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Original Article

Responsive feeding and child interest in food vary when rural Malawian children are fed lipid-based nutrient supplements or local complementary food

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Abstract

Caregiver and child behaviours during feeding have been used to measure responsiveness, which has been recognised as important for child growth and development. The aims of this study were to understand how caregiver and child behaviours differ when feeding lipid-based nutrient supplements (LNS) vs. local complementary food and to detect associations between behaviours and child interest in food. Sixteen moderately underweight 6–17-month-old Malawian children receiving 50 g/day of supplementary LNS for 12 weeks were videotaped during LNS ($n = 32$) and local complementary feeding ($n = 28$) episodes. Behaviours were coded at the level of the intended bite (1674 total bites). The analysis used regression models adjusted for within-subject correlation. Caregivers were less likely to allow children to self-feed and more likely to use physical pressure during LNS vs. complementary food bites. Positive caregiver verbalization was infrequent and did not differ by type of food. Higher odds of accepting a bite were associated with the bite containing LNS, odds ratio (OR) 3.05; 90% confidence interval (CI) (1.98, 4.71), the child self-feeding, OR 5.70; 90% CI (2.77, 11.69), and positive caregiver verbalization, OR 2.46; 90% CI (1.26, 4.80), while lower odds of acceptance were associated with negative child verbalization during feeding, OR 0.27; 90% CI (0.17, 0.42). In this sample, caregivers used more responsive feeding practices during bites of local complementary food and were more controlling when feeding LNS. Responsive caregiver behaviours predicted child acceptance of food. These results could be used to design interventions in Malawi to improve responsive feeding practices in general and during LNS use.

Keywords: lipid-based nutrient supplements, LNS, responsive feeding, feeding behaviours, Malawi.

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Introduction

Lipid-based nutrient supplements (LNS) are multiple micronutrient-fortified ready-to-use foods that typically contain peanut butter, vegetable oil, sugar and milk powder. They are effective for home treatment of children with severe acute malnutrition (Manary *et al*. 2004; World Health Organization/World Food Programme/United Nations Standing Committee on Nutrition/United Nations Children's Fund 2007), and initial studies suggest that they improve weight, length, development and micronutrient status in healthy to moderately undernourished children (Adu-Afarwuah *et al*. 2007; Adu-Afarwuah *et al*. 2008; Phuka *et al*. 2008). There is great interest in the possibility of scaling up the use of LNS for prevention of undernutrition (PLoS Medicine Editors 2008), and several large trials are underway testing the effects of preventive doses of LNS on child growth (iLiNS Project 2011). In addition to data

on the amount and type of LNS to feed, information about socio-cultural issues related to the home use and acceptability of LNS is needed to design large-scale interventions in different settings.

A few such studies have already been conducted, with some indicating that LNS is highly acceptable to young children of varying nutritional status (Briend *et al*. 1999; Kuusipalo *et al*. 2006; Adu-Afarwuah *et al*. 2008; Adu-Afarwuah *et al*. 2011; Hess *et al*. 2011; Parker *et al*. 2011; Phuka *et al*. 2011) and others showing that mothers have positive attitudes towards its home use (Adu-Afarwuah *et al*. 2008; Flax *et al*. 2009). Our previous research on home use of LNS in Malawi found that the frequency of feeding and the number of feeding episodes were similar, while some observed behaviours, such as hand washing before meals, differed among children who were assigned to receive either LNS or corn-soy blend (CSB), a common supplementary food (Flax *et al*. 2010). When Malawian caregivers mixed LNS with a regular portion of porridge, there was more likely to be food left over than when LNS was served plain (Flax *et al*. 2008, 2010). This led to incomplete consumption of the recommended daily LNS dose by the target child. In contrast, Ghanaian mothers, who were counselled to mix the LNS with a small quantity of porridge and serve it in one dose, reportedly did so in the majority of cases (Adu-Afarwuah *et al*. 2008).

One aspect of home use of LNS that has not been studied is how it affects caregiver and child behaviours during feeding. The importance of parental responsiveness during child feeding for ensuring appropriate dietary intake as well as promoting cognitive and psychosocial development is well recognised (United Nations Children's Fund 1990; Engle *et al*. 1997; Pan American Health Organization & World Health Organization 2003; Bentley *et al*. 2011; Black & Aboud 2011). Responsiveness during feeding is defined as caregivers' prompt, contingent, and developmentally and emotionally appropriate reactions to their children (Ainsworth *et al*. 1974; Black & Aboud 2011). Within the context of feeding, responsiveness includes offering physical assistance appropriate to the age of the child and with respect to the child's hunger and satiety cues, feeding patiently, offering verbal encouragement to eat, trying different foods and methods of encouragement if the child refuses, keeping distractions to a minimum during meals, and talking and making eye contact during feeding (Pan American Health Organization & World Health Organization 2003). Studies of caregiver styles of feeding in resource-poor settings suggest that responsive feeding behaviours are associated with higher child acceptance of food (Ha *et al*. 2002; Moore *et al*. 2006; Dearden *et al*. 2009; Bentley *et al*. 2011). Caregivers have also been shown to feed children more actively during certain types of meals (Engle & Zeitlin 1996).

Many caregivers in high- and low-income countries have feeding styles that are non-responsive (Dettwyler 1986; Bentley *et al*. 1991a,b; Birch & Fisher 1995; Bentley *et al*. 2011; Hurley *et al*. 2011). Their styles may be laissez-faire, controlling/pressuring or indulgent. There is no published information on the feeding styles of Malawian caregivers or on the influence of LNS on caregivers' responsiveness during feeding. This study was designed to fill these gaps. It had two aims: to examine the associations between

Key messages

- In this context, caregivers tended to use more responsive feeding practices during bites of local complementary food and were more controlling during bites of LNS.
- In general, controlling feeding behaviours were negatively associated with child acceptance of food. However, LNS consumption was positively associated with acceptance, suggesting that the characteristics of LNS helped overcome the negative effect of controlling behaviours during its use.
- Responsive feeding behaviours, such as encouragement of self-feeding and positive verbalization, were positively associated with child acceptance of food.
- Infant and young child feeding programmes in Malawi, particularly those using LNS as a supplementary food, could provide messages that reinforce responsive caregiver feeding behaviours and minimise controlling behaviours.

type of food and feeding behaviours and to detect associations between caregiver and child behaviours during feeding and child acceptance of food.

Methods

Setting and study overview

This study was conducted in six villages around Lungwena and Malindi, a rural area in Mangochi District, southern Malawi. The participants were taking part in a 12-week study on the incorporation of LNS into home diets. The details of the design have been described elsewhere (Flax *et al*. 2008). Briefly, research assistants conducted 10 full-day home observations, during which they recorded all the food and drinks the child consumed as well as caregiver and child behaviours during feeding episodes. In addition, participants were videotaped on two other days to allow for a more detailed analysis of caregiver and child behaviours during feeding. Data on socioeconomic variables were collected by questionnaire during the first visit of the observation portion of the study. Children's anthropometric measurements were taken at the beginning and end of the study. Weight was measured using a UNICEF Salter scale and length was measured with a length board (Shorr Productions, Olney, MD, USA). Weights and lengths were converted to *z*-scores using the Center for Disease Control and Prevention tables (Kuczmarski *et al*. 2002).

Ethical approval for the study was obtained from the College of Medicine Research and Ethics Committee at the University of Malawi, the Ethical Committee of the Pirkanmaa Hospital District in Finland, and the Institutional Review Board of the University of North Carolina at Chapel Hill.

Participants

Participants were 16 caregivers and their moderately underweight 6–17-month-old children. To select the sample, research assistants collaborated with community health workers to prepare complete lists of children in the age group in the selected villages. The research team then measured the identified children and verified eligibility ($-3.0 <$ weight-for-age z-score < -2.0; weight-for-length z-score > -3.0; not participating in another study; looked after by biological mother; no peanut allergy following a 6 g LNS test dose; no chronic illness; and guardian-signed informed consent). Of the 200 children measured, 177 were ineligible (119 not underweight, 38 not correct age, 18 in another study, 1 chronically ill and 1 mother was deceased) and 23 were eligible. A maximum of four participants were randomly selected in each village; if fewer were eligible in a particular village, all were recruited. Children who were eligible but not selected for the study were referred to the nearest health centre for nutrition counselling.

LNS supplementation

During 12 weeks of supplementation, research assistants delivered three plastic jars of LNS (≈250 g each) to participants' homes every 2 weeks. The LNS was produced by Project Peanut Butter (Blantyre, Malawi) and was made of peanut butter, milk powder, sugar, oil and vitamin/mineral mix. A daily dose contained 256 kcal, 7 g protein, 17 g fat and the recommended daily allowance for 17 vitamins and minerals (Phuka *et al*. 2009). Caregivers were advised to feed the participating child seven teaspoons or three tablespoons (≈50 g) of LNS per day using their own utensils. Research assistants did not provide caregivers with advice on how or when to feed LNS or on responsive feeding practices as the overall aim of the research was a naturalistic description of home use of LNS.

Videotaping and coding

Videotape recordings of each caregiver–child pair were taken on 2 days. The first recording was made at least 1 month after the child started eating LNS and the second was taped at least 2 weeks after the first. Caregivers and children were recorded during one LNS and one complementary feeding episode on each day. The videographer arrived at participants' homes early in the morning and remained at the house until the child had eaten both LNS and local

complementary food. Caregivers chose when and how to feed their children. The videographer was instructed to encourage caregivers to follow their usual feeding practices and to interact with participants as little as possible (Dearden *et al*. 2009). A Chiyao- and Chichewa-speaking research assistant viewed the tapes, translated verbalizations into English and inserted English subtitles.

Recorded feeding episodes were randomly assigned to two observers (VF, SM) for coding. The coding scheme was adapted from studies in Vietnam (Dearden *et al*. 2009), Peru (Bentley *et al*. 1991b) and Guatemala (Bentley *et al*. 1997) by trying it with five video clips and making minor adjustments to fit the Malawian context. Prior to coding all the tapes, the observers independently coded 10% (randomly selected) of the feeding episodes and achieved >80% agreement on all variables. Feeding episodes were coded at the level of the intended bite. An intended bite was defined as the caregiver or child bringing the food with a utensil or hand to the child's mouth whether the food was consumed or not. The length of an intended bite was measured as the number of seconds from the offering of one intended bite until the next.

Variable definition

Type of food consumed was divided into two categories: LNS or local complementary food (hereafter referred to as complementary food). LNS feeding episodes included plain LNS and LNS mixed with porridge. Complementary feeding episodes included nsima and relish (or sauce), plain porridge and other foods (such as rice). Nsima is a stiff maize porridge (approximately 28% dry matter) usually eaten with a relish made of green leafy vegetables, beans or fish. Porridge is typically made from maize flour (approximately 10% dry matter). The types of food consumed were recorded by the videographer at the time of videotaping. Breastfeeding and consumption of other liquids was recorded by observers, but liquids were excluded in the analysis as this research focuses on differences in feeding LNS and complementary food. ***Consistency*** of the foods consumed was recorded as semi-solid or solid. Porridge and LNS were considered to be semi-solid, whereas nsima, relish and rice were solid.

Child interest in food was the main study outcome. Observers coded child interest in food using five categories (accepts eagerly, accepts not eagerly, rejects initially then accepts, accepts initially then rejects, and rejects). As some of the categories occurred infrequently, the first three categories were counted as 'accepts' and the latter two categories were counted as 'rejects' in the analysis. Other child-related variables measured were the child's position, physical actions and verbal actions. ***Child's position*** was coded as sitting on caregiver's lap, sitting on floor or mat, standing and walking/crawling. Standing, walking and crawling were combined for the analysis. ***Child's physical actions*** included no actions, plays without object, plays with object, plays with person and other actions. Plays with object and plays with person were combined. Other actions were physical actions that could not be considered a form of play, such as the child moving away from the feeding place or pushing the spoon or caregiver's hand away. ***Child's verbal actions*** were coded as none, flat, positive or negative.

Three types of caregiver behaviours were measured. ***Who fed the child*** was coded as self, mother, grandmother or other caregiver. The mother, grandmother and other caregiver categories were combined in the analysis to give two categories of feeders – self and other. ***Caregiver's physical actions*** included no action, facilitates feeding/directly helps, uses physical pressure and force feeds. Physical pressure was defined as pressing down the spoon or hand in the child's mouth or lightly restraining the child to facilitate eating. A bite was coded as force feeding if the caregiver used strong physical pressure to restrain the child or forced the child to accept or swallow the bite. ***Caregiver's verbal actions*** were recorded as none related to eating, positive, mechanical/direct (e.g. 'eat your food') or negative. Facilitating feeding, positive verbalization and allowing the child to self-feed when developmentally appropriate were considered to be responsive caregiver behaviours, whereas using physical pressure, force feeding and using mechanical or negative verbalizations were non-responsive or controlling behaviours.

Statistical analysis

Statistical analyses were conducted using Stata 11.2 (College Station, TX, USA). All analyses were adjusted for within-subject correlation using the Huber–White robust standard error (Binder 1983). As this was a small, exploratory study without pre-set hypotheses, the level of significance for statistical tests was set at $\alpha = 0.10$, two-sided. Linear regression was used to estimate the mean bites per episode, mean length of episode and mean length of bite, and to test for differences by type of food. Strengths of association of caregiver behaviours, child behaviours and food-related characteristics with type of food or child interest in food were assessed using overall Wald tests. For those variables with overall test results that indicated a significant association with type of food, multinomial logistic regression was subsequently used to examine relative differences in proportions of the food type between the categories of each variable, using the behavior as the outcome and the type of food as the explanatory variable (Agresti 2002). Multivariable logistic regression was used to characterize associations of caregiver and child behaviours with child interest in food, adjusting for child's sex and age, and the other possible confounders of maternal age, maternal education and level of wealth. The maternal and socioeconomic variables did not influence estimates and were not included in the final model. We tested for two-way interactions between child's age and consistency and all explanatory variables. There were no significant interactions, so interaction terms were not retained in the model.

Results

The socioeconomic and demographic characteristics of study participants are described in Table 1. Of the 64 planned tapes of feeding episodes, 60 were completed. There were four children who were only taped during one feeding episode on one of the days of videotaping because the caregiver was not present or the caregiver needed to leave with the child after the morning meal.

There were 28 feeding episodes during which complementary food was the most frequently consumed item and 32 episodes that contained LNS during the majority of bites. During three of the LNS feeding episodes, the main food consumed contained LNS, but one or more bites of complementary food were also eaten. Overall, the mean number of bites during feeding episodes was 30.1 [90% confidence interval (CI) 23.7, 36.4]. The mean length of a feeding episode was 9.6 min (90% CI 8.4, 10.9). The mean length of an intended bite was 19.9 s (90% CI 16.3, 23.5). There were no statistically significant differences by type of food in the number of bites per feeding episode, length of a feeding episode or length of a bite (Table 2).

Overall, children accepted the majority of intended bites (85%), sat (97%), were not active (82%) and did not verbalize (83%) while eating. Caregivers fed the child during slightly more than half of the bites (54%). They typically provided normal facilitation (50%) or no physical help (41%), and physical pressure and force feeding were infrequent. Caregivers did not verbalize during nearly three-quarters of the bites. The majority of their verbalizations were mechanical, such as 'here's food'.

The child's position and verbalization, who fed the child, caregiver's physical actions, utensil and consis-

Table 1. Demographic and socioeconomic characteristics of participants

Mean (SD) age of child at enrolment	13 (3) months
Mean (SD) age at videotaping	15 (3) months
Proportion female	63%
Mean (SD) baseline anthropometric measurements	
Weight	7.5 (0.8) kg
Length	69.8 (3.9) cm
Weight-for-age *z*-score	–2.6 (0.3)
Length-for-age *z*-score	–1.8 (0.7)
Weight-for-length *z*-score	–1.2 (0.9)
Mean (SD) age of mother at enrolment	26 (7) years
Mother's education	
None	37%
1–3 years	31%
4–6 years	13%
7–9 years	19%
Mean (SD) number household members	5 (2)
Mean (SD) number of children <5 years	2 (1)
Housing materials	
Unburned mud brick	56%
Burned brick	44%

SD, standard deviation.

Table 2. Descriptive data about the feeding episodes, by food type

	Complementary food* ($n = 28$)				LNS† ($n = 32$)				*P*-value§
	Mean	90% CI‡	Median	Interquartile range	Mean	90% CI	Median	Interquartile range	
Bites per feeding episode	29.5	21.7, 37.2	24.5	18.0, 46.8	30.6	16.8, 44.4	27.0	20.0, 37.3	0.749
Length of feeding episode (min)	9.0	6.9, 11.1	8.9	5.4, 11.8	10.2	6.0, 14.5	9.8	7.6, 12.1	0.317
Length of bite (s)	18.5	14.6, 22.3	13.0	8.0, 22.0	20.6	13.3, 27.9	15.0	9.0, 24.0	0.285

CI, confidence interval; LNS, lipid-based nutrient supplements. *Complementary food = nsima and relish, plain porridge, and other foods. †LNS = plain LNS and LNS mixed with porridge. ‡90% confidence intervals adjusted for within-subject correlation. §*P*-value for comparison of mean values for complementary food and LNS.

tency varied by type of food (Table 3). Compared to bites of complementary food, children were more likely during LNS bites to stand/walk/crawl than sit on the caregiver's lap [relative risk ratio (RRR) 6.6; 90% CI 2.4, 17.9] or on the floor (RRR 11.5; 90% CI 3.9, 33.5). Children were more likely to make negative rather than no verbalizations (RRR 1.9; 90% CI 1.1, 3.3) during LNS vs. complementary food bites. Caregivers more frequently fed the child rather than the child self-feeding during bites of LNS than complementary food (RRR 3.5; 90% CI 1.6, 7.6). As compared to no physical facilitation, caregivers were more likely to offer normal physical assistance (RRR 2.4, 90% CI 1.0, 5.4) and to physically pressure the child (RRR 5.8; 90% CI 2.0, 16.5) during bites of LNS than complementary food. Caregivers also used physical pressure more often during bites of LNS than complementary food (RRR 2.4; 90% CI 1.1, 5.5), as compared to normal physical facilitation. The utensil used and consistency of the food varied greatly by type of food. LNS bites were all semi-solid (either LNS mixed with porridge or plain LNS). Most of them were offered as LNS mixed with porridge (92%), which is usually eaten with a spoon. Complementary food bites mainly consisted of nsima and relish (89%), eaten using hands.

All of the studied caregiver and child behaviours varied by child interest in food (Table 3). The associations between behaviours and child interest in food were examined further in a multivariable regression model (Table 4). Lower odds of accepting an intended bite were associated with the child making flat and negative verbalizations, the caregiver making mechanical verbalizations and the timing of the bite at the end of the feeding episode. Higher odds of accepting a bite were associated with the bite containing LNS; the child self-feeding or sitting on the floor; and the caregiver making positive verbalizations, offering no physical help or force feeding the child. Because there were few observations of positive caregiver verbalizations and force feeding, those particular results should be interpreted with caution. The child standing/walking/crawling, child's physical actions, negative caregiver verbalization, age at videotaping and sex were not associated with acceptance of food.

Discussion

Given the lack of literature on feeding behaviours in this part of Africa and in the presence of supplementary food, such as LNS, this study was conducted without pre-set hypotheses regarding whether and how caregiver and child behaviours during bites of LNS and complementary food would differ or which behaviours would predict acceptance of food. When children were fed LNS, we found that they were less likely to self-feed and more likely to be physically pressured by the caregiver. Self-feeding and positive caregiver verbalization were positively associated with child interest in food, while flat and negative child verbalization were negatively associated with acceptance. Although there was no statistically significant difference in the proportion of bites accepted by type of food, when caregiver and child behaviours were controlled in the model consumption of LNS had a positive association with acceptance. This suggests that some aspects of LNS (e.g. the taste) may

Table 3. Caregiver and child behaviours during intended bites ($n = 1674$)*, by type of food and child interest in food

	Type of food					Child interest in food				
	Complementary food† ($n = 786$)		LNS‡ ($n = 888$)		*P*-value§	Accepts ($n = 1419$)		Rejects ($n = 255$)		*P*-value§
	n	%	*n*	%		*n*	%	*n*	%	
Child's behaviours										
Child's interest in food					0.277					
Reject	134	17	121	14		n.a.		n.a.		
Accept	652	83	767	86						
Child's position					<0.001					<0.001
Sitting on lap	301	38	439	50		559	39	181	71	
Sitting on floor/mat	480	61	401	45		818	58	63	25	
Standing/walking/crawling	5	1	48	5		42	3	11	4	
Child's verbalization					0.006					<0.001¶
None	671	85	714	80		1232	87	153	60	
Positive	8	1	11	1		19	1	0	0	
Flat	44	6	34	4		56	4	22	9	
Negative	63	8	129	15		112	8	80	31	
Child's physical actions					0.288					0.029
None	689	88	698	79		1198	84	189	74	
Plays without object	23	3	15	2		32	2	6	2	
Plays with object or person	50	6	136	15		148	10	38	15	
Other actions	24	3	39	4		41	3	22	9	
Caregiver's behaviours										
Who fed the child					0.009					<0.001
Mother or other person	297	38	593	67		670	47	229	90	
Self	491	62	286	32		749	53	26	10	
Caregiver's verbalization					0.388					<0.001
None related to eating	588	75	621	70		1076	76	133	52	
Positive	4	<1	10	1		12	1	2	1	
Mechanical or direct	191	24	250	28		324	23	117	46	
Negative	3	<1	7	1		7	1	3	1	
Caregiver's physical actions					0.057					<0.001
None	419	53	265	30		669	47	15	6	
Facilitates feeding/directly helps	333	42	501	56		333	45	189	74	
Uses physical pressure	28	4	102	12		82	6	48	19	
Force feeds	6	1	20	2		23	2	3	1	
Food variables										
Consistency					n.a.**					0.298
Semi-solid	2	1	888	100		768	54	122	48	
Solid	784	99	0	0		651	46	133	52	
Utensil					<0.001					0.832
Child's or caregiver's hand	721	92	125	14		714	50	132	52	
Spoon	65	8	763	86		705	50	123	48	
Type of food										0.277
Complementary food	n.a.		n.a.			652	46	134	53	
LNS						767	54	121	47	

LNS, lipid-based nutrient supplements; n.a., not applicable. *Intended bites are from 16 participants observed eating complementary food and LNS. †Complementary food = nsima and relish, plain porridge, and other food. ‡LNS = plain LNS and LNS mixed with porridge. §*P*-value by Wald test adjusted for within-subject correlation. ¶*P*-value obtained by dropping the positive child verbalization category from the regression model as there was one empty cell. **No regression was performed on consistency in relation to food type as there was one empty cell.

Table 4. Odds of accepting an intended bite

Caregiver or child behavior	OR ($n = 1655$[§])	90% CI
Type of food (ref = complementary food)		
LNS	3.05‡	1.98, 4.71
Child's position (ref = sitting on lap)		
Sitting on floor/mat	2.13*	1.14, 3.99
Standing/walking/crawling	1.38	0.51, 3.73
Child's verbalization (ref = none)		
Flat	0.40†	0.25, 0.66
Negative	0.27‡	0.17, 0.42
Child's physical action (ref = none)		
Plays without object	1.48	0.66, 3.29
Plays with object or person	1.09	0.52, 2.29
Other actions	0.64	0.26, 1.58
Person feeding (ref = mother or other caregiver)		
Self	5.70‡	2.77, 11.69
Caregiver's verbalization (ref = none)		
Positive	2.46*	1.26, 4.80
Mechanical/direct	0.55*	0.33, 0.90
Negative	0.90	0.31, 2.60
Caregiver's physical action (ref = none)		
Facilitates feeding/directly helps	0.42†	0.26, 0.68
Physical pressure	0.26†	0.38, 1.04
Force feeding	3.72	0.92, 15.01
Bite timing (ref = first three bites of the feeding episode)		
Middle bites of the episode	0.81	0.47, 1.40
Last three bites of the episode	0.37†	0.20, 0.69
Child's age	0.56	0.28, 1.13
Child's gender	1.66	0.95, 2.88

CI, confidence interval; LNS, lipid-based nutrient supplements; OR, odds ratio. *$P < 0.05$; †$P < 0.01$; ‡$P < 0.001$. §The sample size is decreased by 19 bites because the positive child verbalization category was dropped from the model as there were no children with positive verbalizations who rejected bites.

help overcome non-responsive feeding behaviours associated with LNS use that might otherwise negatively impact acceptance. Based on our observations of child feeding and discussions with caregivers, controlling behaviours during LNS feeding may be related to caregivers' perception of LNS as a special food and their feeling that it is important for the child to consume it. Changes over time in caregiver behaviours during LNS feeding could be examined in future studies.

Our study had several strengths. To our knowledge, it is the first study using videotaped data of home use of LNS and child feeding in Africa, which allows us both to present novel findings on behaviours related to LNS use and to compare our findings on child acceptance of food to those of studies in different settings. We used a coding scheme that was tested in several other locations (Bentley *et al*. 1991b, 1997; Dearden *et al*. 2009). The use of videotaped data allowed us to code at a greater level of detail and accuracy than could be achieved during live observations of feeding (Ryan *et al*. 1995). Because it is known that people may modify feeding and other household behaviours on the first day they are observed (Bentley *et al*. 1994; Gittelsohn *et al*. 1997), we minimised reactivity by ensuring that participants were exposed to several full days of observation before they were taped.

This research also had some limitations. Although the coding scheme made comparisons across studies easier, it only allowed us to detect associations and did not capture whether caregivers were responding to their children's actions or cues, or whether children's behaviours influenced those of the caregivers. This issue has been noted in some other studies of responsive feeding (Engle & Zeitlin 1996; Ha *et al*. 2002; Dearden *et al*. 2009) and indicates that causality should not be inferred from these results. The strong correlation between food type and consistency in this study limits our ability to detect the possible confounding effect of consistency. The videotapes we obtained include LNS feeding episodes that had a semi-solid consistency and complementary food meals that were mainly solid family foods. One would expect that caregivers would provide more physical assistance and possibly place the child in a different position when feeding semi-solids, which often require the ability to handle a spoon (Engle *et al*. 2000), as opposed to solids, which can be eaten with hands in the Malawian context. In a larger sample of similarly aged Malawian children, there were no differences in who fed the child or the child's position during feeding episodes of LNS and CSB, both of which are semi-solids (Flax *et al*. 2010). This suggests that some of the differences in behavior by food type detected in the present sample are associated with the consistency of the food. The wide age range of participating children was another possible weakness of this study. Age could be a confounding factor for many of the observed behaviours, as a child's ability to self-feed is linked both to age and stage of development (Connolly & Dalgleish 1989). However, the sample is

actually weighted towards the upper end of the age range, with only one child near the lower end. This may explain why, unlike other studies (Ha *et al*. 2002; Moore *et al*. 2006; Dearden *et al*. 2009), age was not associated with acceptance of food.

Studies of behaviours during feeding in both high- and low-income settings indicate that caregivers may behave differently in relation to the type of food or type of meal (Engle & Zeitlin 1996; Fisher & Birch 1999; Batsell *et al*. 2002). This parallels the behavioural differences we found during LNS and complementary food bites. Our finding that LNS is better accepted than complementary food adds to the growing literature on LNS acceptability (Briend *et al*. 1999; Kuusipalo *et al*. 2006; Adu-Afarwuah *et al*. 2011; Hess *et al*. 2011; Phuka *et al*. 2011). We do not know why bites containing LNS appear to be more acceptable. One possible explanation is the taste or consistency of LNS. The version of LNS used in this study contains more sugar than typical complementary foods consumed in this area. Mothers in this part of Malawi have reported that their children like the sweet taste of LNS (Flax *et al*. 2009). Furthermore, it is known that Malawian children have a monotonous diet as compared to children in other African countries (Ferguson *et al*. 1993). As a result, LNS may be preferred over complementary foods because it is a new food that breaks the tedium that can negatively influence child's appetite (Bentley *et al*. 1996).

Previous research on caring behaviours during child feeding in Africa used ethnographic or mixed methods to provide a picture of the typical caregiver styles of feeding in Mali and Nigeria (Dettwyler 1987; Dettwyler 1989; Bentley *et al*. 1991a). Malian mothers had a laissez-faire style of feeding, meaning that they did very little to assist or encourage their children to eat (Dettwyler 1987), while Nigerian mothers were controlling, tending to hand feed a liquid gruel to young children (Bentley *et al*. 1991a). The Malawian mothers who participated in this study provided physical assistance and some verbal directives, but were not particularly engaged or responsive. A similar passive or laissez-faire style of feeding has been described in several other locations (Bentley *et al*. 1991b; Engle & Zeitlin 1996; Ha *et al*. 2002; Moore *et al*. 2006; Dearden *et al*. 2009).

Researchers studying responsive and non-responsive feeding in low- and middle-income countries have not used consistent definitions for these concepts across studies (Bentley *et al*. 2011). The results of the present study are most comparable to those of two reports from Vietnam (Ha *et al*. 2002; Dearden *et al*. 2009) because they used videotaped data and the same coding scheme. Our findings were generally similar to previous research on responsive feeding. Studies in Vietnam and Bangladesh found that self-feeding (Moore *et al*. 2006; Aboud *et al*. 2009; Dearden *et al*. 2009; Aboud & Akhter 2011) and positive caregiver verbalization (Ha *et al*. 2002; Moore *et al*. 2006; Dearden *et al*. 2009) were associated with higher child acceptance of food, while caregiver physical pressure was associated with lower acceptance (Ha *et al*. 2002). Across settings, the similarities in caregiver behaviours that promote acceptance of food suggest that positive caregiver verbalization and encouragement of self-feeding, as age-appropriate, are key elements of responsive feeding.

In terms of child behaviours, one of the Vietnam studies showed that children who verbalized were less likely to accept bites of food and researchers speculated that child verbalization may have indicated disinterest (Dearden *et al*. 2009). Our study confirms this supposition through more detailed coding of child verbalization, which indicated that children were less likely to accept food when they made flat or negative verbalizations. Negative child verbalization occurred more frequently when caregivers physically pressured the child than during normal or no facilitation, suggesting that the children were reacting to caregivers' efforts to make them eat.

In summary, caregivers in this study allowed their children a fair amount of autonomy in self-feeding and provided some physical assistance but rarely offered positive verbal encouragement. When feeding LNS, they tended to use more physical pressure than for complementary foods. Two recent studies indicate that it is possible to modify feeding practices through group health education (Aboud *et al*. 2009; Aboud & Akhter 2011). This suggests that the results of the present study could be used to design and test an intervention in Malawi to increase positive verbalization by caregivers, reinforce age-appropriate self-

feeding and promote the importance of caregivers' reading child satiety cues, especially when feeding LNS.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

VLF designed and conducted the study, carried out the analysis and drafted the manuscript. SM, UA, KM, PA and MEB contributed to the study design, analysis and manuscript. YBC advised on the statistical methods and contributed to the manuscript.

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