary to studies where children 12–17 and 18–23 months had higher MNP consumption (Madagascar) and greater odds of obtaining MNP (Nepal) relative to children 6–11 months (Jefferds et al., 2015; Locks et al., 2017). However, our analyses did not include children 6–11 months, thus may not be comparable. Alternatively, our findings could reflect the evolving MNP distribution strategy. As distribution changed during the pilot to increase coverage, it might have become easier to obtain MNP as the pilot progressed. Whereas younger children were only exposed to the more "accessible" intervention (i.e., more numerous distribution points and home delivery), older children were exposed to the intervention from the beginning of the pilot when distribution points were more limited. Thus, it may have been more difficult for older children to achieve high-MNP coverage over the course of the pilot year relative to the younger children; however, delivery method the most recent time the caregiver received MNP did not vary by child age group (data not shown). Lastly, as intervention staff recognized that a large proportion of families were experiencing food colour changes after using MNP, IYCF counselling increasingly emphasized continuing MNP despite colour changes. It is possible that this message started too late for older children, and their caregivers stopped MNP earlier and never restarted or heard about food colour changes that made them more reticent to ever start giving their child MNP.

Programme planners could consider some common strategies at the early stages of design and implementation in an effort to support high coverage and adherence during programme scale-up. Decision makers examine various factors when making choices about MNP delivery designs and intake regimens. Considering designs that are conducive to habit building may help support sustained coverage and intake. In the Uganda pilot, MNP receipt and intake were designed to be continuous (i.e., MNP box receipt every 2 months and consumption every other day without a break) to support establishing and sustaining repeated MNP receipt and intake patterns. Furthermore, MNP receipt every 2 months enabled routine opportunities for caregivers to speak with delivery staff and troubleshoot. In comparison, other designs distribute 60 MNP sachets every 6 months with a recommended daily intake regimen (i.e., daily intake for 2 months followed by a 4-month break) so that families have to re-establish MNP receipt and intake patterns. Additionally, programme planners can aim to identify a minimum package of behaviour change strategies needed

to achieve programme goals. Pilot projects often have more comprehensive packages (e.g., multiple distribution channels) that may not be feasible to maintain at scale. Understanding which behaviour changes communication channels and strategies supports effective delivery and intake regimens during the pilot phase and over time is critical to achieving desired program outcomes and can help program planners design effective, lower resource intervention packages at scale. Findings from various analyses show that some programme materials (e.g., ration/reminder cards) may be useful to consider including as part of any minimum behaviour change package at large scale. With the variation in MNP distribution and intake regimens, we would not necessarily expect the same behaviour change channels and strategies to show associations with higher coverage or recent intake across all settings. Thus, testing programme materials and channels during the pilot phase is critical. Finally, behaviour change communication needs can change over time, and programmes may need to consider refreshing or refocusing the behaviour change component as the programme matures or new issues arise.

4.1 | Strengths and limitations

These analyses used data from a population-based cross-sectional survey, representative of children 12–23 months in Amuria district, Uganda. We had rich and comprehensive data on MNP distribution channels, exposure to intervention package components, IYCF and MNP knowledge and practices, sociocultural and demographic factors, and covariates. Owing to the high percentage of children who had ever received MNP (90.5% of all children surveyed), we were able to evaluate factors associated with children having received the recommended number of sachets during the pilot year based on the WHO, 2011 recommendation. Due to limited sample size, we may have lacked power to detect small effect sizes. Further, we were unable to explore factors related to MNP sachet coverage according to the most up-to-date 2016 WHO recommendations (WHO, 2016). It would have been helpful to collect qualitative data among caregivers to better understand their ideas and experiences, as well as evaluate the experiences and perceptions of health facility staff and VHT involved in programme delivery. Finally, caregivers reported MNP sachet receipt and intake, which could be subject to desirability or recall bias.

5 | CONCLUSION

We found high-MNP sachet coverage and recent intake among children 12–23 months in a yearlong pilot of an integrated MNP-IYCF programme in Eastern Uganda. Beyond a well-managed MNP supply chain, several proxy indicators for exposure to the intervention, perceptions of the MNP pilot, IYCF and MNP knowledge and practice, and sociocultural and demographic factors were associated with greater odds of MNP coverage and recent intake. With the exception of child age, all significant factors were potentially modifiable, suggesting that MNP programmes could be designed to leverage known contributors to high coverage and sustained intake. Although the pilot was supported by an implementing partner, the lessons learned could be used to inform programme scale-up. In settings with limited resources and where front-line health workers have heavy workloads, it is especially important to identify during pilot phases which delivery designs, intake regimens, activities, and behaviour change strategies influence MNP sustained coverage and use.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

LJR, CM, RDW, MEJ, SN, SH, MA, and AL contributed to the conception and design of the study. SN, SH, MA, and AL contributed to the acquisition of the data. NDF performed the literature search, conducted the statistical analyses, and wrote the initial draft of the paper. All authors interpreted findings, edited subsequent drafts, and approved the final version to be published.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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