VALERIE L. FLAX

Caregiver Behaviors and Attitudes in the Home Use of Lipid-based Nutrient Supplements for Treating Underweight Children in Malawi

ACADEMIC DISSERTATION
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University of Tampere, School of Public Health
University of Tampere, Medical School
Finland

Supervised by
Professor Per Ashorn
University of Tampere
Finland
Professor Anssi Auvinen
University of Tampere
Finland

Reviewed by
Professor emerita Aulikki Nissinen
University of Kuopio
Finland
Professor Tuula Vaskilampi
University of Eastern Finland
Finland

Distribution
Bookshop TAJU
P.O. Box 617
33014 University of Tampere
Finland

Tel. +358 40 190 9800
Fax +358 3 3551 7685
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SUMMARY

Undernutrition is an important public health problem that affects millions of children. It contributes to poor health and mortality and has negative consequences that continue into adulthood. The burden of child undernutrition is highest in sub-Saharan Africa. Strategies for improving nutritional status have usually targeted dietary intake. Providing supplementary or better complementary food is one of the most direct interventions for the problem of child undernutrition. To implement effective supplementary feeding interventions, it is essential to understand the sociocultural and behavioral factors that affect how supplementary foods are used in a particular setting. Such information can be used to design improved supplementary feeding programs.

The present study took place in Malawi, a long, narrow landlocked country in southeast Africa with high levels of some forms of child undernutrition. This research was carried out in the same rural area of Mangochi District where clinical trials testing the effectiveness of a new type of supplementary food, lipid-based nutrient supplements (LNS), for treating underweight 6-17-month-olds and for preventing undernutrition were underway. Other members of the research team focused on the growth and developmental outcomes of children receiving LNS as compared to a common supplement, corn-soy blend (CSB), whereas this research investigated sociocultural aspects of supplementary food use.

The study was situated within the positivist scientific tradition and it assessed the feasibility of compliance with supplementary feeding interventions in this setting. Its main aim was to identify caregivers' attitudes, practices, and behaviors related to the home use of LNS. We investigated feeding patterns and caregiver behaviors before and during LNS use (n=16), how patterns of LNS use changed over time (n=16), how the supplement was used during illness and convalescence (n=16), and how its use compared to that of CSB (LNS n=85, CSB n=85). Quantitative and qualitative data on mothers' attitudes towards LNS and CSB were also obtained (LNS n=249, CSB n=255). Data were collected through direct observations and interviews. The majority of the data were obtained in 2005 and 2006, but interviews on maternal attitudes continued until mid-2008.

As compared to feeding practices at baseline and during CSB supplementation, use of LNS did not affect the frequency of feeding solid foods, the number or duration of breastfeeds, or the total amount of time spent feeding the child. When LNS was provided in jars containing a 5-day supply, caregivers first tried giving it in different ways, but after four weeks of use they integrated LNS into their regular feeding regimen by nearly always adding it to porridge. When LNS was provided in packets for daily use, it was more often eaten plain than mixed with porridge. As compared to CSB, LNS was less frequently offered as a meal, caregivers washed their hands less often before feeding it, and it was less likely that some of the supplement was left over at the end of a feeding episode. The same types of behavioral patterns were identified when plain LNS was compared to LNS mixed with porridge, indicating that most of the differences in behaviors during CSB and LNS supplementation were linked to the distinctive behaviors associated with plain LNS. The presence of leftovers at the end of supplementary feeding episodes was associated with low child weight-for-age.

LNS consumption was significantly lower on days when the child was ill. The reduction in mean consumption was about 15%. LNS intake was lowest on days with fever, followed by days when the child had

diarrhea. There was no difference in LNS intake on convalescent and healthy days.

Maternal attitudes towards LNS and CSB were generally similar. Mothers reported that both supplements were highly acceptable, most children adapted to eating them within two weeks, and mothers would be willing to use them again or buy them. Supplements tended to be thought of as food rather than medicine. Mothers whose children were in the LNS group were willing to pay more than those in the CSB group for a one-week supply of the supplement. They were also more likely to say that they would withhold the supplement during cough because the sweetness could worsen symptoms. Maternal education was negatively associated and child's initial weight-for-height *z*-score was positively associated with maternal attitudes towards withholding of supplements during fever, diarrhea, and cough.

Similar attitudes towards LNS and CSB suggest that caregivers would have little trouble adopting LNS, if it were to replace CSB, in supplementary feeding programs. The sweetness of LNS may deter its use during cough, indicating that a less sweet version of LNS might be beneficial in this setting. As use of LNS during illness and convalescence is good, programs could promote its use during these periods as a possible way of maintaining nutritional status. LNS supplementary feeding programs might be able to influence the way the supplements are used by providing clear messages that promote specific caregiver behaviors, such as hand washing before supplement meals and mixing LNS in a small amount of porridge to minimize leftovers.

The results of the present study were obtained from southern Malawi. They are important because they could be used to design interventions promoting optimal use of LNS in this setting through information, education, and communication targeted at caregivers. The applicability of these results for programs in other locations may vary depending on similarities and differences in the cultural context.

CONTENTS

LIST OF ORIGINAL ARTICLES

The dissertation is based on the following original papers, referred to in the text by their roman numerals I-IV.

I. Flax VL, Ashorn U, Phuka J, Maleta K, Manary MJ and Ashorn P. Feeding patterns of underweight children in rural Malawi given fortified spread at home. *Matern Chi Nutr* 2008;4:65-73.

II. Flax VL, Maleta K, Ashorn U, Manary MJ, Briend A and Ashorn P. Intake of lipid-based nutrient supplements during illness and convalescence among moderately-underweight Malawian children. *J Health Popul Nutr* 2008;26(4):468-470.

III. Flax VL, Thakwalakwa C, Phuka J, Ashorn U, Cheung YB, Maleta K and Ashorn P. Malawian mothers' attitudes towards the use of two supplementary foods for moderately malnourished children. *Appetite* 2009;53:195-202.

IV. Flax VL, Phuka J, Cheung YB, Ashorn U, Maleta K and Ashorn P. Feeding patterns and behaviors during home supplementation of underweight Malawian children with lipid-based nutrient supplements or corn-soy blend. *Appetite* 2010 Feb 11. [Epub ahead of print].

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ABBREVIATIONS

ACC/SCN	Administrative Committee on Coordination/Sub-Committee on Nutrition
CDC	U.S. Centers for Disease Control
CEE/CIS	Central and Eastern Europe/Commonwealth of Independent States
CSB	Corn-soy blend
DPT	Diphtheria, pertussis, and tetanus
FAO	Food and Agriculture Organization
FS	Fortified Spread (an earlier name for lipid-based nutrient supplements)
Hib	Haemophilus influenzae b
HAZ	Height-for age *z*-score
LNS	Lipid-based nutrient supplements
NCHS	U.S. National Center for Health Statistics
PAHO	Pan-American Health Organization
UNICEF	United Nations Children's Fund
WAZ	Weight-for-age *z*-score
WHO	World Health Organization
WHZ	Weight-for-height *z*-score

1. INTRODUCTION

Undernutrition is a major public health problem that affects millions of young children in low income countries (Black et al. 2008). The largest number of undernourished children is found in South Asia, but the only region of the world where a high prevalence of undernutrition continues unabated is sub-Saharan Africa (de Onis and Blössner 2003). Undernutrition increases children's risk of morbidity and mortality (Pelletier et al. 1993, Black et al. 2008) and has consequences for human capital formation (Victora et al. 2008). Mild and moderate undernutrition are the most common forms and children are most affected between the ages of 6 and 24 months (Shrimpton et al. 2001).

There are numerous factors that contribute to child nutritional status at the immediate, underlying, and basic levels (UNICEF 1990). Interventions to treat or prevent undernutrition have typically targeted the immediate determinants of child growth by trying to minimize infections or by improving dietary intake.

The most common interventions provide supplementary or better complementary food. Cereal/legume blends, such as corn-soy blend (CSB), have traditionally been used to improve child feeding, but their benefits to child nutritional status have been mixed (Beaton and Ghassemi 1982, Allen and Gillespie 2001, Dewey and Adu-Afarwuah, 2008). A newer strategy for improving dietary intakes is a fat-based spread that includes milk powder and micronutrients, known as lipid-based nutrient supplements (LNS) (Briend 2001). LNS are now widely accepted as a community-based treatment for severe acute malnutrition (World Health Organization/World Food Program/United Nations Standing Committee on Nutrition/United Nations Children's Fund 2007). As the numbers of children with mild and moderate undernutrition are much larger than those with severe forms, there is widespread interest in the use of LNS at the community level for prevention and treatment (The PLoS Medicine Editors 2008).

While finding effective dietary solutions to the problem of undernutrition is very important, it is also necessary to understand and study the other factors that contribute to undernutrition and that may influence how supplementary foods are used. The behavioral aspects of child feeding can affect how much of the supplement is consumed and can have an impact on morbidity, particularly through hygiene practices (Engle et al. 1997, Brown et al. 1998). Child feeding practices are context-dependent and must be identified in different locations where supplementary foods are used (Pelto et al. 2003). Such information may be helpful in designing programs that promote the use of supplements in a given setting.

The present study was carried out among underweight 6-17-month-old children in a rural area of Mangochi District, Malawi. Malawi was selected as the research site because of the high levels of some types of child undernutrition. Several studies on maternal and child health were on-going in the research area at the time when the present study took place. Other members of the research team investigated the effects of LNS and CSB on child growth and development. This study focused on the sociocultural aspects of supplement use. It was designed to describe patterns of LNS use over time, during illness, and as compared to a commonly used alternative, CSB. Caregiver behaviors during LNS and CSB supplementation were also investigated, and maternal attitudes towards the use of the two supplements were examined.

2. LITERATURE REVIEW

The aim of this literature review is to provide the background for the present research. The review defines undernutrition and describes the global status of child undernutrition as well as its consequences. The factors that contribute to undernutrition are also discussed, with particular emphasis on the behavioral and cultural determinants of child feeding. As this study was conducted in Malawi, country-specific information about child nutritional status, feeding behaviors, and beliefs about child health and feeding are provided. Finally, interventions for the management of undernutrition are described, and the justification for the study is given.

2.1 Definition of undernutrition and measurement of nutritional status

Undernutrition is the inadequate intake and use of energy and nutrients to maintain normal body functions and daily activities, including growth, fighting infections, working, and learning (UNICEF 2006a). There are several forms of undernutrition including stunting, wasting, underweight, and micronutrient deficiencies (Black et al. 2008). Micronutrient deficiencies are usually detected using physical signs or biochemical markers. Other forms of undernutrition can be identified in several different ways, but are commonly found by taking anthropometric measurements, most often weight and height (or recumbent length for children less than two years of age).

Three anthropometric indices are used to assess nutritional status in children: height-for-age, weight-for-height, and weight-for-age. Low height-for-age or stunting indicates chronic or long-term undernutrition (WHO Working Group 1986). A child who is stunted has had a slowing of skeletal growth. Low weight-for-height or wasting is a sign of acute or short-term undernutrition (Cogill 2003). A wasted child has a deficit of tissue and fat as compared to a child of the same height or length. Low weight-for-age or underweight provides information about long- and short-term undernutrition. A child who is underweight may have both low stature and loss of body mass (Allen and Gillespie 2001). The degree of stunting, wasting, and underweight is determined by comparing an individual's measurements to those of children of the same age or height in the reference population and expressing the difference as a *z*-score (Allen and Gillespie 2001, Cogill 2003). *Z*-scores allow for comparisons between children of different ages or heights and make it possible to compare the nutritional status of populations. Severe undernutrition occurs when an individual is more than 3 standard deviations below the reference, moderate undernutrition is when a child is between 2 and 3 standard deviations below the reference, and mild undernutrition occurs when a person is between 1 and 2 standard deviations below the reference.

The proportion of the population who are considered to be undernourished depends on which growth reference or standard is used. Until recently the U.S. National Center for Health Statistics (NCHS/WHO) 1976 and the U.S. Centers for Disease Control (CDC) 2000 growth charts were often used as references (U.S. Public Health Service 1976; Kuczmarski et al. 2002). These have been criticized due to the type of reference population (largely formula fed, affluent children from one U.S. community) and the statistical methods used to construct the growth curves (WHO 1995, Garza and de Onis 1999, Kuczmarski et al. 2002). Due to these concerns, WHO began its Multicentre Growth Reference Study in the late-1990s with the aim of producing a growth standard that could be used worldwide and that would represent the growth of breastfed children living in optimal conditions (WHO 2006). A growth standard differs from a growth reference in that it is based on a population of children who are deemed to be growing normally and living in optimal conditions, whereas a reference can be developed from any large enough population of reasonably healthy children (WHO Working Group 1986). When using the new WHO standard as compared to the NCHS/WHO reference, stunting is detected more frequently throughout childhood, rates of underweight are higher during the first six month of life and then decrease, and rates of wasting are higher during the first year of life (WHO 2006).

2.2 Consequences of undernutrition

Poor nutrition during the first two years of life is linked to a variety of negative health and other outcomes both in the short- and long-term (Martorell 1999). The most obvious short-term effects of undernutrition are delayed growth and increased risk of childhood morbidity and mortality. More than half of all child deaths are attributable to low weight-for-age (Pelletier et al. 1993, Caulfield et al. 2004), and more than 80% of these deaths are in children with mild to moderate undernutrition (Pelletier et al. 1995). A recent review found that mortality is associated with all forms of child undernutrition (underweight, wasting, and stunting), not just underweight (Black et al. 2008). Globally, approximately 15-20% of deaths (and a similar proportion of disability adjusted life years) are due to underweight, stunting, and wasting among children less than 5 years of age.

Undernutrition, including mild and moderate forms, is also associated with delayed cognitive, motor, and behavioral development during childhood (Sigman et al. 1989, Grantham-McGregor et al. 1991, Gorman and Pollitt 1992, Grantham-McGregor et al. 1997, Cheung et al. 2001, Siegel et al. 2005, Olney et al. 2009). The effects of undernutrition on cognitive abilities persist, but may become somewhat attenuated later in childhood and into adulthood, and they are dependent on the severity of stunting during the first two years of life (Grantham-McGregor 1997, Mendez and Adair 1999, Walker et al. 2005).

Pre- and post-natal nutritional status also has an effect on schooling, adult height, adult earnings, and size of offspring (Victora et al. 2008). Poor nutritional status (particularly low height-for-age) during early childhood is associated with delayed entry in school, fewer years of schooling completed, and lower school performance (Alderman et al. 2003, Li et al. 2003, Daniels and Adair 2004). Both intrauterine growth restriction and linear growth failure during the first 1-2 years of life affect adult stature (Li et al. 2003, Stein et al. 2009). The effects of early nutrition on attained height and schooling are important because individuals who are shorter and have reduced lean body mass are less capable of doing manual labor. This together with lower educational attainment leads to decreases in earnings and household income levels (Alderman et al. 2003, Hoddinott et al. 2008, Victora et al. 2008). Adult height of mothers also affects the birth size of the next generation, which causes the cycle of undernutrition to continue (ACC/SCN 2000, Victora et al. 2008).

2.3 Occurrence of undernutrition

Child undernutrition is highly prevalent in low- and middle-income countries. Globally, among children younger than 5 years of age, 20% (111 million) are estimated to be moderately or severely underweight, 32% (178 million) are moderately or severely stunted, and 10% (55 million) are moderately or severely wasted (Black et al. 2008). In relation to the WHO growth standard, underweight is most common in south-central Asia and east Africa. The prevalence of stunting is highest in east and central Africa, while wasting occurs most frequently in south Asia. Due to the large size of the population in south Asia, this region accounts for the largest number of undernourished children. However, the

Table 1: Regional prevalence of undernutrition in children < 5 years of age as compared to the NCHS/WHO reference

	% of children < 5 years with:		
	Moderate or severe underweight	Moderate or severe wasting	Moderate or severe stunting
Sub-Saharan Africa	28	9	38
Middle East and North Africa	17	8	26
South Asia	45	18	38
East Asia and Pacific	14	-	16
Latin America and Caribbean	6	2	16
CEE/CIS	5	2	12

Source: UNICEF 2008

absolute and relative burdens of undernutrition are higher in children living in sub-Saharan Africa than in other regions (Black et al., 2008). Table 1 shows the proportion of children in different regions who are underweight, wasted, and stunted as compared to the NCHS/WHO reference.

Regional trends in the prevalence of stunting from 1980 to 2020 have been estimated using the WHO global database on child growth and malnutrition (de Onis and Blössner, 2003). The prevalence of stunting during childhood has been decreasing worldwide, but the rate of decrease is much slower in Africa than in other regions. In addition, the actual number of stunted children has been increasing in Africa while it has decreased in other regions (de Onis and Blössner 2003). The prevalence of stunting and wasting vary by age (WHO Working Group 1986). Severe wasting has a higher prevalence at younger ages and declines by the age of 2 years, whereas the prevalence of stunting increases until it levels off at the age of 2 years (Shrimpton et al. 2001, Black et al. 2008).

It has been recognized that the period from 6-24 months is the most important time for preventing undernutrition because it is when growth faltering is most likely to occur (Martorell et al. 1994, Allen and Gillespie 2001, Shrimpton et al. 2001). Food supplementation trials have also shown that this is the period of greatest impact on growth (Lutter et al. 1990, Schroeder et al. 1995). Stunting during this age range can be reversed if the period of growth is lengthened by delayed maturation. However, the delays in maturation in developing countries are not adequate to allow for full catch-up growth so that stunting early in life is difficult to reverse if children continue to live in the same environment where the stunting occurred (Martorell et al. 1994).

2.4 Determinants of nutritional status

Although human growth is determined by an interaction between genes and environment, studies of growth concur with epidemiological evidence that environmental factors have the largest impact on nutritional status during the first 2 years of life (Tse et al. 1989, Tanner 1990, Silventoinen et al. 2008a, Silventoinen et al. 2008b). The influence of the environment on nutritional status can also be seen in research on growth potential, which has demonstrated that the growth of children in low- and high-income countries is similar if an appropriate environment is provided (Martorell et al. 1988, Quinn et al. 1995, Bhandari et al. 2002, WHO Multicentre Growth Reference Study Group 2006).

Because the environment in which a child lives is amenable to change, while genetic factors are not, programs and research to improve child nutritional status have focused on factors in the environment. The environmental factors that contribute to a child's nutritional status and the connections between them were first elucidated in a conceptual model developed by the United Nations Children's Fund (UNICEF 1990) and later modified several times (Engle et al. 1997, Smith and Haddad 2000, Black et al. 2008). An adapted version of the model is found in Figure 1.

The factors that contribute to nutritional status can be divided into three levels: immediate, underlying, and basic. The immediate determinants focus on the individual and include the child's dietary intake and health status. The underlying determinants include elements at the household and community level, such as caring behaviors, household food security, health services, and household environment plus the resources required for these to occur. The basic determinants of child nutritional status are the social, political, and economic context and the resources available at the broader societal level. As the basic determinants influence those at the underlying level and the underlying determinants contribute to the immediate ones, a lack or inadequacy of one or more factor at any level has a negative impact on the child's nutritional status.

The development of the UNICEF conceptual model represented a shift in the focus of research and programs targeting child undernutrition by placing emphasis on the behavioral aspects of child feeding and the context in which feeding occurs. In addition to the biological aspect of feeding (*what* is being fed), the model indicates that the behavioral aspects (the *when*, *where*, *who, how,* and *why* of feeding) are also important (Pelto et al. 2003). *When* is concerned with the frequency and timing of feeding. *Where* refers to the place where the child is fed, the amount of distraction present, and the possibility for interaction with the caregiver. *Who* looks at the relationship of the feeder to the child. *How* focuses on issues such as the type of utensil used, the method of feeding, and the feeding style. *Why* refers to the determinants of feeding practices, including beliefs, knowledge, and attitudes.

This section of the literature review first discusses the immediate determinants of child nutritional status (the role of illness in feeding and growth and *what* children are fed) then turns to the behavioral aspects of child feeding (*when, where, who, how, why*). The highlighted elements of the conceptual model (in Figure 1) were included in this study and are the focus here.

2.4.1 The role of illness in child feeding and growth

Children in low-income countries suffer frequently from common infectious diseases and other illnesses (Mata et al. 1977, Lindjtorn et al. 1992, Muhe et al. 1995, Vaahtera et al. 2000). The relationship between infection and undernutrition has been described as synergistic (Scrimshaw et al. 1968, Scrimshaw and SanGiovanni 1997). Infections are said to precipitate or aggravate undernutrition while undernutrition lowers resistance to infection, resulting in a vicious cycle. The lower immunity present in undernourished children makes it easier to get infections and more likely that the infections will be more severe than in well-nourished children (Allen and Gillespie 2001). Undernutrition, including micronutrient deficiencies, predisposes children to diarrhea, respiratory infections, malaria, other infections, and comorbidities (Scrimshaw et al. 1968, Briend 1990, Caulfield et al. 2004, Kazembe and Namangale 2007).

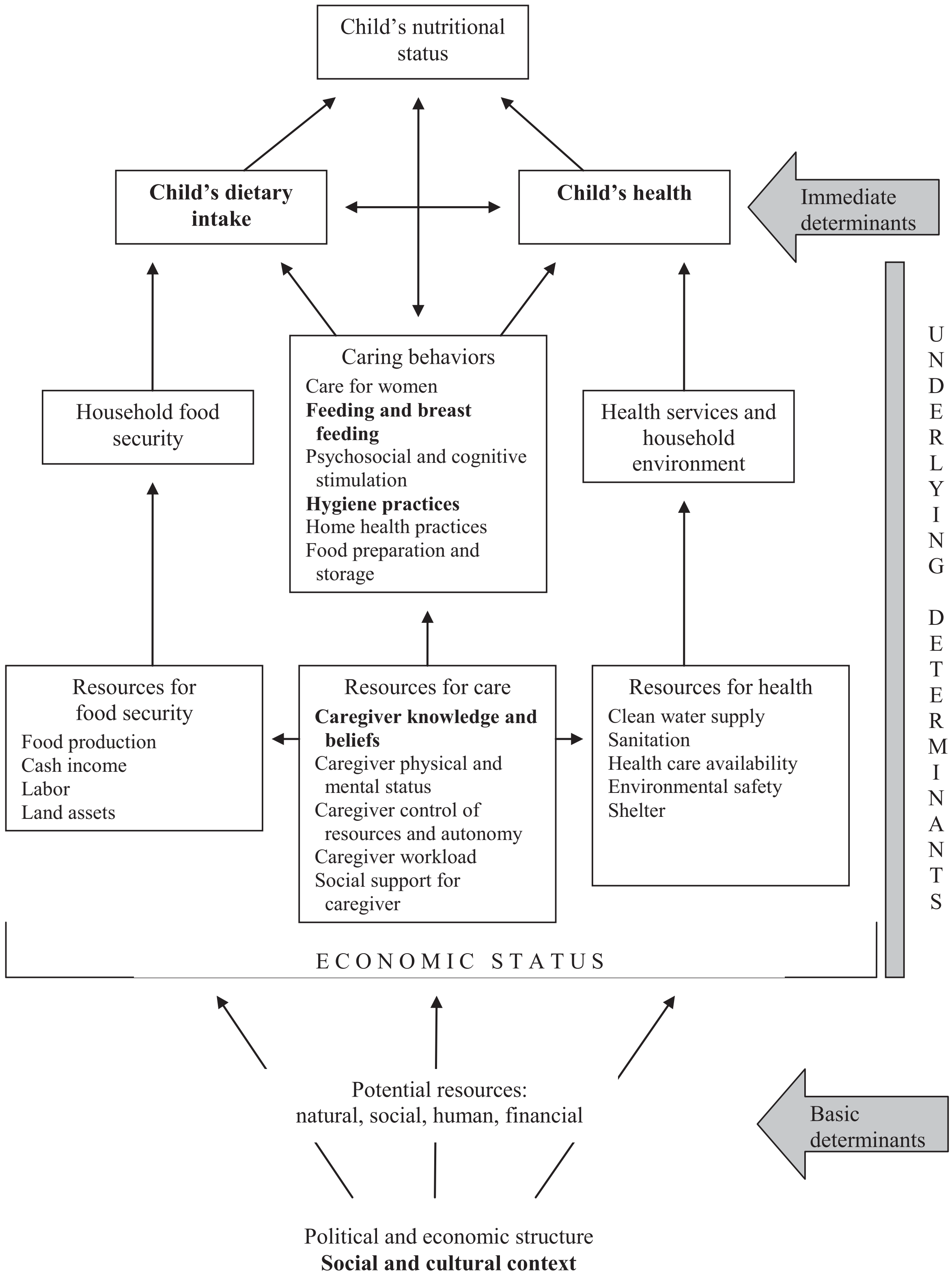

Figure 1. Conceptual model of factors influencing child nutritional status
(Adapted from UNICEF 1990, Engle et al. 1997, Smith and Haddad 2000, Black et al. 2008)

The association between common infections, such as diarrheal disease, respiratory infections, and malaria, and child undernutrition has also been demonstrated in numerous studies (Mata et al. 1972, Martorell et al. 1975, Condon-Paoloni et al. 1977, Rowland et al. 1977, Black et al., 1984, Zumrawi et al. 1987, Rowland et al. 1988, Moore et al. 2001, Checkley et al. 2003). Infections are thought to contribute to undernutrition due to decreased intestinal absorption of nutrients, anorexia, catabolism, and increases in the metabolic rate during fever (Scrimshaw and SanGiovanni 1997). Although diarrhea appears to have the strongest and most consistent negative effect on growth (Black et al. 1984, Moore et al. 2001, Checkley et al. 2003, Black et al. 2008, Checkley et al. 2008), the link between diarrhea and undernutrition has been questioned due to temporal ambiguity and the transient effects of diarrhea on growth of children older than 6 months (Briend 1989, Briend 1990).

During episodes of illness, children tend to lose their appetites and their intake of complementary food is decreased, especially when they have fever and diarrheal disease (Mata et al. 1977, Brown et al. 1995a). Mothers report that their infants and young children have poor appetite most frequently on days with fever, followed by days with diarrhea and respiratory illness (Brown et al. 1995a, Gryboski 1996). Several studies indicate that there are no reductions in breastmilk intake during illness, but that energy intake from non-breastmilk sources is reduced by 5-30% (Mata et al. 1977, Martorell et al. 1980, Brown et al. 1985, Brown et al. 1990, Dickin et al. 1990).

There is some evidence to support the idea that an adequate dietary intake may be more important to growth than the prevention of infections. Modeling of data from Bangladesh showed that increasing children's energy intake to the recommended values would have a greater effect on their weight gain than eliminating fever and diarrhea combined (Becker et al. 1991). This is consistent with findings from Colombia which showed that diarrhea did not affect the linear growth of children with adequate dietary intake (i.e., those who received food supplements during the first three years of life) (Lutter et al. 1989). Further, data from Peru indicate that only among those children who usually had low energy intake was there a significant relationship between diarrhea and increments of weight gain (Brown 1990).

The fact that children have poor appetite during illness and that adequate feeding during illness could minimize the effects on nutritional status has led to a recommendation by WHO that caregivers should encourage their children to continue eating during illness (PAHO/WHO 2003). It has been suggested that targeted supplementary feeding during illness (and convalescence) could assist caregivers to continue feeding children, but information about the consumption of supplements during illness and other evidence to support this hypothesis are not yet available.

2.4.2* What *the child is fed - child's dietary intake

There are several aspects of breastfeeding and complementary feeding that are necessary for achieving adequate dietary intake in children, and they have been summarized in the *Guiding Principles for Complementary Feeding of the Breastfed Child* (PAHO/WHO 2003). Those guiding principles that are relevant to the present study are cited in different sections of this literature review.

It is recommended that after six months of exclusive breastfeeding children should continue to be breastfed up to two years of age or more while receiving complementary foods (WHO 1995). Breastmilk is an important component of child nutrition beyond the first year of life. Once complementary foods are introduced, breastmilk still provides a considerable proportion of daily dietary energy, fat, essential fatty acids, and micronutrients (Prentice and Paul 1990, Brown et al. 1998, Agostoni et al. 1999, Dewey and Brown 2003, Kimmons et al. 2005, Brown et al. 2009). It is also likely to have an important nutritional benefit during illness, when breastfeeding is usually continued even if the child's appetite for complementary foods is reduced (Brown et al. 1985, Brown et al. 1990, Dickin et al. 1990).

In addition to maintaining breastfeeding, caregivers should start feeding children small quantities of complementary food at the age of six months and gradually increase the amount as the child grows older (PAHO/WHO 2003). Estimates for the amount of energy breastfed 6-8, 9-11, and 12-23 month olds need from complementary food have been made by subtracting the average breastmilk energy intake from the total energy requirements and are available in Brown et al. (1998) and Dewey and Brown (2003).

2.4.3 **When *the child is fed***

Caregivers should increase meal frequency with age so that breastfed children would receive complementary food meals 2-3 times per day at 6-8 months and 3-4 times per day thereafter (PAHO/WHO 2003). Data compiled from studies in 16 countries indicate that feeding young children 3 or more times per day is the common practice in most locations, but lower frequencies were detected in a few places (Pelto et al. 2003). At the individual level, actual meal frequency depends on the energy density of the complementary food, the amount of food consumed during meals, and the level of breastmilk intake (Brown et al. 1998, Dewey and Brown 2003). Children consume more of low than high density foods, but their total energy intake is positively associated with energy density and meal frequency (Bennett et al. 1999, Islam et al. 2008). However, as the number of meals increases, children consume less at each subsequent meal so that increasing the number of meals beyond 4-5 per day has a limited impact on the total amount ingested (Brown et al. 1995b). The amount of time spent feeding children depends on the number of meals, not on the energy density of the food (Brown et al. 1995b).

Feeding frequency and the types of food offered to children may also depend on broader socioeconomic factors. Seasonal patterns of food security and agricultural labor have been shown to affect the amount of food present in the home and the number of meals prepared per day (Quinn et al. 1990).

2.4.4 **Where *the child is fed***

Although feeding the child in a protected location, where disturbances are limited and interaction with the caregiver is possible, is considered to be an important part of appropriate care during feeding (Engle et al. 2000, PAHO/WHO 2003, Pelto et al. 2003), very few studies have reported *where* children were fed. The most detailed information comes from an observational study in Bangladesh, where both the physical location (e.g., in the house, on the porch) and the child's position (e.g., on an earth surface, in arms of caregiver) during feeding were recorded (Guldan et al. 1993a). A study using videotaped data from Vietnam provided data on the child's position during feeding and found that this varied by age (Dearden et al. 2009). It is notable that some studies have reported that children ate on an earth surface some or most of the time as this could have implications for diarrhea transmission if the child touches the soil and then uses his or her hands to continue eating (Dettwyler 1986, Guldan et al. 1993a). However, the influence of where the child eats on intake and child health outcomes has not been adequately studied (Pelto et al. 2003).

2.4.5 **Who *feeds the child***

In a review of the behavioral aspects of child feeding, mothers clearly played a major role in feeding, with other relatives assisting part of the time (Pelto et al. 2003). The amount of self feeding by the child increases with age (Moore et al. 2006, Dearden et al. 2009), and self feeding occurs more often during snacks than meals (Engle and Zeitlin 1996). There is some evidence that children who self feed (when they have reached the appropriate developmental stage) consume more food than those who do not (Moore et al. 2006), which could be important in settings where child undernutrition is common.

2.4.6* How *the child is fed

The *how* of child feeding includes several elements focused on different aspects of care, such as responsiveness, the type of utensil used for feeding, and hygiene during meals. Care has been defined as "the provision in the household and the community of time, attention, and support to meet the physical, mental, and social needs of the growing child" (Engle et al. 1997, pg. 2). It is a transaction between the caregiver and child in which the interactions between the pair depend on the characteristics of each individual and on their previous interactions (Engle et al. 1997). One of the key aspects of care is the caregiver's responsiveness to the child's physical and verbal cues (Bornstein et al. 1992, Bornstein et al. 2008). Responsiveness is defined as caregivers' prompt, contingent and appropriate reactions to their children (Ainsworth et al. 1974).

Several elements of responsiveness during feeding have been measured in studies conducted in developing countries, including how caregivers adapt to the child's psychomotor abilities to self feed, their reactions to the child's hunger and satiety cues, and the amount of physical assistance and verbal encouragement offered (Bentley et al. 1991b, Engle and Zeitlin 1996, Ha et al. 2002, Moore et al. 2006, Dearden et al. 2009). The ratio of self feeding to caregiver physical assistance is important in defining the caregiver's feeding style, which runs on a continuum from laissez-faire to controlling, with a responsive style located somewhere in between (Birch and Fisher 1995). Observational research in Nigeria indicates that caregivers can be very controlling, force feeding their children at nearly every meal (Bentley et al. 1991a, Oni et al. 1991a). However, data from many other developing countries shows that caregivers' feeding styles are most often laissez-faire. They either expect children to self feed from an early age (Dettwyler 1986) or offer little assistance or encouragement (Bentley et al. 1991b, Engle and Zeitlin 1996, Gittlesohn et al. 1998, Ha et al. 2002, Moore et al. 2006, Dearden et al. 2009). Caregivers' level of responsiveness is not static and may vary in response to children's appetite, age, and by type of feeding episode (Bentley et al. 1991b, Engle and Zeitlin 1996, Arimond and Ruel 2002, Ha et al. 2002, Moore et al. 2006). There is evidence that some aspects of responsiveness are linked with food intake and growth (Ruel et al. 1999, Dearden et al. 2009).

The type of utensil used during feeding is related to the age of the child, the consistency of the food, and to cultural ideas about the appropriate way to eat specific types of food. It can also indicate the level of caregiver control over feeding and how the caregiver reacts to the child's ability to self feed with different utensils, such as a spoon. A review of complementary feeding studies grouped cup, bowl, or spoon into one category and found that this was the most common utensil type (Pelto et al. 2003). Use of certain types of utensils for feeding can have implications for child growth. One study in Guatemala found that mothers with undernourished children frequently fed their children gruels and broths from a bottle while those with normal weight children did not (Izurieta and Larson-Brown 1995).

Hygiene during meals is another important aspect of care during feeding. Household hygiene behaviors are linked to the prevalence of child diarrhea (Bartlett et al., 1992, Gorter et al. 1998, Ejemot et al. 2008, Fewtrell et al. 2005). Specific hygiene practices that are essential to child health and nutrition include: safe disposal of feces, cleaning children after defecation, and hand washing (Almedom 1996, Curtis et al. 2000, Arimond and Ruel 2002). Washing hands before eating is one way to break the oral-fecal cycle, thereby preventing diarrhea. Caregivers were observed to wash their hands before child feeding about 2/3 of the time in Zaire (Manun'Ebo et al. 1997), while they reported washing hands 3/4 of the time in the Philippines (Sakisaka et al. 2002) and all of the time in the Dominican Republic (McLennan and Spady 1994). Information about child hand washing before eating is sparse. A study in Nicaragua found that children's hands were rarely washed before any type of eating event (snack, midday meal, or bottle) (Engle and Zeitlin 1996).

Feeding, hygiene, and other caring practices tend to cluster and some minimum number of good practices may be necessary to make a difference (Dettwyler 1986, Kaltenthaler and Drasar 1996, Arimond and Ruel 2002). Evidence from positive deviance programs and studies indicates that while some mothers perform many good practices and have well-nourished children, most mothers with undernourished children do not do these practices (Zeitlin et al. 1990, Guldan et al. 1993b, Wollinka et al. 1997, Sternin et al. 1998).

2.4.7 **Why** ***the child is fed in this manner - caregiver education, knowledge, and beliefs***

Maternal education, knowledge, and cultural beliefs have an important influence on feeding behaviors and child nutritional status (Pelto et al. 2003). A number of studies have found a strong, positive association between maternal education and child nutritional status (Frongillo et al. 1997, Smith and Haddad 2000, Heaton et al. 2005, Boyle et al. 2006, Semba et al. 2008). In some settings, maternal education has the strongest effect on child nutrition at the lowest end of the economic scale, while in others a certain socio-economic threshold must be attained for education to have an influence (Ruel et al. 1992, Reed et al. 1996, Ruel et al. 1999). Maternal schooling is also positively associated with hygiene and health-seeking behaviors (Gorter et al. 1998, Armar-Klemesu 2000). The mechanisms by which maternal education affects child outcomes are complex and not fully understood. Formal education could influence child nutritional status and health through maternal nutrition knowledge (Ruel et al. 1992, Glewwe, 1999); child care practices (Cebu Study Team 1991, Joshi 1994, Ruel et al. 1999); ability to access and process information (Barrera 1990, Thomas et al. 1990); acquisition of skills, such as literacy (Joshi 1994); greater decision-making power over household resources (Wachs 2008); or some combination of these.

It is known that women obtain nutrition and health information from a variety of sources other than schools, including media, relatives, and community health services (Thomas et al. 1990, Glewwe 1999, Block 2002, Webb and Block 2004), but it is not clear whether formal maternal schooling and nutrition knowledge interact (Thomas et al. 1990, Ruel et al. 1992, Glewwe 1999, Block 2002) or act independently on child nutritional status (Guldan et al. 1993a, Lamontagne et al. 1998, Heaton et al. 2005). It is possible that formal education and nutrition knowledge are related to different aspects of child nutritional status. Webb and Block (2004) found that maternal nutrition knowledge was more important than formal schooling in determining short-term child nutritional status (WHZ) while the reverse was true for long-term outcomes (HAZ).

Higher levels of maternal education are also associated with better child feeding and caring practices, including introducing complementary foods at the appropriate age, feeding more frequently, feeding responsively, feeding better quality food, and feeding in a cleaner, more protected place (Guldan et al. 1993a, Guldan et al. 1993b, Armar-Klemesu et al. 2000, Wamani et al. 2005). Educated mothers are reported to take more control over feeding and to be committed to more labor-intensive child care (Guldan et al. 1993a).

In addition to the influence of mothers' knowledge and education on child care and nutrition, the cultural context plays an important role in the formation of mothers' beliefs about child feeding and caring practices (Engle et al. 1997, Pelto et al. 2003). Beliefs about *what*, *where*, *when*, and *how* to feed infants and children are frequently linked to local perceptions about child growth and development (Pelto et al. 2003). This point is illustrated below with examples from Malawi. Other aspects of child growth and feeding in Malawi are also described in the following section.

2.5 Child health, nutritional status, and feeding in Malawi

The present study took place in Malawi, a small country in southeast Africa. General background information about Malawi and the study site are provided in the Methods section (Chapter 4). Details about child health, nutritional status, feeding practices, and beliefs related to infant and child feeding are described here.

During the first year of life in a rural area of Malawi, infants were reported to be ill for an average of 32 days, comprising about 4 illness episodes (Vaahtera et al. 2000). The most common illnesses were diarrhea and acute respiratory infection, followed by malaria (Vaahtera et al. 2000). The mean number of illness episodes documented in Malawi was towards the low end of the range reported in other studies of morbidity in sub-Saharan Africa (Oni et al. 1991b, Lindtjorn et al. 1992, Muhe et al. 1995). This was probably because the study in Malawi included only infants (< 1 year of age), who receive some protection from infections through breastmilk, while the other studies included infants plus children up to 5 years of age.

As compared to the NCHS/WHO reference, the prevalence of moderate and severe undernutrition in Malawian children < 5 years is: 21% underweight, 4% wasted, and 46% stunted (UNICEF 2008). The prevalence of underweight and wasting are slightly lower in Malawi than in the whole of sub-Saharan Africa, while the prevalence of stunting is somewhat higher (see Table 1). The patterns of prevalence of wasting and stunting in Malawi are similar to those at the global level, with the prevalence of stunting in Malawi increasing until 18 months and then leveling off and the prevalence of wasting peaking from 15-21 months and then declining (Maleta et al. 2003a). Rural Malawian children weighed 510 g less and were 2.5 cm shorter at birth than the CDC 2000 reference (Maleta et al. 2003b). Their weight gain was lower than the reference population until the age of 18 months, after which it was comparable up to 36 months. There was no catch-up in height during the first three years of life, so that the Malawian children were 10.5 cm shorter than the reference by 36 months of age (Maleta et al. 2003b).

There are marked seasonal changes in food security in Malawi, with food supplies at their lowest during the rainy season and at their highest during the harvest period. Meals are prepared less frequently during the food shortage season due to mothers' participation in agricultural labor and low household food stocks (Quinn et al. 1990). Children consume more of their energy from cereals and less from legumes in the food shortage season (Ferguson et al. 1993). Seasonal differences in patterns of food use and availability are reflected in the age-dependent seasonality of growth in Malawian children (Maleta et al. 2003c).

Nearly all Malawian mothers breastfeed their children and the mean duration of breastfeeding is 23 months (National Statistical Office [Malawi] and ORC Macro 2005). Complementary food, in the form of very thin maize gruel, is given at 2-3 months of age and family foods, most frequently stiff maize porridge (nsima) and relish made of beans, green vegetables, or fish, are given at 4-6 months of age (Hotz and Gibson 2001, Vaahtera et al. 2001, Kalanda et al. 2006). The mean complementary feeding frequencies are 3 ± 1 in 6-8 month-olds and 4 ± 1 in 9-23 month-olds (Hotz and Gibson 2001). The energy densities are adequate for the feeding frequency in all age groups compared to densities recommended in Brown et al. (1998). This is most likely due to the fact that family foods are introduced early so that the food is thick enough to have adequate energy density. Among 6-23-month-olds, energy intakes are low in comparison to international recommendations by age and the diet lacked adequate calcium, iron, zinc, and niacin (Hotz and Gibson 2001). In relation to the international recommendations outlined by PAHO/WHO (2003), the duration of breastfeeding, the feeding frequency, and the energy densities of complementary foods are adequate, but exclusive breastfeeding is short-lived, complementary foods are introduced very early, and energy and nutrient intakes are deficient.

Some of these feeding practices are determined, in part, by local cultural beliefs. Malawian mothers usually breastfeed their infants, and colostrum and breastmilk are considered to be good because they protect infants from diseases and give them energy (Bezner Kerr et al. 2007). However, exclusive breastfeeding ends early because different types of herbal water are given during the first 1-2 months of life to protect the child from illnesses believed to be caused by the parents' failure to follow sexual abstinence rules (Bezner Kerr et al. 2008). Thin maize porridge and other complementary foods are typically introduced in the first 2-4 months of life in response to the baby crying (Hotz and Gibson 2001, Bezner Kerr et al. 2007). The baby's cries are taken to be a sign that the child is hungry because its mother's milk is insufficient. In this region of Africa, porridge is the only type of food that is prepared especially for the infant (Cosminsky et al. 1993, Mabilia 1996, Hotz and Gibson 2001). Grandmothers in the northern part of Malawi play an important role in decision-making about child feeding and caring, particularly with respect to introduction of herbal water and complementary foods (Bezner Kerr et al. 2008).

Beliefs about child illness also play an important role in the care and nutrition of young children in Malawi. In several locations in Malawi (as well as in other parts of the region), children are thought to get the signs and symptoms of moderate or severe undernutrition when their parents ignore sexual abstinence rules (Zulu 1996, Howard and Millard 1997, Van Breugel 2001, Munthali 2002, Bezner Kerr et al. 2008). This is said to occur either because parents resume sexual intercourse too early, resulting in another pregnancy closely spaced with the previous one, or because they have sexual intercourse after a funeral, following a miscarriage, etc. when it is not permitted (Zulu 1996, Van Breugel 2001). Due to the stigma associated with signs of child undernutrition, these beliefs have important consequences not only for the early cessation of exclusive breastfeeding due to the use of herbal water as a preventive measure (Bezner Kerr et al. 2008), but also for the type of care and the speed with which appropriate health care and advice is sought for an undernourished child (Howard and Millard 1997, Amuyunzu-Nyamogo and Nyamogo 2006).

2.6 Interventions for managing undernutrition

Previous sections of this literature review indicated that to manage childhood undernutrition there are multiple points and different levels at which it is possible to intervene. The majority of interventions with data available about the effects on child nutritional status have targeted the immediate and underlying determinants of growth. These have most often focused on the child's dietary intake (the *what* of child feeding), while a few have targeted the behavioral aspects of feeding. Efforts to prevent illness (the other immediate determinant of child nutritional status) have frequently been aimed at the underlying causes, such as clean water supply or improved sanitation, and caregiver behaviors, such as hand washing.

2.6.1 Interventions to improve the child's health

Because diarrhea is thought to have the largest effect on nutritional status, we focus here on interventions aimed at preventing diarrhea. Three reviews of water, sanitation, and hygiene interventions indicate that the risk of diarrhea is reduced by at least 25% through education or through provision of latrines or clean water supply (Curtis and Cairncross 2003, Fewtrell et al. 2005, Ejemot et al. 2008). However, evidence for the effects of reductions in the incidence of diarrhea on child nutritional status is mixed. One study showed that hygiene education improved child growth in intervention versus control communities (Ahmed et al. 1993), while two others found that hygiene education and a combined intervention of clean water supply, provision of latrines, and hygiene education decreased diarrhea in children but had no effect on nutritional status (Stanton et al. 1988, Hasan et al. 1989). The estimated effect of 99% coverage of the population with hygiene interventions in countries with the majority of stunted children is quite small (approximately a 2% relative reduction in the risk of stunting at 12, 24, and 36 months of age) (Bhutta et al. 2008).

2.6.2 Interventions to improve the child's dietary intake

Research and programs have tested numerous interventions to improve children's dietary intake. The main types of dietary interventions include: provision of improved complementary or supplementary foods; nutrition education; or a combination of food and education. Interventions that provide only food target the biological aspects of child feeding, while those that use only education focus on the behavioral aspects, and the combined interventions work on biology and behavior simultaneously.

Interventions to improve complementary food or to supply supplementary food have had the same main aim: to fill the gap in the child's energy and/or nutrient intake. Complementary foods are foods that are given to infants and young children during the period when they are still being breastfed. Supplementary foods are complementary foods that are intended to be given in addition to the food the child usually receives, and they are often targeted at children who are already undernourished. The distinction between complementary and supplementary foods is somewhat artificial. In a recent review of feeding interventions, any type of additional food given to breastfed children was considered to be complementary (Dewey and Adu-Afarwuah 2008).

The type of food given to children during interventions has varied considerably. Studies and programs have used: (1) local ingredients to create recipes for improved complementary food (Bentley et al. 1991a, Creed Kanashiro et al. 1991, Dickin et al.,1997, Schroeder et al. 2002); (2) cereal/legume blends with or without milk powder (Lartey et al. 1999, López de Romaña 2000, Roy et al. 2005, Gartner et al. 2007, Owino et al. 2007, Paul et al. 2008);

or (3) micronutrient-fortified cereals or milk powder (Bhandari et al. 2001, Oelofse et al. 2003, Rivera et al. 2004, Santos et al. 2005). All of these types of food either require cooking or have to be mixed with water before they can be served to the child.

Among the different types of complementary foods that have been studied, cereal/legume blends, such as corn-soy blend (CSB), are worth mentioning in more detail because they have been widely used for many years in food aid and distribution programs (Hoppe et al. 2008). In the first decades of food aid, blended cereals contained milk powder as the main protein source. As the availability of milk powder decreased in the 1980s, milk was no longer included and proteins were derived entirely from plant sources. Although soy is one of the best sources of plant-based protein, it is difficult for young children to digest and is a poorer source of amino acids than milk (Hoppe et al. 2008). In addition, both corn and soy contain anti-nutrients which affect absorption of some minerals. Reviews of food distribution programs and complementary feeding interventions have found that the effect of blended flours (such as CSB) on child nutritional status was small (Beaton and Ghassemi 1982, Dewey and Adu-Afarwuah 2008). A recent study in Malawi, which was the first randomized-controlled trial to include CSB and a control that received no food, found no significant difference in the weight or length gain of children in these two groups (Thakwalakwa, personal communication).

Lipid-based nutrient supplements (LNS) are another category of complementary or supplementary food. They are somewhat different than many other types of foods that have been tested because they require no preparation. LNS can be fed to children directly or mixed with other complementary foods, such as porridge. They often contain peanut butter, milk powder or soy, sugar, oil, and a mix of micronutrients. LNS do not support bacterial growth, can be stored for long periods in warm conditions, and can mask the taste of the micronutrients that are included (Briend 2001). The acceptability of LNS has been demonstrated in children with different levels of nutritional status (Briend et al. 1999, Adu-Afarwuah et al. 2008). LNS have proven to be quite effective for treating children with severe and moderate acute wasting (Diop et al. 2003, Manary et al. 2004, Ciliberto et al. 2005, Patel et al. 2005, Defourny et al. 2007, Matilsky et al. 2009) and are now widely used for community-based management of uncomplicated cases (World Health Organization/World Food Program/United Nations Standing Committee on Nutrition/United Nations Children's Fund 2007). Several studies of LNS have been conducted in adequately nourished to moderately undernourished children. Four of these have shown improvements in child weight or length gain among those given LNS as compared to other interventions or to a control (Kuusipalo et al. 2006, Adu-Afarwuah et al. 2007, Lin et al. 2008, Phuka et al. 2008), while one found no difference in the growth of children who received LNS and CSB (Phuka et al. 2009).

To have an effect on growth, it is necessary for complementary or supplementary feeding interventions to consider not only what type of food is provided but also how the food affects the child's daily energy intake and how much of the supplementary food is actually given to the intended child. If the aim of the intervention is to increase the total amount of food and breastmilk the child consumes, it is important to show that this actually occurred and that the extra food provided by the study or program did not simply replace part of the food or breastmilk the child would have eaten. Energy intake from complementary foods is commonly measured by collecting quantitative dietary intake data, using either a weighed food record or 24-

hour recall (Ferguson 1989). Most feeding interventions have reported increased energy intakes (for example, Krahenbuhl et al. 1998, Durnin et al. 2000, Maleta et al. 2004, Adu-Afarwuah et al. 2007), while a few have reported no change (Owino et al. 2007) or even decreased energy consumption (Santos et al. 2005).

Because complementary foods are usually less nutrient dense than breastmilk and they displace breastmilk (Caulfield et al. 1999), some complementary and supplementary feeding studies have tried to detect whether the food affects breastfeeding frequency or breastmilk intake. The results are mixed, with some studies showing no change in breastmilk intake (Moursi et al. 2003, Owino et al. 2007) or breastfeeding frequency (Mora et al., 1981) and others indicating reductions in breastmilk intake (Bajaj et al. 2005, Islam et al. 2006, Galpin et al. 2007) or breastfeeding frequency (Bhandari et al. 2001) during supplementation.

Compliance with the intervention (i.e., feeding the food to the intended person) has been controlled in studies and programs where participants were required to eat the food at the distribution site or under the supervision of a research assistant (for example, Durnin et al. 2000, Rivera and Habicht 2002). Recent studies where the food was given for home use have rarely measured compliance adequately. This is an important issue because it is estimated that sharing accounts for 30-60% of the food given in take-home programs (Beaton and Ghassemi 1982, Rondó Schilling 1990). Sharing is more common when the food given is acceptable to other family members and similar to the foods they usually eat (Beaton and Ghassemi 1982). Sharing of supplementary foods designated for children is not necessarily related to availability of food in households (Beaton and Ghassemi 1982), but may be linked to social and cultural factors that guide intrahousehold food distribution practices (Gittlesohn 1991).

In their review, which included all types of complementary food interventions (such as cereals, cereal/legume blends, milk, and LNS), Dewey and Adu-Afarwuah (2008) calculated effect sizes to show the strength of the relationship between the nutritional status of children who received a complementary feeding intervention and those who did not. They found that the mean effect size of the interventions on child nutritional status was small (0.26 for weight and 0.28 for length), which agreed with the findings of a review that covered an earlier period (Caulfield et al. 1999). However, the results of individual studies varied, with some showing no response to the intervention (Dewey and Adu-Afarwuah 2008).

Nutrition education interventions have used a variety of channels to provide messages about positive feeding behaviors. Messages have focused on issues such as continued breastfeeding, use of thicker foods, use of a variety of foods, use of animal source foods, use of responsive feeding techniques, and good hygiene practices (Dewey and Adu-Afarwuah 2008). A review of education-only interventions to improve complementary feeding found that the results of individual studies were variable, with many studies having little impact on growth or finding an effect on one of the anthropometric indices. The mean effect sizes were modest (weight 0.28 and length 0.20) (Dewey and Adu-Afarwuah 2008), and comparable to results from a review by Bhutta et al. (2008). Studies where use of animal source foods was promoted had a greater effect on growth than other types of nutrition education interventions (Guldan et al. 2000, Penny et al. 2005, Roy et al. 2005).

Interventions that combined provision of food and nutrition education had a positive impact on growth, with the effect sizes for efficacy trials and program evaluations combined in the same range (weight 0.35, length 0.17) as for food or education alone (Dewey and Adu-Afarwuah 2008). Two studies conducted in Asia were designed specifically to look at differences in growth when education was provided alone or with food, and found that education was more effective together with food in these settings (Bhandari et al. 2001, Roy et al. 2005).

Although the results from complementary feeding trials and programs are mixed, overall they improved growth rates by about 0.10 to 0.50 SD, which would reduce the prevalence of undernutrition by 1-19% (Caulfield et al. 1999, Dewey and Adu-Afarwuah et al. 2008). Interventions that provided complementary food (with or without education) were more effective in younger children and in Africa and South Asia, probably due to higher levels of food insecurity than in other regions (Dewey and Adu-Afarwuah 2008). This finding points to the importance of designing complementary feeding interventions that take the epidemiology of undernutrition and the context into consideration.

2.7 Research on behavioral aspects of supplementary feeding

A number of studies have used observations, in-depth interviews, and rapid ethnographic data collection techniques to describe attitudes, behaviors, and other contextual factors related to child feeding (Dettwyler 1986, Bentley et al. 1991b, Cosminsky et al. 1993, Guldan et al. 1993a, Mabilia 1996, Gittlesohn et al. 1998, Pelto et al. 2003). In some cases, this type of information has been collected specifically to assist in designing research and programs aimed at improving child nutritional status by modifying complementary feeding practices (Bentley et al. 1991a, Creed Kanashiro et al. 1991, Paul et al. 2008). A review of these ethnographic studies noted that nutrition-related behaviors are part of a larger set of care-giving behaviors and are situated within a wider sociocultural context, so that interventions targeting behavior change must incorporate local determinants into the design (Pelto et al. 2003). There is evidence that child feeding practices or behaviors can be changed or improved (Dickin et al. 1997, Guldan et al. 2000, Bhandari et al. 2004, Hotz and Gibson 2005, Penny et al. 2005, Roy et al. 2005, Aboud et al. 2009) and that they have an effect on growth (Ruel et al. 1999, Griffiths 2000, Arimond and Ruel 2002, Ruel and Menon 2002).

Although feeding behaviors and beliefs about feeding could have an impact on the benefits to child growth achieved by supplementary feeding interventions, to date, the only available information on such issues comes from a trial in Ghana, where maternal attitudes towards different supplements were compared (Adu-Afarwuah et al. 2008). Studies of the behavioral aspects of feeding have not yet been carried out during supplementary feeding trials. There is no published information on *when*, *who*, *how*, and *where* supplements are fed to children or how maternal knowledge and beliefs (*why*) might influence supplement use. This type of information is context-specific, but is needed from different locations to plan research and design programs that supply or promote the use of supplements.

2.8 Justification for the present study

Childhood undernutrition is a major public health problem with serious short- and long-term consequences. Complementary and supplementary feeding interventions have had a larger effect on children's nutritional status than efforts to reduce or control illness. LNS are a relatively new type of supplementary food with attractive properties and potential for managing and preventing undernutrition. Several studies have been conducted to measure the effect of LNS on child nutritional status. Many of these have been carried out in Malawi, a country with seasonal food insecurity and a high level of child undernutrition, especially stunting. LNS are typically given for home use, but adequate information about the behavioral aspects (*how*, *when*, *where*, *who*, and *why)* of their use is lacking. The present study was designed to fill this gap by providing contextual information about LNS use that could assist in planning future programs and studies in Malawi.

3. AIMS

The main aim of this study is to identify attitudes, practices, and behaviors related to the home use of a new type of supplementary food, lipid-based nutrient supplements (LNS), that may be relevant for the design of future interventions targeting underweight children. To achieve this aim, attitudes and behaviors are examined during LNS use and compared to those during the use of a common supplement, corn-soy blend (CSB). The specific objectives are:

1. To compare feeding patterns among moderately underweight children before and during LNS supplementation, to document how patterns of LNS use change throughout 12 weeks of supplementation, and to describe selected child feeding behaviors during LNS use (I)

2. To compare LNS intake on days when moderately underweight children were healthy, ill, and convalescing from illness (II)

3. To compare maternal attitudes towards the use of LNS or CSB for treating underweight children and to identify predictors of selected attitudes (III)

4. To compare feeding patterns and behaviors during supplementation of underweight children receiving either LNS or CSB, to compare child feeding behaviors by the mode of serving LNS (plain or mixed with porridge), and to identify feeding behaviors associated with child growth (IV).

4. METHODS

4.1 Approach to the study

The aims of this research were largely met by using data from two studies (Figure 2). Study A investigated patterns of LNS use and caregiver feeding behaviors before and throughout 12 weeks of supplementation in a small sample of children. This study, including sub-studies 1 and 2, was conducted by the author. Study B and the additional trials were clinical trials assessing the effects of LNS and CSB on child growth and development. The clinical trials were carried out by other members of the research team (principally John Phuka and Chrissie Thakwalakwa) whereas sub-studies 3 and 4 were the responsibility of the author. Sub-study 3 collected data on maternal attitudes towards LNS and CSB at the end of Study B and pooled them with results on attitudes from two other trials with similar research designs conducted in the same geographical area. Sub-study 4 obtained information on patterns of supplement use and caregiver feeding behaviors in the two supplement groups at a single point of time. The attitudes and behaviors assessed in sub-studies 3 and 4 were distinct from the outcomes of the clinical trials.

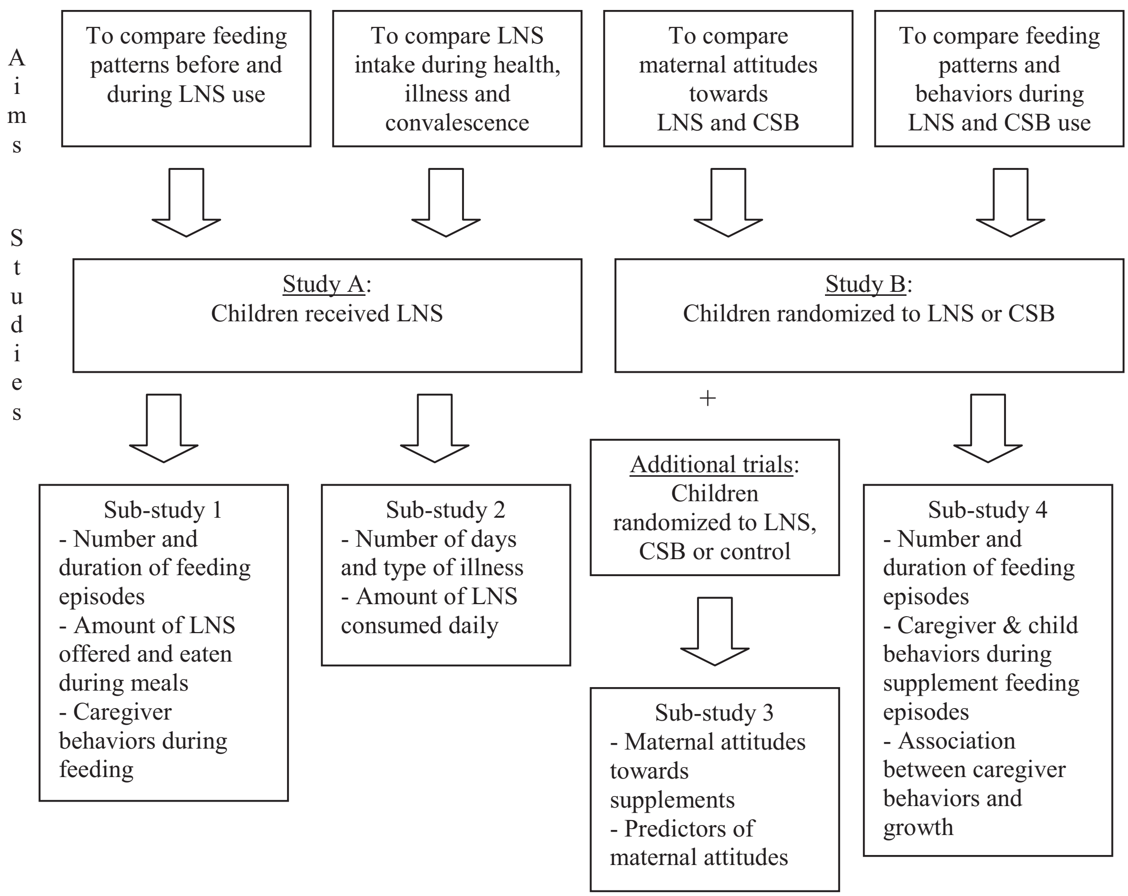

Figure 2: Overall study design for the thesis

4.2 Study setting and subjects

4.2.1 Study area

This research took place in Mangochi District, southern Malawi. Malawi is a long, narrow landlocked country in southeast Africa covering a land area of approximately 94,000 km^2 (Figure 3). The main geographical feature of the country is Lake Malawi, which forms much of the eastern border. The country has a tropical, continental climate marked by three seasons: cool (May – August), hot (September – November), and rainy (December – April).

Malawi has a population of approximately 13 million inhabitants and an annual growth rate of 2.1%. The per capita gross national income is 160 U.S. dollars and 74% of the population lives below the international poverty line (UNICEF 2006b, UNICEF 2008). About 83% of the population live in rural areas and the average annual growth rate of the urban population is 4.6% (National Statistical Office [Malawi] and ORC Macro 2005). Much of the adult population (70% of women, 57% of men) is employed in the agricultural sector, usually as subsistence farmers producing food for their own families (National Statistical Office [Malawi] and ORC Macro 2005). Food security has major seasonal fluctuations, with the lowest levels of household food supplies in the early part of the rainy season. Key health, socioeconomic, and demographic indicators for Malawi are presented in Table 2.

Most of the research for this study was carried out within the catchment areas of health facilities located in Malindi, Lungwena, and Namalaka on the eastern side of Lake Malawi in Mangochi District (see Figure 3). The area is approximately 40 km long and 5 km wide, bounded by mountains to the east and the lake to the west. It is a rural area with 68 villages and a population of 69,000 people. For substudy 3, four additional rural health center catchment areas (Katema, Koche, Kuka-

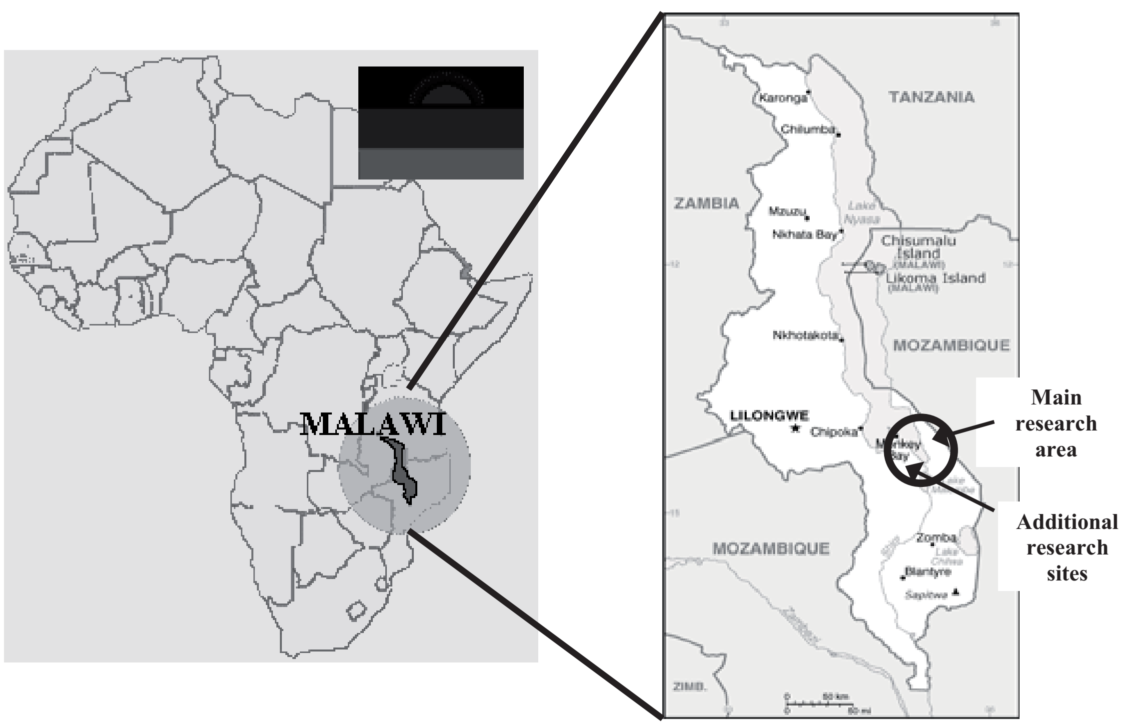

Figure 3: Map of research area

Table 2: Selected health and demographic indicators for Malawi

Indicator	Measure
Total fertility rate	5.9
Maternal mortality ratio	984 / 100,000
Female literacy rate	54%
Male literacy rate	75%
Life expectancy at birth	40 years
HIV+ adults (> 15 years of age)	14%
Infant mortality rate	125 / 1,000
Under-five mortality rate	221 / 1,000
Child nutritional status	
Moderate and severe underweight	22%
Moderate and severe wasting	5%
Moderate and severe stunting	48%
Exclusively breastfed (< 6 months of age)	28%
Immunization coverage (by 12 months of age)	
DPT	93%
Polio	94%
Measles	82%
Hepatitis B	93%
Hib	93%

Sources: National Statistical Office [Malawi] and ORC Macro 2005, UNICEF 2006b.

langa, and Jalasi) in Mangochi District with 171 villages and a population of 148,000 people were included.

Lungwena was selected as one of the sites for the present study, in part, because of on-going research and program activities in the area that began in the early 1990s. Initially, the University of Malawi's College of Medicine, the Malawi Ministry of Health, and the Mannerheim League for Child Welfare collaborated to develop Lungwena into a model health center that could be used for professional training and related activities. Other activities were built upon this basic plan. The University of Tampere and the University of Malawi have carried out several maternal and child health research projects in the Lungwena area since 1995. Two Finnish non-governmental organizations, the Mannerheim League for Child Welfare (*Mannerheimin Lastensuojeluliitto*) and the Finnish Family Federation (*Väestöliitto*), have had projects in the area. The Mannerheim League supported a child health project in Lungwena from 1993 to 2002, and the Finnish Family Federation has had a project to improve existing sexual and reproductive health services in Lungwena and Namalaka since 1998. The Norwegian Programme for Development, Research and Education began its Lungwena health, nutrition and agriculture research project in the area in 2004. The strong focus of research, training, and intervention activities in the villages served by Lungwena health center has meant that nearly all families in the area have either participated in or been touched by the research process in some way. An overall evaluation of the effects of research and other projects on the health of Lungwena's population has not been conducted, so it is not possible to determine whether or in what ways health status or health-seeking behavior has changed.

Prior to the present study, research activities similar to those in Lungwena had not taken place in the Namalaka and Malindi catchment areas nor in the other four catchment areas included in sub-study 3. The Namalaka and Malindi catchment areas were added to Lungwena to allow for the selection of an adequately large sample for Study B. The additional areas used in sub-study 3 were selected because they were accessible, had large enough catchment populations, and similar demographics and levels of child undernutrition as Lungwena.

The population in the study area is mainly from the Yao ethnic group and speaks the Chiyao language. Chichewa, the national language, is also widely understood and spoken, but not all women in the area are comfortable using it. Economic activities are focused on subsistence farming and fishing. Maize (corn) is the main crop, which is grown during the annual rainy season. Sweet potatoes, cassava, pumpkin, beans, green leafy vegetables, and various fruits (bananas, mangoes, and papayas) are also common; many of these are available only seasonally. Most people in the study area are Muslims, but there are some pockets of Christians, particularly around Malindi, where there is an Anglican mission. Religion is important in the area for its historical influence on participation in formal education (Bone 1986). Mangochi District has the highest proportion in the country of both men (36%) and women (50%) with no education (National Statistical Office [Malawi] and ORC Macro 2005).

A variety of types of health care and health-related services are available in the research area. Traditional healers, including diviners and herbalists, are found in most villages. Diviners are consulted to find out the cause of a health problem, especially if it has persisted. Herbalists are healers who use local plants to treat their clients' illnesses. People in the area frequently explain that they may choose herbalists over the public health system because herbalists take payment in-kind, they are believed to be better at curing certain ailments, and they are located closer than health centers. Drugs or pills (e.g., antibiotics) are sold in small groceries throughout the research area, and can be purchased one or two at a time, without a prescription. The people selling drugs in groceries usually have no medical training.

Within the main study area, preventive and curative health services are provided by public health centers in Lungwena and Namalaka, and by a mission-run hospital in Malindi. In the additional study area included in sub-study 3, Kukalanga and Jalasi health centers are public, while Katema and Koche are run by the Christian Health Association of Malawi. All of these facilities provide maternal and child health services (antenatal and delivery care, growth monitoring, vaccinations, family planning, insecticide-treated bednets) and treat illnesses. Patients from Lungwena and Namalaka can be referred to the hospital in Malindi for secondary level care and all of these facilities (including Lungwena and Namalaka) can refer more complicated cases directly to Mangochi District Hospital. Health surveillance assistants and trained traditional birth attendants, covering several villages each, provide services (including growth monitoring, vaccination campaigns, home deliveries, and referrals) at the community level.

4.2.2 Study subjects

Individuals participating in this research were moderately to severely underweight young children living in the selected communities or health center catchment areas. Three sets of study subjects were used to complete this thesis (Table 3). As described above, the children included in sub-study 4 also formed part of the pool of participants for sub-study 3, together with children from two other trials. The two trials that took place in Katema, Koche, Kukalanga, and Jalasi had a no supplement control group, which was excluded from the analysis as the purpose of the sub-

Table 3: Comparison of the three groups of subjects used for the thesis

Criteria	Sub-studies 1 & 2	Sub-study 3		Sub-study 4
Location	6 villages in Lungwena and Malindi	Lungwena, Namalaka, Malindi, Katema, Koche, Kukalanga, and Jalasi catchment areas		Lungwena, Namalaka, and Malindi catchment areas
Number of subjects	16	504		170
Enrollment age	6.0-17.9 months	6.0-14.9 months		6.0-14.9 months
Key enrollment criteria	-3.0 < WAZ < -2.0	WAZ < -2.0		WAZ < -2.0
Number of study groups	1	2 or 3		2
Types of study groups	LNS (*FS) 50 g/d	LNS 50 g/d	LNS 43 g/d	LNS 50 g/d
	-	CSB 71 g/d	CSB 71 g/d	CSB 71 g/d
	-	-	control	-
Type of LNS packaging	jars	foil packets	jars	foil packets
Period of intervention	12 weeks	12 weeks		12 weeks
Timing of study	Jan – Apr 2005	Mar – Jul 2005 Jan – May 2007 Nov 2007 – Apr 2008		Mar – Jul 2005

*FS (fortified spread) was an earlier name for LNS. The ingredients in the FS and LNS used in this research were the same.

study was to investigate maternal attitudes towards supplement use.

Children were initially screened in communities for age (all sub-studies) plus weight-for-age *z*-score (sub-studies 3 and 4). All children within the appropriate age and/or weight-for-age range were then invited to an enrollment visit (in the community for sub-studies 1 and 2, in the health facility for sub-studies 3 and 4). In sub-studies 1 and 2, specific villages were selected and a target number of participants was pre-set. The target was met in some villages by enrolling all eligible children and in others (where there were more than enough eligible individuals) by randomly selecting from among the eligible population. In sub-studies 3 and 4, all children who attended the enrollment visit and who fulfilled the inclusion criteria were invited to participate. As shown in Table 3, age and WAZ were key inclusion criteria. Additional details of the inclusion and exclusion criteria are described in the articles (I, II, III, and IV).

4.3 Supplementary feeding interventions

Participants were supplied with supplementary food (either LNS or CSB) for a 12-week period. The LNS used in this research was made of peanut butter, sugar, milk powder, cooking oil, vitamins and minerals. CSB was a mixture of corn and soy flours, vitamins, and minerals. The LNS could be eaten plain or mixed with other food, while the CSB had to be prepared as porridge before serving. In sub-studies 1 and 2, children received 50 g/day of LNS, which was delivered to their homes by research assistants every two weeks. Children in sub-study 4 received either 50 g/day of LNS or 71 g/day of CSB. Participants in the additional trials included in sub-study 3 were assigned to 42 g/day of LNS or 71 g/day of CSB. The main difference between the two additional trials was the amount of follow-up. In one of these, research assistants visited participants' homes weekly to collect information about supplement compliance and morbidity and to deliver supplements, whereas, in the other, caregivers went to the health center once per month to get the child's supplement and there were no home visits.

The LNS used in sub-studies 1 and 2 and in the additional trials in sub-study 3 were produced by Project Peanut Butter (Blantyre, Malawi) and supplied in plastic jars, containing enough for five (sub-studies 1 and 2) or seven (additional trials) days. In sub-study 4, the LNS were produced by Nutriset (Malaunay, France) and packed in foil sachets for daily use. The CSB used in sub-studies 3 and 4 was produced by Rab Processors (Blantyre, Malawi) and supplied in 500 g bags. Information about the nutrient composition of LNS and CSB is found elsewhere (Phuka et al. 2009). The daily quantity of LNS was selected so as to achieve a biological effect on growth, based on an earlier dose-finding trial (Kuusipalo et al. 2006). A comparable amount of CSB (in terms of calories) was offered to the other study group. The exact daily quantities were chosen for the practicality of delivering the supplements to participants (e.g., 1 bag or jar per week).

At enrollment, caregivers were told that their child was underweight and would be receiving supplementary food for 12 weeks, but it was not known if LNS (or CSB, in sub-studies 3 and 4) would improve the child's growth. They were also informed about the frequency of home visits by research assistants. Caregivers were not educated by research staff about other health-related issues, such as hand washing during meals or child feeding practices, either before or during the study. In sub-studies 1, 2, and 4, caregivers were told how much of the supplement to feed the child per day, but were not advised on how many times per day to feed it or, for LNS, in what manner it should be served. Caregivers were not given health education about supplement feeding because the aim of these sub-studies was to see how families used the supplements in practice. In sub-study 3, the advice to caregivers varied by the trial. Caregivers from sub-study 4 were advised as described above, while those in the other two trials were told to feed the child the supplement 2-3 times per day.

4.4 Researcher and research assistants

4.4.1 Author's role in the research

The author planned the research and drafted data collection tools before going to Malawi. She was based in Malindi, Mangochi District, Malawi from October 2004 to August 2005, and travelled daily to field sites or to meet research assistants at the project office in Lungwena. During the period of fieldwork, the author hired and trained the research assistants, guided the pre-testing of data collection forms, and participated in and supervised data collection. Data entry and analysis were carried out by the author after the period of fieldwork ended.

4.4.2 Research assistants' background

Four female research assistants were hired to collect data for sub-studies 1 and 2. Their ages ranged from 20-45 years. Three of the research assistants had their own children. Two were Yaos and the other two were Chewas, but all of them spoke Chiyao. All of the assistants had completed high school. None of them had previous experience doing research. The research assistants were selected from the villages where the research was conducted or from neighboring villages so as to minimize the amount of travel required for data collection.

Three of the same research assistants from sub-studies 1 and 2 also collected data during sub-study 4. In addition, three new female assistants were hired. The new assistants were 20-26 years of age, and none of them had any children. Two were Yaos and one was Chewa, but she spoke Chiyao. They had all finished high school, and they lived in the research area.

A different group of research assistants conducted the exit interviews for sub-study 3. These assistants were employed to collect data and distribute supplements during the clinical trials.

4.5 Follow-up and data collection procedures

4.5.1 Overview of follow-up

Although the length of the supplementary feeding interventions was 12 weeks in all the sub-studies, the type and timing of data collection differed. Figures 4 and 5 illustrate the follow-up process for sub-studies 1 and 2 and for sub-study 4. Follow-up for the other two trials included in sub-study 3 was the same as in Figure 4, but background data were collected at enrollment, there was no observation visit, and exit interviews were conducted during the final visit to the health center.

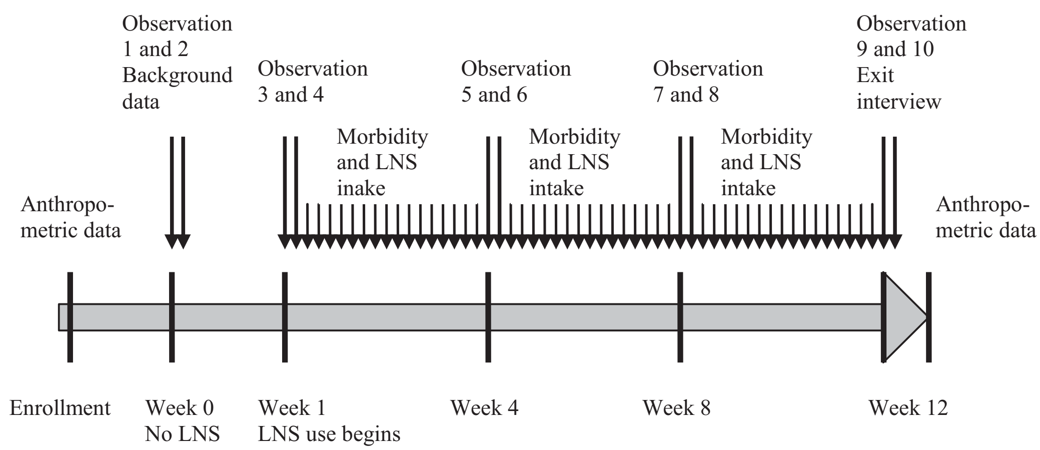

Figure 4: Follow-up of participants in sub-studies 1 and 2

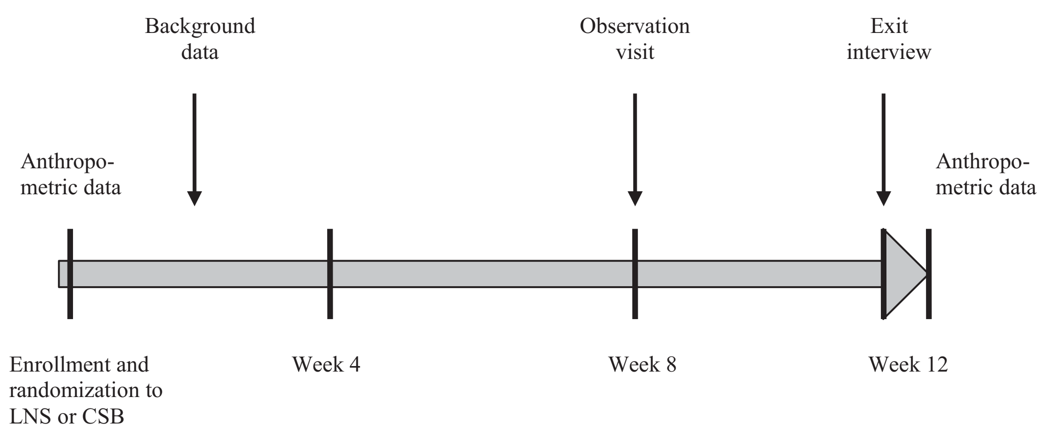

Figure 5: Follow-up of participants in sub-study 4

4.5.2 Training and quality control

Research assistants doing observations were trained and their data collection standardized to at least 80% agreement between assistants and the author before observations began. Assistants were also taught interviewing techniques and how to use the background and morbidity questionnaires. The training and pre-testing for sub-studies 1 and 2 lasted approximately six weeks. The new research assistants for sub-study 4 were trained and did field practice with the old assistants during the last month of sub-study 1. Research assistants who conducted observations were instructed to keep their interactions with the participants to a minimum so as to interfere with participants' regular behaviors as little as possible. They were told that the purpose of the study was to learn more about how caregivers use supplements at home and about caregiving practices.

The research assistants who carried out the exit interviews had previous experience doing research. They participated in one day of training on how to conduct the exit interviews.

All questionnaires (background, morbidity, and exit interviews) were translated into Chiyao and Chichewa and back-translated to check for accuracy. Questionnaires and observation forms were pre-tested during field practice sessions and modified before starting data collection. Completed data collection forms were checked by the author daily whenever possible or latest during weekly research meetings.

During sub-study 1, the author participated in approximately 25% of the observation visits and independently recorded her observations. This procedure allowed the estimation of inter-observer reliability for individual variables and served as an ongoing training and quality control mechanism. The author independently observed about 5% of the observation visits in sub-study 4.

4.5.3 Socioeconomic background of participants

Social and economic information about each participant's family was collected through an interview with one of the child's parents during the enrollment visit to the health center or a home visit within the first weeks of the study. The types of data obtained included: characteristics of the parents, household size and characteristics, socioeconomic characteristics, food availability, feeding practices, preventive health care, maternal health, and maternal control of resources.

4.5.4 Observation visits

Research assistants made one-day visits to participants' homes (ten visits per child in sub-study 1, one visit per child in sub-study 4). They informed the caregiver that they were there to observe the child and that the family should go about their daily activities as usual. Research assistants used semi-structured forms to log the food and drinks the child ate throughout the day, to record caregiver and child behaviors during meals, and to summarize the events they observed. Feeding episodes were counted as separate if there were at least 15 minutes between the end of one episode and the beginning of another. Food recorded on logs was divided into five main categories: plain porridge, nsima (stiff corn porridge) and relish, supplement, other meals, and snacks. Supplement was recorded as either LNS or CSB. Research assistants noted the mode of serving LNS, either plain or mixed with porridge. Other meals were counted in both sub-studies 1 and 4, but were omitted from the analysis in sub-study 4 because there were very few of them. Detailed descriptions of the definitions for the different types of food are found in articles I and IV.

Several types of child and caregiver behaviors were observed during feeding episodes. Child behaviors included the child's position and appetite (number of bites accepted and rejected). Caregiver behaviors that were recorded during all feeding episodes included: the location of the feeding episode, hand washing before feeding, who fed the child, and the utensil used for feeding. During supplement feeding episodes, research assistants also marked whether and how much was shared and leftover. Specific definitions for each type of behavior are found in articles I and IV.

In sub-study 1, the schedule for observations was determined before the study began, so the number of days after supplement delivery when the participants were observed was approximately the same for all participants for each pair of visits. During sub-study 4, the timing of the visits in relation to supplement delivery was not pre-determined. However, none of the visits took place during the first four weeks of the study to allow participants time to adapt to eating the supplement.

4.5.5 Morbidity

During sub-study 2, a semi-structured form was used by research assistants to collect information about morbidity, health-seeking, and LNS consumption at participants' homes five days per week. Research assistants also weighed the jar of LNS currently in use with a kitchen scale to determine how much had been consumed in the last 24 hours. On each day when data were collected, children were counted as 'ill' or 'not ill'. Days when children were 'ill' were divided into four categories: fever, diarrhea, cough, and other illnesses. The definitions for coding specific illnesses are provided in article II. Days when children were 'not ill' were coded into three groups: early convalescence (1-7 days following illness), late convalescence (8-14 days following illness), and healthy (> 14 days following illness).

4.5.6 Exit interviews

At the end of sub-study 1, tape-recorded open-ended interviews were conducted with caregivers of participants to obtain information about their attitudes and perceptions regarding the use of LNS. A semi-structured questionnaire was then developed and used during exit interviews in the three supplementary feeding trials (sub-study 3). Mothers were asked questions about the following topics: what they liked and disliked about the supplement; their child's adaptation to eating the supplement; changes they noticed in the child during supplementation; whether they thought the supplement was food or medicine and why; whether the supplement should be used during illness and why; whether they would be willing to use the supplement again or buy it; how much they would pay for the supplement; and what would be the most convenient place to obtain it.

4.5.7 Anthropometric measurements

Two researchers (John Phuka and Chrissie Thakwalakwa) were responsible for making anthropometric measurements (weight and length) at the beginning and end of sub-studies 1 and 4. For sub-study 1, weight was measured using a UNICEF Salter scale and length was measured using a recumbent length board (Shorr Productions, Olney, MD, USA). For sub-study 4, weight was obtained with an electronic child scale (SECA 834, Chasmors Ltd., London, UK) and length was obtained using a length board (Kiddimetre, Raven Equipment Ltd., Essex, UK). Weight and length were measured three times during each visit and the average of the scores was used in the analysis. A more detailed description of the methods used for anthropometric measurements is available in Phuka et al. (2009). Anthropometric indices (WAZ, HAZ, and WHZ) were calculated using the CDC 2000 growth reference, which was the latest reference available at the time of enrollment.

4.6 Statistical approach

4.6.1 Sample size

The sample size for sub-studies 1 and 2 (n=16) was purposely quite small to allow for multiple full-day observations of participants and frequent collection of data on morbidity. This sample was selected mainly for descriptive purposes.

The samples for the supplementary feeding trials in sub-studies 3 and 4 were selected based on expected values for the main outcome measure (weight gain). The pooled sample in sub-study 3 was n=249 in the LNS group and n=255 in the CSB group, which allowed for reasonably precise (±6%) estimates of the variables of interest. The sample in sub-study 4 (LNS n=85, CSB n=85) had adequate power for detecting small to moderate differences between the study groups. Additional details about the sample sizes are available in the original papers (III, IV).

4.6.2 Data management and analysis

Data were collected on paper forms and entered to specially-designed Microsoft Access databases. Missing and extreme values in Microsoft Excel tables exported from databases were checked against the paper files. Statistical analyses were carried out using Stata (9.2). For continuous and categorical outcomes, the hypothesis that there was no difference between the study groups was tested using *t*-test and Fisher's exact test, respectively (III, IV). The age of the child at observation and whether the supplement was given as a meal or snack could have influenced behaviors in sub-study 4, so logistic regression was used to determine if controlling for these variables had an effect on the comparisons. Logistic and linear regression were used to study predictors associated with specific maternal attitudes (III) and behaviors associated with child growth (IV). To adjust for within-subject correlation, linear regression analysis with the Huber-White robust standard error was used to calculate means and binomial regression was used to calculate proportions for comparisons (I, II).

Qualitative data from open-ended questions in the exit interviews were coded using content analysis to identify themes. The coder was blinded to participants' study group assignment.

4.7 Ethical approval

Ethical approval for all of the sub-studies was obtained from the Pirkanmaa Hospital District in Finland and from the College of Medicine Research and Ethics Committee at the University of Malawi. For the clinical trials from which the samples for sub-studies 3 and 4 were drawn, details of the trial protocols were registered on the U.S. National Library of Medicine website, Bethesda, MD (http://www.clinicaltrials.gov, trial ID NCT00131222, NCT00420368, NCT00420758).

5. RESULTS

The same sample of children was used to obtain information about patterns of LNS use throughout the course of a 12-week intervention (I) as well as during illness, convalescence, and health (II). These results are explained first and results comparing mothers' attitudes (III) and use of LNS with CSB (IV) are described thereafter.

5.1 Patterns of LNS use over time and during illness

5.1.1 Enrollment and background characteristics

The target enrollment of 16 participants for sub-studies 1 and 2 was obtained by following the process outlined in Figure 6. Two consecutive days of observation at five time points were planned for each participant. Out of 160 possible 12-hour observation days, 155 (97%) were completed. Eleven (7%) of these were partial days, which included < 8 hours of observation. One child moved away from the study area at the end of Week 8. His caregiver completed the exit interview and his final measurements were taken at that time. Data on LNS intake and illness status were collected on a total of 845 days, of which 13 were excluded due to large measurements (>150 g/day) that suggested sharing.

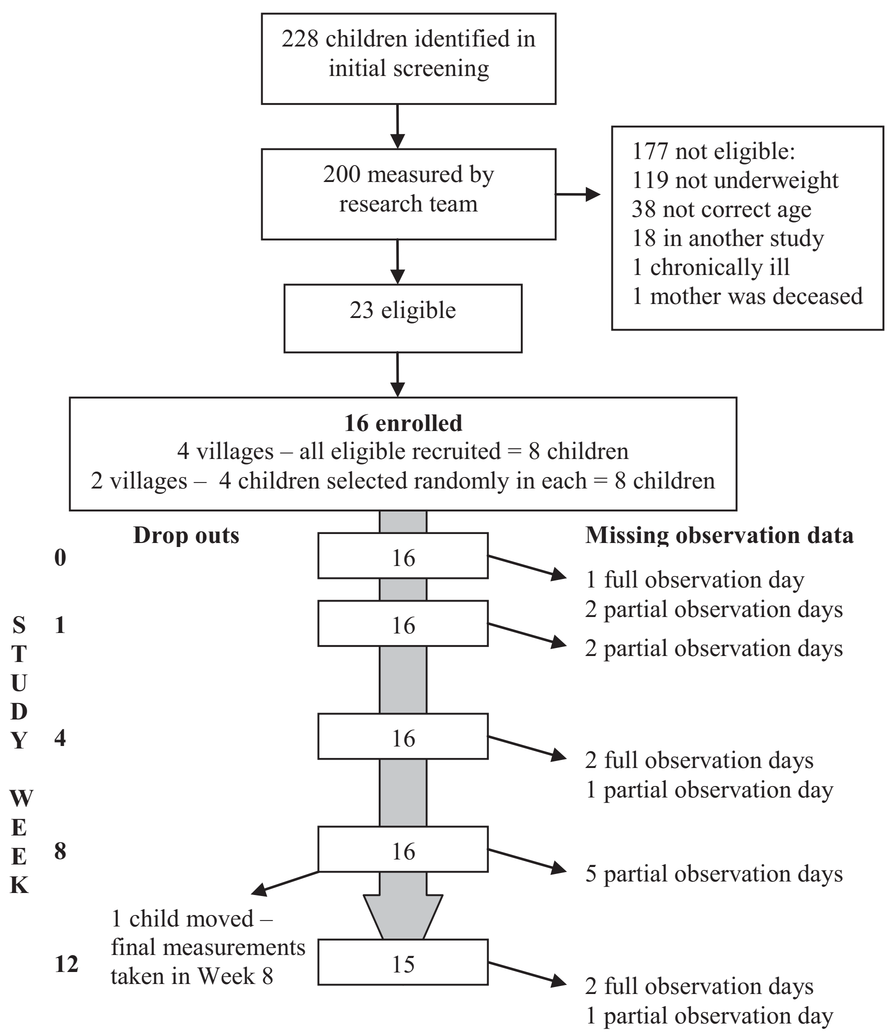

Figure 6: Enrollment and follow-up for sub-studies 1 and 2

At enrollment, the mean age of participants was 13 ± 3 months and their mean WAZ was -2.6 ± 0.3. Half of their mothers had < 4 years of education and half of their fathers did not live in the same household. The mean number of household members was 5 ± 2 and the mean number of children < 5 years of age per household was 2 ± 1. Fifteen of the 16 participants were breastfed at enrollment. By Week 4, fourteen children were breastfed, and by Week 12, thirteen of them were breastfed.

5.1.2 Patterns of LNS use throughout supplementation (I)

LNS were generally acceptable to the participating children. Participants ate at least some LNS on 85% of the observation days. Among those who did not eat LNS during observation, the main reason was that there was no LNS left (9/19). Most of the days when there was no LNS left (7/9) occurred during Week 12 visits, which were timed during the last days of the intervention. Other reasons for not offering LNS included: the child was ill, the parents left the home to seek health care for themselves or the child, and the caregiver was shy to feed LNS in front of the observer during the first days of LNS use. On average, participants were offered 58% of the recommended dose of 7 teaspoons of LNS per day.

There were no significant differences in the total mean number of feeding episodes (16.7 vs. 15.5, difference (95% CI) -1.1 (-4.5, 2.2), p=0.467) or the total mean daily feeding time (130.2 vs. 116.3 min, difference (95% CI) -13.9 min, p= 0.398) before and during LNS supplementation. When specific types of food were compared before and during LNS use, significant decreases were detected in the mean number of episodes of plain porridge (1.5 vs. 0.3, difference (95% CI) -1.2 (-1.6, -0.8), p<0.001) and the mean daily feeding time for plain porridge (21.5 vs. 3.2 min, difference (95% CI) -18.3 min (-25.3, -11.3), p<0.001) and for snacks (17.7 vs. 10.0 min, difference (95% CI) -7.7 min (-14.8, -0.6), p=0.035).

There were some changes in the feeding pattern as well as in the use of LNS during the course of the study (see Figure 1a, article I). Initially, the mean number of LNS feeding episodes per day was fairly high (about 2 per day), and this contributed to an increase in the total number of feeding episodes between Weeks 0 and 1. By Week 4, the total mean number of episodes was the same as before the study, but there was a decrease during Weeks 8 and 12. The mean number of LNS feeding episodes declined during the study, probably due to the large drop in the mean number of plain LNS episodes. The mean number of LNS mixed with porridge feeding episodes remained fairly stable throughout the study. The mean daily feeding time followed a similar pattern as that for the feeding episodes (see Figure 1b, article I).

To better understand differences in LNS use by mode of serving (plain vs. mixed with porridge), we compared mean teaspoons offered and eaten and the proportion "lost" or leftover during feeding, both overall and by study week (see Table 3, article I). Similar amounts of LNS were offered whether the supplement was given plain or mixed with porridge. However, significantly more of the LNS were leftover when they were mixed with porridge than when offered plain (46% vs. 3%, difference (95% CI) 43% (27%, 58%), p<0.001).

Caregivers were the primary feeders and a spoon was used to feed the child during most of plain LNS and LNS mixed with porridge episodes. Caregivers washed their own hands and those of the child significantly more often before LNS mixed with porridge than plain LNS feeding episodes (Caregiver's hands 71% vs. 30%, difference (95% CI) 41% (22%, 59%),

$p<0.001$; Child's hands 38% vs. 8%, difference (95% CI) 30% (8%, 52%), $p=0.011$).

5.1.3 LNS consumption during health, illness, and convalescence (II)

Of the 16 participants, 15 were reported to be ill during the intervention, with a mean of 10 ± 5 days of illness. Caregivers reported that children were ill on 142 (17%) days. Days when children were ill were classified as follows: 40% fever; 31% cough; 21% diarrhea; and 8% other illnesses. Children were reported 'not ill' on 690 days, divided into 32% early convalescence, 19% late convalescence, 44% healthy, and 5% days when the child was not reported ill but the state of convalescence or health could not be determined.

The mean LNS intake was significantly higher by about 7 g (14%) during not ill than ill days. When LNS intake was examined on an individual level, the majority of children had a higher intake when they were not ill than when ill (Figure 7). Mean LNS intake varied by type of illness, with the lowest intake during fever, followed by diarrhea and cough (see Table, article II). There was no difference in intake during convalescence and health.

5.2 Maternal attitudes towards LNS and CSB use (III)

Children were initially screened in communities and then invited to the health center for an enrollment visit. Of those who met the enrollment criteria for the clinical trials, 522 were randomized to the LNS and CSB groups. Follow-up was completed by 506 participants, and exit interviews were obtained from 504 of these (LNS 249, CSB 255). There were no differences in the background characteristics of the two study groups at enrollment (see Table 1, article III). On average, children were 11 months old and were moderately underweight at the start of the study. They had families with 4-5 members, lived in homes of unburned mud bricks, and few of their mothers were literate.

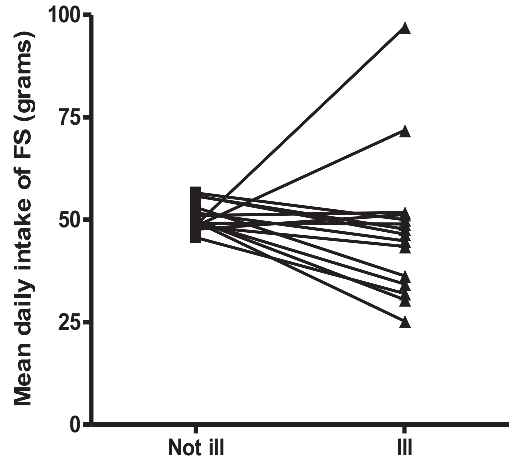

Figure 7: Mean quantity of LNS consumed by individual children on days when they were not ill and ill

This figure is based on interviews during which LNS jars were weighed. Each line represents one individual and shows the mean intake when that individual was not ill and ill.

Mothers' attitudes towards the two supplements were generally quite similar (see Table 2, article III). Large proportions of mothers in both groups described positive aspects of the supplement, did not name any negative aspects of the supplement, said they noticed positive changes in the child, stated that it was easy for the child to eat the supplement as compared to regular food, and reported that the child learned to eat the supplement within the first two weeks of the study. Nearly all mothers in both groups said that they were willing to: use the supplement again if it is provided for free, travel to the health center for free supplements, and buy the supplement if it is for sale.

On a few questions, the variability in the responses was greater and there were some differences between the study groups. About 70% of mothers in both groups said that the supplement was food rather than medicine. Similar proportions of mothers in both groups stated that the supplement should not be given during fever. Mothers in the LNS group were significantly more likely than those in the CSB group to say that they would not give their child the supplement during cough. There was a similar pattern with regard to feeding the supplement during diarrhea, although the difference between the groups did not achieve statistical significance. Some explanations for these differences could be found in the open-ended responses. Mothers said that LNS were so sweet that they would make the child's cough worse, and some mothers thought that giving LNS during diarrhea could lead to more severe symptoms. The mean price mothers would be willing to pay for a one-week supply of supplement was also significantly higher in the LNS than the CSB group.

We conducted exploratory analyses to detect factors associated with some attitudes by doing separate logistic regression analyses with mothers' belief that the supplement was food and mothers' reports that the supplement should not be given during fever, diarrhea, and cough as the outcomes (see Table 3, article III). None of the predictor variables were associated with mothers' belief that the supplement was food not medicine. However, child's WHZ at the start of the study was positively associated and maternal literacy was negatively associated with withholding of supplements during fever, cough, and diarrhea. Mothers whose child was in the LNS group were 1.5 and 2 times more likely than those in the CSB group to say they would withhold the supplement during diarrhea and cough.

5.3 Feeding patterns and caregiver behaviors during LNS and CSB supplementation (IV)

Of the 280 children invited to the enrollment visit after initial screening in villages, 176 were randomized to the LNS and CSB groups. Observation visits were made to 86 children in the LNS group and 85 children in the CSB group. Data from the observation of one child in the LNS group were excluded because the type of supplement consumed could not be determined from data collection forms, giving a final sample of 85 children in each study group.

During observations, three children ate only the supplement that was not assigned. Two children in the CSB group ate LNS and one child in the LNS group ate CSB.

The socioeconomic and demographic characteristics of the two groups were similar at enrollment (see Table 1, article IV). On average, participants were moderately to severely underweight. They were usually the third or fourth child born in the family. Their mothers were in their late 20s and about half of them reportedly had no formal education. The majority lived in houses made of bricks (burned or unburned). The mean age at observation of participating children was 13 months.

There were no differences between the study groups in terms of the timing of the observations (see Table 2, article IV). Children in the CSB group were less likely to eat the supplement during observation and more likely to have no supplement left than those in the LNS group, but these differences were not statistically significant.

The overall feeding pattern was similar in the two groups (see Table 3, article IV). Most children had one supplement meal in the morning, nsima and relish in the afternoon, and 1-3 snacks. There were no differences between the groups in total mean number of feeding episodes or total mean daily feeding time. When specific types of food were examined, the mean number of supplement meals was significantly higher in the LNS group, while the mean daily feeding time for nsima and relish was significantly higher in the CSB group.

There were some similarities and several differences in caregiver and child behavior during LNS and CSB feeding episodes (see Table 4, article IV). There were no differences between the groups in the location of feeding or the child's position during the feeding episode. Feeding episodes took place on the veranda approximately as often as in the yard. More than half of the episodes occurred directly on an earth surface. Children nearly always sat on the caregiver's lap or on the floor while eating the supplement. Mothers were the main feeders of supplements in both groups, and children self fed infrequently. However, children in the LNS group were more likely to be fed by another caregiver than those in the CSB group. Children who received LNS were also slightly more likely to accept the supplement than those in the CSB group. Sharing was more common in the CSB than LNS group, but this difference was not statistically significant. Caregivers in the CSB group were significantly more likely than those in the LNS group to offer the supplement as a meal rather than a snack, feed the child with a spoon, and wash their hands before feeding. There were leftovers at the end of the feeding episode significantly more frequently and the proportion leftover was larger for CSB than LNS.

Behaviors during LNS mixed with porridge and plain LNS feeding episodes generally followed a similar pattern as for CSB compared to LNS (see Table 5, article IV). There were no differences between LNS mixed with porridge and plain LNS in terms of location, child's appetite, child's position, person feeding, or sharing. Caregivers were significantly more likely to feed LNS mixed with porridge than plain LNS as a meal, wash their hands before feeding, and use a spoon. There were also leftovers more frequently and the proportion leftover was larger during LNS mixed with porridge than plain LNS feeding episodes. Approximately 63% of the daily dose of LNS was offered to the participants.

Statistical adjustment for age and use of the supplement as a meal or snack did not make a difference in the comparison of behaviors between CSB and LNS or between LNS mixed with porridge and plain LNS.

Presence of leftovers after supplement feeding episodes was negatively associated with change in child's WAZ, when age at observation and the child's initial WAZ were controlled. Number of feedings per day, caregiver hand washing before supplement feeding episodes, and supplement sharing did not predict change in child's WAZ.

6. DISCUSSION

The present research was guided by the positivist scientific tradition. It was planned to describe and compare selected caregiver behaviors and attitudes related to the home use of LNS for treating underweight children. The main aim was to identify issues related to LNS use that might be important in planning future interventions in this setting.

In this chapter, the strengths and weaknesses of the study are outlined. The findings with regard to feeding patterns and caregiver behaviors during LNS use are discussed together in one section followed by a discussion of maternal attitudes towards LNS and CSB.

6.1 Strengths and weaknesses of the study

The two main strengths of the study were longitudinal data collection (I, II) and the use of study populations drawn from randomized clinical trials with few drop-outs (III, IV). Multiple observations of the same participants (I) made it possible to study patterns of supplement use over time and let participating families become accustomed to the observers, presumably reducing reactivity (Bentley et al. 1994, Cousens et al. 1996, Gorter et al. 1998). Frequent measurement of child health status (II) minimized recall bias. Mothers were asked to report on their child's health status only during the last 24 hours, although maternal reports of child illness in developing countries have been validated for a two-week recall period (Rousham et al. 1998). Drawing study populations from randomized clinical trials (III, IV) afforded us fairly large sample sizes, which improved the generalizability of the results.

The study benefited from combined quantitative and qualitative data collection (III), and insight gained from many hours in the field (I). Integrating qualitative and quantitative methods, as was done in article III, has been shown to result in a more accurate picture of feeding behaviors and the decisions that lead to them (Bauer and Wright 1996). Training, testing, and supervision of observers through hundreds of independent observations of the same children by the researcher and research assistants ensured the quality of observation data (I, IV) and gave the researcher a realistic picture of family habits and child feeding practices in this area of Malawi. In addition, the researcher used ethnographic methods to collect another data set (not included in this study) on local concepts of child growth and undernutrition, which afforded her a broader understanding of the setting.

This study used structured observations to obtain information on feeding patterns and caregiver behaviors (I, IV). Observational methods have both positive and negative qualities. On the positive side, observations allow for the direct measurement of behavior and they have proven to be more accurate than recall or survey methods for collecting data about food consumption patterns and other household behaviors (Stanton et al. 1987, Basch et al. 1990, Curtis et al.1993). In the present study, observations made it possible for us to report on several issues related to the use of supplementary foods, such as hygiene before supplement meals and various types of supplement sharing, which had not previously been described in the literature.

On the negative side, observational methods tend to be subjective and participants may react to the presence of observers. The present study attempted to overcome these issues by using careful definitions of the observed behaviors, by standardizing the observations of several observers, and by using multiple observations to minimize reactivity. Reactivity to observers is usually decreased with 2 or more observations (Bentley et al. 1994, Cousens et al. 1996, Gittelsohn et al. 1997, Gorter et al. 1998). It is possible that there was more reactivity in sub-study 4, where there was only one day of observation per child. To check this, we compared the feeding patterns in sub-study 4 with those of sub-study 1, where there were 10 days of observation per child and reactivity was expected to be low. We found that many of the results were similar, which suggests that reactivity was low for most of the variables included in sub-study 4.

This study had several weaknesses, which differed between the sub-studies and which should be considered when interpreting the results. The sample size used to study LNS feeding patterns over time (I) and during illness (II) was small. A small sample was selected to allow for multiple full-day observations and other data collection points, and these data were intended mainly for description.

To study LNS use during illness (II), we measured LNS consumption by weighing LNS jars five days per week and asking mothers who else ate the supplement and how much they consumed. Although reports of other individuals eating the supplement were infrequent, other types of behavioral studies have found that negative behaviors are frequently underreported (Curtis et al. 1993, Manun'Ebo et al. 1997), so we cannot be sure how much LNS was eaten by other family members or whether the amount they ate varied by the participating child's health status. However, the pattern of LNS consumption during illness detected in this study, with the lowest mean level of consumption during fever, followed by diarrhea, then cough, is consistent with other studies (Mata et al. 1977, Brown et al. 1990) and suggests that family members did not systematically eat more LNS when the child was ill.

There were two main limitations in our research on maternal attitudes towards supplement use (III). The study was designed to allow mothers to try only one of the supplements before giving their opinions about it. While this allowed us to make comparisons between the two groups, we cannot be certain that mothers' opinions would be the same if they had tried both of the supplements before the interviews, as has been often been done in acceptability trials (Paul et al. 2008). We also lacked complete information on some socio-economic variables, such as maternal age and household food security, which could have been included in the regression analyses as predictor variables of maternal attitudes. Information on maternal age was available for a sub-sample of our data set, but was not significantly associated with any of the outcomes and was excluded in the final models. Data on food security were not collected. Given these limitations and the exploratory nature of the regression analyses, the models should be interpreted cautiously, but could point to new avenues for future research.

The main limitation in our work comparing patterns of LNS and CSB use (IV) was the lack of a control group. At the time this study was designed, it was considered unethical not to provide treatment to children who were known to be moderately undernourished, so no control group was included (Phuka 2009). As such, we were able to make comparisons between feeding patterns in the LNS and CSB groups, but lacked information about the patterns in children who did not receive any supplement. One other possible limitation was the use by three participants of the other supplement on the day of observation. Although swapping supplements is a serious issue that should be considered in future trials, the effect on the results of the present study was minimal as the number of individuals involved was very small.

Our research on LNS feeding patterns over time (I) and as compared to CSB (IV) might have benefited from concurrent collection of quantitative information on dietary intakes, which would have allowed us to report both patterns and quantities of food consumed. We decided not to obtain quantitative intake data during observations as these procedures often interfere with normal feeding routines (Ferguson et al. 1989) and our main aim was to observe usual feeding patterns and behaviors.

The use of a study population living in an area where many previous research projects had been conducted could have influenced participating caregivers' attitudes and behaviors. However, less than half of the villages were located in the Lungwena catchment area, where families had experience with other research projects, and we did not find major differences in feeding patterns or caregiver behavior between the Lungwena villages and those with no prior contact with research staff.

6.2 Feeding patterns and caregiver behaviors during supplementary food use (I, II, IV)

There is very little other research on feeding patterns, and particularly on caregiver behavior, during supplementary feeding. Consequently, our results are compared to those of complementary feeding studies, when available, and similarities and differences in behaviors in the results of articles I and IV are discussed.

***6.2.1 LNS feeding patterns as compared to baseline and to CSB* (I, IV)**

Despite the differences in study design and sample size, there were many similarities in feeding patterns when we studied LNS use over time (I) and as compared to CSB (IV). The lack of change in breastfeeding frequency detected before and during LNS supplementation (I) is consistent with results from Colombia, where there was no difference in the breastfeeding frequency of supplemented and control groups (Mora et al. 1981), but contrasts with data from India, where breastfeeding frequency was significantly lower in supplemented than control children (Bhandari et al. 2001). The similar frequency of breastfeeding detected in the LNS and CSB groups here (IV) is in line with results from Ghana, where four intervention groups had similar breastfeeding frequency (Lartey et al. 1999). Our breastfeeding frequency results (IV) also concur with a study in Malawi that found no difference in the breastmilk intake of children receiving either LNS or CSB (Galpin et al. 2007). Maintenance of energy intake from breastmilk is important for optimal complementary feeding, especially during the second half of infancy (Brown et al. 1998). This is particularly an issue within the context of complementary and supplementary feeding programs as some studies have found that the additional food replaced part of the energy provided by breastmilk (Caulfield et al. 1999, Bajaj et al. 2005, Islam et al. 2006).

The mean complementary feeding frequencies detected in this study are similar to those of other studies of children in this age group in southern Malawi (Ferguson et al. 1989, Hotz and Gibson 2001), which suggests that the introduction of either LNS or CSB has little effect on feeding frequency. The lack of influence on feeding frequency when a supplement with high energy density (such as LNS) was introduced is somewhat surprising as other studies have shown that as energy density increases feeding frequency decreases (Brown et al. 1995, Brown et al. 1998, Islam et al. 2008). However, it may be that because the energy intakes of children in this part of Malawi are lower than international recommendations (Hotz and Gibson 2001), increasing energy density allows them to achieve recommended intakes but has little impact on feeding frequency. In addition, because the children in these substudies were undernourished, their energy requirements may be higher than for healthy children of the same age (FAO 2001).

Although quantitative dietary data would be needed as confirmation, our results point to increased intakes with LNS as compared to both the baseline and to CSB because LNS was frequently added to porridge or offered as a snack, whereas CSB was usually given instead of a meal. This fits with the pattern in another study of LNS and CSB in Malawi, which found that the energy intake from staple foods decreased in the CSB group whereas mean energy and nutrient intakes increased in the LNS group as compared to the baseline (Maleta et al. 2004). It is also consistent with results from the Gambia, where a high carbohydrate supplement acted as a significant replacement of regular food while a high fat supplement did not (Krahenbuhl et al. 1998).

Our results showing a lack of change in the amount of time spent feeding a highly energy dense food as compared to the baseline or to a low energy density food (CSB) are supported by data from Peru, which showed that the daily amount of time spent feeding children was related to the number of feedings rather than the energy density of the food (Brown et al. 1995). Although the total time spent feeding did not differ before and during LNS use, the mean minutes per episode decreased slightly for most types of food and breastmilk (I). There are several possible explanations for this. The decreases in the length of breastfeeding episodes towards the latter part of the study are likely due to the drop in the number of children breastfed. The small decreases in time spent feeding complementary foods could be related to the increasing age and abilities of the children (Brown et al. 1998; Engle et al. 2000) or possibly because there was less reactivity to observers after the first pair of visits (Bentley et al. 1994).

One important difference between the feeding patterns in the sub-studies is the way LNS itself was used. During comparable periods (e.g., weeks 5-11 of supplementation), most children in sub-study 1 received their LNS mixed in porridge while those in the LNS group in sub-study 4 more often had plain LNS. Because caregivers were given no instructions about how to serve LNS to the child, the different packaging of the LNS is the most likely explanation for the variation in use in the sub-studies. In sub-study 1, LNS was packed in plastic jars containing 5 days worth of LNS, whereas, in sub-study 4, LNS was provided in foil packets containing a daily dose. The ease of feeding plain LNS directly from the packets may have promoted greater use of the plain supplement than when it was provided in jars, where the LNS usually had to be mixed before serving.

6.2.2 Caregiver behaviors during LNS use and for LNS compared to CSB (I, IV)

The present study identified differences in certain caregiver behaviors during CSB and LNS use and during LNS mixed with porridge as compared to plain LNS feeding episodes. It is possible that the differences found in this study are linked to the more frequent use of LNS than CSB and plain LNS than LNS mixed with porridge as a snack than a meal. Research in another setting found that some caregiver behaviors differ during meals and snacks (Engle and Zeitlin 1996). However, controlling for the use of the supplement as a meal or snack did not change our comparisons between LNS and CSB or between LNS plain and mixed with porridge. This suggests that certain caregiver behaviors are related to the mode of serving LNS.

For those behaviors that appear to be most strongly linked to the use of plain LNS, failure of caregivers to wash their hands before feeding and less frequent and smaller proportions of leftovers, we had similar results in our comparisons of LNS plain and mixed in both sub-studies. Hand washing before eating is one way to prevent diarrhea transmission (Ejemot et al. 2008), and differences in hand washing by type of supplement or mode of serving could have an impact on the benefits achieved by the intervention. The proportions of caregivers washing their hands before CSB and LNS mixed with porridge feeding episodes are similar to those reported in other developing countries, while those for plain LNS are somewhat lower (Manun'Ebo et al. 1997, Sakisaka et al. 2002).

Frequency of leftovers and the proportion of the food that was leftover were among several aspects of compliance with the intervention that were studied. How much of the supplement is consumed by participating children is important because feeding interventions cannot improve nutritional status without increasing intake of nutrients and energy (Beaton and Ghassemi 1982, Caulfield et al. 1999, Dewey and Adu-Afarwuah 2008). Other studies in Malawi have used maternal reports or focus group discussions to monitor compliance during CSB and LNS supplementation and have found very low levels of sharing (Phuka et al. 2008; Matilsky et al. 2009; Phuka et al. 2009). In the same study population used in article IV, mothers reported during weekly interviews that supplements were used by other family members < 1% of the time (Phuka et al. 2009). These data differ markedly from our in-home observations, where we recorded sharing, leftovers, and supplies of supplements that were finished early. The differences in reported and observed behaviors noted here are similar to those found in research on household hygiene (Manun'Ebo et al. 1997), indicating that caregivers tend to under-report undesirable behaviors (Curtis et al. 1993).

The greater proportion of CSB than LNS leftover is probably due to the fact that children were typically fed CSB only once per day and the usual preparation of the daily dose of CSB flour makes about 0.7 liters of porridge, which most children of this age cannot consume at one sitting (Sanchez-Griñan et al. 1992; Brown et al. 1998). The greater frequency and larger proportion of leftovers with LNS mixed with porridge than plain LNS was similar in the sub-studies. It is possible that CSB and LNS mixed with porridge are more frequently leftover than plain LNS because caregivers purposely make more porridge than the child can eat so that there is some available for the child's siblings or other family members. This idea fits with research on intrahousehold food allocation, which has shown that caregivers may channel at least a portion of special or high status foods to specific family members (Gittlesohn 1991).

It is important to consider the amount of observed sharing and leftovers within the context of how much of the daily dose of the supplement was offered to children because giving only part of the dose is another possible avenue by which the supplement can be diverted away from the participating child and towards other household members. The proportion of the daily dose of LNS offered to children here was consistent with findings from supplementary feeding programs (Beaton and Ghassemi 1982, Rondó Schilling 1990), but was somewhat higher than reported in a study of CSB and LNS in Malawi (Maleta et al. 2004), most likely because data on intakes in Maleta et al. were collected just before a new supply of supplement was delivered.

Although there were several similarities in the caregiver behaviors measured in the sub-studies, there were also some differences, particularly in the type of utensil used for feeding. Differences in the utensil used for CSB and LNS and between the sub-studies for plain LNS are related to the LNS packaging. The type of utensil used to feed certain types of food depends on what is practical and culturally appropriate (Pelto et al. 2003). In this part of Malawi, spoons are commonly used to eat porridge, which explains why CSB and LNS mixed with porridge are usually fed to children with a spoon. Since plain LNS is a new food, there is no set cultural pattern for its use, and it appears that when it is supplied in jars plain LNS is often fed with a spoon while LNS in packets is frequency fed directly from them. The differences in patterns of plain LNS use and the type of utensil used to feed LNS in the two substudies indicate that Malawian caregivers are able to adapt their child feeding strategies to a new situation. Similar types of adaptation to new complementary foods have been found in feeding interventions and trials of improved practices in other locations (Bentley et al. 1991a, Creed Kanashiro et al. 1991, Paul et al. 2008).

While identifying behaviors related to supplementary food use may help in planning future interventions, it is also useful to know whether these behaviors have an influence on child growth. Of several behaviors entered into a regression model, we found that only the presence of leftovers was associated with growth (IV). There is evidence from several studies that consumption of supplements was inadequate to increase energy intake due to sharing or replacement (Beaton and Ghassemi et al. 1982, Santos 2005, Owino et al. 2007). This is consistent with our finding that leftovers are negatively associated with change in the child's WAZ, but contrasts with our result showing no association between sharing of supplements and child growth. Although leftovers and sharing both reduce consumption by the target child, our lack of detection of an association between sharing and growth is likely due to the infrequent occurrence of sharing. Our finding that feeding frequency did not predict growth could be explained by low variability in the number of daily feeding episodes in our sample. Research on hygiene practices has shown that they tend to cluster (Arimond and Ruel 2002), so it is likely that we were not able to detect an association between hand washing before supplementary feed episodes and child growth because this single indicator does not adequately represent household hygiene practices.

6.2.3 LNS feeding patterns during illness, convalescence, and health (II)

Our findings in terms of LNS use during illness are consistent with the results of several other studies that have shown lower levels of appetite and energy intake in children during illness, especially during fever (Mata et al. 1977, Martorell et al. 1980, Brown et al. 1990, Brown et al. 1995). Although our scheme for coding illnesses did not affect the main comparisons (ill vs. not ill, convalescing vs. healthy), it could have influenced our estimates of mean LNS consumption by type of illness. Because fever together with any other symptom was counted as fever, these were probably the days when the children were most ill, so it is no surprise that mean consumption was lowest on these days.

The fact that the drop in LNS consumption was small on ill versus not ill days and the mean intake was equally good on convalescent and healthy days suggests that LNS could be used to help parents follow complementary feeding recommendations during and following illness (PAHO/WHO 2003), which might promote catch-up growth or prevent deterioration of nutritional status. However, based on current scientific evidence, it is not possible to say whether use of a special feeding regimen, such as LNS supplementation, during and following illness would have a long-term impact on child growth.

6.3 Maternal attitudes towards LNS and CSB use (III)

This research found that mothers' attitudes towards LNS and CSB were positive and quite similar. There is very little information in the literature about maternal attitudes towards supplementary foods for their children. One study, conducted in Ghana, reported on maternal attitudes towards LNS and two non-food micronutrient supplements, and also found that mothers had positive and similar attitudes towards them (Adu-Afarwuah et al. 2008). Although many of the specific attitudes examined in the present and the Ghanaian studies were different, where the types of questions overlapped, the results of the two studies converged. In both our study and the one in Ghana, most mothers reported that supplements were highly acceptable, they would be willing to buy supplements if available for sale, and they would be willing to pay more for LNS than for other supplements.

Despite the overall similarity in Malawian mothers' attitudes towards LNS and CSB, there were a few important differences between the study groups, and we uncovered some issues that may be of programmatic importance. We found that the majority of mothers believed that LNS and CSB were food, not medicine. Whether supplements are considered to be food or medicine has potential implications for how much they are shared, particularly in a culture where sharing food is the norm. One approach to prevent sharing of supplements has been tried in a trial of LNS and CSB supplementation in Malawi, where mothers were told that the supplements were medical treatments for their undernourished children (Matilsky et al. 2009). Whether this type of advice to mothers was effective at preventing supplement sharing was not adequately measured, but use of such an approach is worrying because our study indicates that mothers tend to think of these supplements as food and promoting their medicinal qualities, in the absence of further research on the issue, might have unintended consequences. It is known that mothers in developing countries tend to discontinue medical treatments, such as oral rehydration solution and antibiotics, when their child's symptoms subside or the child begins to look healthy (Bentley 1988, Dy 1997). Early discontinuation of supplementary food use could limit its potentially beneficial effect.

Mothers whose children received LNS were more likely than those who were assigned CSB to state that they would withhold the supplement during diarrhea and cough. Frequent illnesses during childhood have a negative impact on growth (Mata et al. 1977, Scrimshaw and SanGiovanni 1997, Checkley et al. 2003, Checkley et al. 2008), but continuing to consume food or supplements during illness could assist in maintaining children's nutrient intake and minimize the effect of illness on nutritional status (PAHO/WHO 2003, Dewey and Adu-Afarwuah 2008). Reasons for possible withholding of supplements during diarrhea and cough were similar in the sense that, in both cases, mothers were more likely to think that LNS would increase the severity of the symptoms than CSB. In the case of cough, this was clearly due to the sweetness of LNS, indicating that this version might be too sweet for this cultural context. On the other hand, the most frequently cited positive aspect of both supplements was the sweetness. The sweetness of a processed complementary food developed for children was praised by mothers in another study (Paul et al. 2008), and it is known that it is easier to feed children sweet food because they learn this taste very early in life (Kare and Beauchamp 1985). Our results indicate the importance of taking a balanced view of mothers' opinions in developing acceptable and culturally appropriate supplementary foods for their children (Bentley et al. 1991a, Creed Kanashiro et al. 1991).

We found that maternal literacy and child's WHZ at the start of the study were associated with maternal attitudes about withholding of supplements during fever, diarrhea, and cough. Higher levels of maternal education are associated with better child feeding and caring practices (Guldan et al. 1993a, Engle et al. 1997), which is consistent with our finding that literate mothers are less likely to withhold supplements during illness. Preferential feeding practices (i.e., offering more or better quality food) for thin or poorly growing children have been reported in other developing countries (Piwoz et al. 1994, Simondon and Simondon 1995) and fit with the association between child's nutritional status and maternal feeding behaviors identified in this study. Several ethnic groups in Malawi have beliefs that child undernutrition and health are linked to the actions of their parents. For example, if parents do not follow rules about abstinence, they believe that their young children may fall ill, become thin, or have other signs of undernutrition, such as edema (Zulu 1996, Van Breugel 2001, Munthali 2002). As having a poorly growing child is an indication of parental misbehavior in this context, one would expect that Malawian mothers would tend to make a special effort to feed their children if they appear thin or wasted.

Other issues that could be important for planning future interventions involving supplements, particularly LNS, emerged from the data. Our results showing that most mothers controlled the use of supplements within their families and that they discussed the use of supplements with their husbands and their own mothers are supported by the findings of a study on health-seeking behavior in the same area of Malawi (Ashorn 2003). Because mothers are clearly the main controllers of LNS, they could be the focus for health education about supplements, but, as important sources of advice and social support, husbands and grandmothers could also receive such information. Research from another part of Malawi points to the necessity of targeting information and education to grandmothers because they play an important role in decision-making about child feeding (Bezner Kerr et al. 2008).

7. SCIENTIFIC CONCLUSIONS

The purpose of the present study was to identify issues related to the home use of LNS that might be useful in planning future programs and research. The main focus was on feeding patterns and caregiver and child behaviors during LNS use. We investigated how patterns of LNS use changed over time and how the supplement was used during illness, convalescence, and health. Patterns of LNS use and mothers' attitudes towards the supplement were also compared with those of a common supplementary food, CSB. Because the sample size in sub-studies 1 and 2 was small, conclusions from these studies may not be widely generalizable. However, several of the results in sub-study 4 are similar and support the findings from sub-study 1. Sub-studies 3 and 4 used large, randomized samples that should allow conclusions to be made within the appropriate cultural context.

LNS do not affect the frequency of breastfeeding and complementary feeding or the amount of time spent feeding children, as compared to the baseline or to CSB. There is no difference in LNS intake on healthy and convalescent days, but there is a small decrease in LNS consumption on days when children are ill versus when they are not ill. The way LNS is used changes over time, with a period of acclimation and testing different modes of serving (plain or mixed with porridge) during the first weeks of use. The preferred mode of serving LNS is not clear and may depend on the type of packaging used. Differences in specific behaviors, such as use of the supplement as a meal or snack, hand washing before feeding, use of a spoon to feed the supplement, and presence and quantity of leftovers, are linked to the mode of serving LNS. The issue of leftovers may be important to future supplementary feeding interventions as the presence of leftovers is negatively associated with child growth. On average, children are not offered the full daily dose of LNS, suggesting that other aspects of supplement sharing may also be relevant.

Mothers' attitudes towards LNS and CSB are positive and quite similar. Attitudes related to whether the supplement is food or medicine and use of supplements during illness are more variable than other maternal attitudes towards supplements. Withholding LNS during cough and diarrhea is related to the perceived effect of the LNS on symptom severity. For cough, this is due to the sweetness of the LNS. Maternal literacy and child's initial WHZ are predictors of maternal attitudes about withholding of supplements during illness.

8. PUBLIC HEALTH IMPLICATIONS AND FUTURE RESEARCH NEEDS

While more data on the effectiveness of supplements are needed, there has been much international interest in using LNS to improve the nutritional status of undernourished children and to prevent growth failure (The PLoS Medicine Editors 2008). This level of interest has necessitated research on the behavioral aspects of supplement use that can be employed in designing programs and future research. The present study was a first attempt to fill part of the gap in the behavioral research by examining caregivers' attitudes and behaviors during the home use of supplementary foods for young, undernourished Malawian children.

As the issues studied are context-dependent, the implications for public health programs cannot be generalized beyond Malawi and are likely to be most appropriate for the southern part of the country. Similar attitudes towards LNS and CSB suggest that caregivers would have no trouble adapting to using LNS, if it were to replace CSB, in supplementary feeding programs. It may be worthwhile trying a less sweet version of LNS to ensure that it is used during cough. As use of LNS during illness and convalescence is good, programs could promote its use during these periods to help children maintain their nutritional status and/or prevent growth faltering. Strategies for minimizing leftovers and preventing other forms of sharing are needed. One way programs might be able to influence the way supplements are used is by providing clear messages that promote specific behaviors. The present study indicates that mothers control supplement use but discuss its use with their husbands and their own mothers, suggesting that these three groups could be targeted with health education. Based on this research, some possible key messages are as follows:

- If LNS is mixed with porridge, the quantity of porridge should be small enough for the child to finish.
- Continue offering the child LNS during illness and when the child is recovering from illness. Using LNS during cough or diarrhea will not make the child more ill.
- Wash your own and your child's hands (with soap) before feeding LNS.
- For your child to grow better, it is important to offer the full daily dose of LNS, but do not force the child to eat more than he or she wants.

The results of this study also point to several areas where further research on LNS and child feeding is needed. These are as follows:

- The effects on child nutritional status of using LNS during illness could be tested in a randomized trial where young children are allocated to receive either no auxiliary treatment or to receive LNS as an auxiliary treatment during and after acute illnesses.
- Research on strategies for dealing with sharing and leftovers is needed to ensure that target children eat an adequate quantity of LNS to make a difference in their growth. At least two types of strategies could be tested. One might be a trial aimed at measuring the effect of advice on minimizing leftovers, where caregivers are randomized either to receive advice about feeding supplements (e.g., to feed LNS mixed in a small quantity of porridge) or to a control group that receives supplements without advice about feeding. A second strategy could focus on the issue of whether LNS should be called food or medicine and whether calling it medicine reduces sharing. Qualitative data on local concepts of food and medicine should be collected to learn how these terms are understood by caregivers. A trial where caregivers

are randomized to groups that are advised that LNS is either food or medicine could be conducted to determine the effects of this type of labeling on sharing and early discontinuation of use.

- A trial where LNS is supplied to each study group in different types of packaging could be conducted to measure how the packaging affects hygiene and other feeding practices. It would be important to determine what type of packaging promotes appropriate feeding behaviors and is also most cost-effective and environmentally-friendly.
- This study provided information on the mean price mothers would be willing to pay for LNS, but this needs to be tested in practice.
- Although the majority of children learned to eat the supplements within a short period of time, we found that 7-10% of them never adapted to eating the supplement. In-depth interviews or focus group discussions with their caregivers should be carried out to identify what types of problems these children and/or their mothers had that made it difficult for the children to eat the supplement and what actions would be needed to help overcome such issues. This type of information would be important for programs using LNS, as a small, vocal minority that has had negative experiences with a product could derail widespread uptake.
- Ethnographic data on local beliefs about child health and undernutrition and how these may affect the identification of undernourished children who need supplements should be carried out to inform program planning.
- Finally, more work is needed to identify feeding and other caring practices that are associated with growth. Such data would be useful both for planning interventions using supplements, like LNS, and for designing associated behavior change interventions.

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10. REFERENCES

Aboud FE, Shafique S and Akhter S (2009): A responsive feeding intervention increases children's self-feeding and maternal responsiveness but not weight gain. J Nutr 139:1738-1743.

ACC/SCN (2000): Fourth report on the world nutrition situation: nutrition throughout the life cycle. United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition (ACC/SCN) with International Food Policy Research Institute, Geneva.

Adu-Afarwuah S, Lartey A, Brown KH, Zlotkin S, Briend A and Dewey KH (2007): Randomized comparison of 3 types of micronutrient supplements for home fortification of complementary foods in Ghana: effects on growth and motor development. Am J Clin Nutr 86:412-420.

Adu-Afarwuah S, Lartey A, Brown KH, Zlotkin S, Briend A and Dewey KH (2008): Home fortification of complementary foods with micronutrient supplements is well accepted and has positive effects on infant iron status in Ghana. Am J Clin Nutr 87:929-938.

Agostoni C, Marangoni F, Bernardo L, Lammardo AM, Galli C and Riva E. Long-chain polyunsaturated fatty acids in human milk. Acta Paediatr Suppl 88:68-71.

Ahmed NU, Zeitlin MF, Beiser AS, Super CM and Gershoff SN (1993): A longitudinal study of the impact of behavioural change intervention on cleanliness, diarrhoeal morbidity and growth of children in rural Bangladesh. Soc Sci Med 37:159-171.

Ainsworth MDS, Bell SM and Stayton DJ (1974): Infant-mother attachment and social development: "socialization" as a product of reciprocal responsiveness signals. In: The integration of a child into a social world. Ed. MPM Richards, Cambridge University Press, London.

Alderman H, Hoddinott J and Kinsey B (2003): Long-term consequences of early childhood malnutrition. Discussion Paper 168. International Food Policy Research Institute, Washington, DC.

Allen LH and Gillespie SR (2001): What works?: a review of the efficacy and effectiveness of nutrition interventions. Asian Development Bank and United Nations Administrative Committee on Coordination/Subcommittee on Nutrition (ACC/SCN), Manila.

Almedom AM (1996): Recent developments in hygiene behaviour research: an emphasis on methods and meaning. Trop Med Int Health 1:171-182.

Amuyunzu-Nyamogo M and Nyamogo IK (2006): Health seeking behaviour of mothers of under-five-year-old children in the slum communities of Nairobi, Kenya. Anthro Med 13:25-40.

Arimond M and Ruel MT (2002): Assessing care: progress towards the measurement of selected childcare and feeding practices, and implications for programs. Food and Nutrition Technical Assistance Project, Academy for Educational Development, Washington, DC.

Armar-Klemesu M, Ruel MT, Maxwell DG, Levin CE and Morris SS (2000): Poor maternal schooling is the main constraint to good child care practices in Accra. J Nutr 130:1597-1607.

Ashorn U (2003): Child health-seeking in Lungwena, Malawi. PhD dissertation. Acta Universitatis Tamperensis 932, Tampere University Press, Tampere, Finland.

Bajaj M, Dubey AP, Nagpal J, Singh PK and Sachdev HPS (2005): Short-term effect of oil supplementation of complementary food to ad libitum consumption in 6- to 10-month-old breastfed infants. J Ped Gastroenterol Nutr 41:61-65.

Barrera A (1990): The role of maternal schooling and its interaction with public health programs in child health production. J Dev Econ 32:69-91.

Bartlett AV, Hurtado E, Schroeder DG and Mendez H (1992): Association of indicators of hygiene behavior with persistent diarrhea of young children. Acta Paediatr Suppl 381:66-71.

Basch CE, Shea S, Arliss R, Contento IR, Rips J, Gutin B, Irigoyen M and Zybert P (1990): Validation of mothers' reports of dietary intake by four to seven year-old children. Am J Pub Health 80:1314-1317.

Bauer MC and Wright AL (1996): Integrating qualitative and quantitative methods to model infant feeding behavior among Navajo mothers. Hum Organ 55:183-192.

Beaton GH and Ghassemi H (1982): Supplementary feeding programs for young children in developing countries. Am J Clin Nutr 35:864-916.

Becker S, Black RE and Brown KH (1991): Relative effects of diarrhea, fever, and dietary energy intake on weight gain in rural Bangladeshi children. Am J Clin Nutr 53:1499-1503.

Bennett VA, Morales E, Gonzalez J, Peerson JM, Lopez de Romaña G and Brown KH (1999): Effects of dietary viscosity and energy density on total daily energy consumption by young Peruvian children. Am J Clin Nutr 70:285-291.

Bentley ME (1988): The household management of childhood diarrhea in rural north India. Soc Sci Med 27:75-85.

Bentley ME, Dickin KL, Mebrahtu S, Kayode B, Oni GA, Versoza CC, Brown KH and Idowu JR (1991a): Development of a nutritionally adequate and culturally appropriate weaning food in Kwara State, Nigeria: an interdisciplinary approach. Soc Sci Med 33:1103-1111.

Bentley ME, Stallings RY, Fukumoto M and Elder JA (1991b): Maternal feeding behavior and child acceptance of food during diarrhea, convalescence, and health in the central sierra of Peru. Am J Pub Health 81:43-47.

Bentley ME, Boot MT, Gittlesohn J and Stallings RY (1994): The use of structured observations in the study of health behaviour. Occasional Paper 27, IRC International Water and Sanitation Centre, The Hague.

Bezner Kerr R, Berti PR and Chirwa M (2007): Breastfeeding and mixed feeding practices in Malawi: timing, reasons, decision makers, and child health consequences. Food Nutr Bull 28:90-99.

Bezner Kerr R, Dakishoni L, Shumba L, Msachi R and Chirwa M (2008): "We grandmothers know plenty": Breastfeeding, complementary feeding and the multifaceted role of grandmothers in Malawi. Soc Sci Med 66:1095-1105.

Bhandari N, Bahl R, Nayyar B, Khokhar P, Rohde JE and Bhan MK (2001): Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. J Nutr 131:1946-1951.

Bhandari N, Bahl R, Taneja S, de Onis M and Bhan MK (2002): Growth performance of affluent Indian children is similar to that in developed countries. Bull World Health Organ 80:189-195.

Bhandari N, Mazumder S, Bahl R, Martines J, Black RE, Bhan MK and other members of the infant feeding study group (2004): An educational intervention to promote appropropriate complementary feeding practices and physical growth in infants and young children in rural Haryana, India. J Nutr 134:2342-2348.

Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E, Haider BA, Kirkwood B, Morris SS, Sachdev HPS and Shekar M for the Maternal and Child Undernutrition Study Group (2008): What works? interventions for maternal and child undernutrition and survival. Lancet 371:417-440.

Birch LL and Fisher JA (1995): Appetite and eating behavior in children. Pediatr Clin N Amer 42:931-953.

Black RE, Brown KH and Becker S (1984): Effects of diarrhea associated with specific enteropathogens on the growth of children in rural Bangladesh. Pediatrics 73:799-805.

Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J for the Maternal and Child Undernutrition Study Group (2008): Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 371:243-260.

Block S (2002): Nutrition knowledge versus schooling in the demand for child micronutrient status. Discussion Paper No. 10, Tufts Nutrition, Boston.

Bone DS (1986): The muslim minority in Malawi and western education. J Institute Muslim Minority Affairs 6:412-419.

Bornstein MH, Tamis-LeMonda CS, Tal J, Ludemann P, Toda S, Rahn CW, Pêcheux M-G, Azuma H and Vardi D (1992): Maternal responsiveness to infants in three societies: The United States, France, and Japan. Chi Dev 63:808-821.

Bornstein MH, Tamis-LeMonda CS, Hahn C-S and Haynes OM (2008): Maternal responsiveness to young children at three ages: longitudinal analysis of a multi-dimensional, modular, and specific parenting construct. Dev Psych 44:867-874.

Boyle MH, Racine Y, Georgiades K, Snelling D, Hong S, Omariba W, Hurley P and Rao-Melacini P (2006): The influence of economic development level, household wealth and maternal education on child health in the developing world. Soc Sci Med 63:2242-2254.

Briend A (1990): Is diarrhoea a major cause of malnutrition among the under-fives in developing countries? a review of available evidence. Eur J Clin Nutr 44:611-628.

Briend A (2001): Highly nutrient-dense spreads: a new approach to delivering multiple micronutrients to high-risk groups. Br J Nutr 85:S175-S179.

Briend A, Hasan HZ, Aziz KM and Hoque BA (1989): Are diarrhoea control programmes likely to reduce childhood malnutrition? observations from rural Bangladesh. Lancet 2(8658):319-322.

Briend A, Lacsala R, Prudhon C, Mounier B, Grellety Y and Golden MHN (1999): Ready-to-use therapeutic food for treatment of marasmus. Lancet 353:1767-1768.

Brown KH, Black RE, Robertson AD and Becker S (1985): Effects of season and illness on the dietary intake of weanlings during longitudinal studies in rural Bangladesh. Am J Clin Nutr 41:343-355.

Brown KH, Stallings RY, Creed de Kanashiro H, Lopez de Romaña G and Black RE (1990): Effects of common illnesses on infants' energy intakes from breast milk and other foods during longitudinal community-based studies in Huascar (Lima), Peru. Am J Clin Nutr 52:1005-1013.

Brown KH, Peerson JM, Lopez de Romana G, Creed de Kanashiro H and Black RE (1995a): Validity and epidemiology of reported poor appetite among Peruvian infants from a low-income, periurban community. Am J Clin Nutr 61:26-32.

Brown KH, Sanchez-Griñan M, Perez F, Peerson JM, Ganoza L and Stern JS (1995b): Effects of dietary energy density and feeding frequency on total daily energy intakes of recovering malnourished children. Am J Clin Nutr 62:13-18.

Brown KH, Dewey KG and Allen LH (1998): Complementary feeding of young children in developing countries: a review of current scientific knowledge. World Health Organization, Geneva.

Brown KH, Engle-Stone R, Krebs NF and Peerson JM (2009): Dietary intervention strategies to enhance zinc nutrition: promotion and support of breastfeeding for infants and young children. Food Nutr Bull 30(1 Suppl):S144-171.

Caulfield LE, Huffman SL and Piwoz EG (1999): Interventions to improve intake of complementary foods by infants 6 to 12 months of age in developing countries: impact on growth and on the prevalence of malnutrition and potential contribution to child survival. Food Nutr Bull 20:183-200.

Caulfield L, de Onis M, Blössner M and Black RE (2004): Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr 80:193-198.

Cebu Study Team (1991): Underlying and proximate determinants of child health: The Cebu Longitudinal Health and Nutrition Study. Am J Epidemiol 133:185-201.

Checkley W, Epstein LD, Gilman RH, Cabrera L and Black RE (2003): Effects of acute diarrhea on linear growth in Peruvian children. Am J Epidemiol 157:166-175.

Checkley W, Buckley G, Gilman RH, Assis AMO, Guerrant RL, Morris SS, Mølbak K, Valentiner-Branth P, Lanata CF, Black RE and The Childhood Malnutrition and Infection Network (2008): Multi-country analysis of the effects of diarrhoea on childhood stunting. Int J Epidemiol 37:816-830.

Cheung YB, Yip PSF and Karlberg JPE (2001): Fetal growth, early postnatal growth and motor development in Pakistani infants. Int J Epidemiol 30:66-74.

Ciliberto MA, Sandige H, Ndekha MJ, Ashorn P, Briend A, Ciliberto HM and Manary MJ (2005): Comparison of home-based therapy with ready-to-use therapeutic food with standard therapy in the treatment of malnourished Malawian children: a controlled, clinical effectiveness trial. Am J Clin Nutr 81:864-870.

Cogill B (2003): Anthropometric indicators measurement guide. Food and Nutrition Technical Assistance, Academy for Educational Development, Washington, DC.

Condon-Paoloni D, Cravioto J, Johnston FE, de Licardie ER and Scholl TO (1977): Morbidity and growth of infants and young children in a rural Mexican village. Am J Pub Health 67:651-56.

Cosminsky S, Mhloyi M and Ewbank D (1993): Child feeding practices in a rural area of Zimbabwe. Soc Sci Med 7:937-947.

Cousens S, Kanki B, Toure S, Diallo I and Curtis V (1996): Reactivity and repeatability of hygiene behaviours: structured observations from Burkina Faso. Soc Sci Med 43:1299-1308.

Creed Kanashiro H, Fukumoto M, Bentley ME, Jacoby E, Verzosa C and Brown KH (1991): Use of recipe trials and anthropological techniques for the development of a home-prepared weaning food in the central highlands of Peru. J Nutr Ed 23:30-35.

Curtis V and Cairncross S (2003): Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. Lancet Infect Dis 3:275-281.

Curtis V, Cousens S, Mertens T, Traore E, Kanki B and Diallo I (1993) : Structured observations of hygiene behaviors in Burkina Faso: validity, variability, and utility. Bull World Health Organ 71:23-32.

Curtis V, Cairncross S and Yonli R (2000): Domestic hygiene and diarrhoea – pinpointing the problem. Trop Med Int Health 5:22-32.

Daniels MC and Adair LS (2004): Growth in young Filipino children predicts schooling trajectories through high school. J Nutr 134:1439-1446.

de Onis M and Blössner M (2003): The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications. Int J Epidemiol 32:518-526.

Dearden KA, Hilton S, Bentley ME, Caulfield LE, Wilde C, Ha PB and Marsh D (2009): Caregiver verbal encouragement increases food acceptance among Vietnamese toddlers. J Nutr 139:1387-1392.

Defourny I, Seroux G, Abdelkader I and Harczi G (2007): Management of moderate acute malnutrition with RTUF in Niger. Field Exchange 31:2-4.

Dettwyler KA (1986): Infant feeding in Mali, West Africa: variations in belief and practice. Soc Sci Med 23:651-664.

Dewey KG and Brown KH. (2003): Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. Food Nutr Bull 24:5-28.

Dewey KG and Adu-Afarwuah S (2008): Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. Matern Chi Nutr 4:24-85.

Dickin K, Griffiths M and Piwoz E (1997): Designing by dialogue: research for improving young child feeding. Academy for Educational Development, Washington, DC.

Dickin KL, Brown KH, Fagbule D, Adedoyin M, Gittelsohn J, Esrey SA and Oni GA (1990): Effect of diarrhoea on dietary intake by infants and young children in rural villages of Kwara State, Nigeria. Eur J Clin Nutr 44:307-317.

Diop EHI, Dossou NI, Ndour MM, Briend A and Wade S (2003): Comparison of the efficacy of a solid ready-to-use food and a liquid, milk-based diet for the rehabilitation of severely malnourished children: a randomized trial. Am J Clin Nutr 78:302-307.

Durnin JVGA, Aitchison TC, Beckett C, Husaini M and Pollitt E (2000): Nutritional intake of an undernourished infant population receiving and energy and micronutrient supplement in Indonesia. Eur J Clin Nutr 54(Suppl 2):S43-S51.

Dy EER (1997): Inappropriate antibiotic use in the Philippines. Phil J Microbiol Infect Dis 26:77-87.

Ejemot RI, Ehiri JE, Meremikwu MM and Critchley JA (2008): Hand washing for preventing diarrhoea. Cochrane Database Syst Rev 23: CD004265.

Engle PL and Zeitlin M (1996): Active feeding behaviour compensates for low interest in food among young Nicaraguan children. J Nutr 126:1808-1816.

Engle PL, Menon P and Haddad L (1997): Care and nutrition: concepts and measurement. International Food Policy Research Institute, Washington, DC.

Engle PL, Bentley M and Pelto G (2000): The role of care in nutrition programmes: current research and a research agenda. Proc Nutr Soc 59:25-35.

FAO (2001): Human energy requirements: report of a joint FAO/WHO/UNU expert consultation. FAO Food and Nutrition Technical Report Series 1, Rome.

Ferguson EL, Gibson RS, Ounpuu S and Sabry JH (1989): The validity of the 24-hour recall for estimating the energy and selected nutrient intakes of a group of rural Malawian preschool children. Ecol Food Nutr 23:273-285.

Ferguson EL, Gibson RS, Opare-Obisaw C, Osei-Opare F, Lamba C and Ounpuu S (1993): Seasonal food consumption patterns and dietary diversity of rural preschool Ghanaian and Malawian children. Ecol Food Nutr 29:219-234.

Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L and Colford JM (2005): Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. Lancet Infect Dis 5:42-52.

Frongillo EA, de Onis M and Hanson KMP (1997): Socioeconomic and demographic factors are associated with worldwide patterns of stunting and wasting in children. J Nutr 127:2302-2309.

Galpin L, Thakwalakwa C, Phuka J, Ashorn P, Maleta K, Wong WW and Manary MJ (2007): Breast milk intake is not reduced more by the introduction of energy dense complementary food than by typical infant porridge. J Nutr 137:1828-1833.

Gartner A, Kameli Y, Traissac P, Dhur A, Delpeuch F and Maire B (2007): Has the first implementation phase of the Community Nutrition Project in urban Senegal had an impact? Nutr 23:219-228.

Garza C and de Onis M (1999): A new international growth reference for young children. Am J Clin Nutr 70(suppl):169S-172S.

Gittelsohn J (1991): Opening the box: intrahousehold food allocation in rural Nepal. Soc Sci Med 33:1141-1154.

Gittelsohn J, Shankar AV, West KP, Ram RM and Gnywali T (1997): Estimating reactivity in direct observation studies of health behavior. Hum Organ 56:182-189.

Gittelsohn J, Shankar AV, West KP, Faruque F, Gnywali T and Pradhan EK (1998): Child feeding and care behaviors are associated with xerophthalmia in rural Nepalese households. Soc Sci Med 47:477-486.

Glewwe P (1999): Why does mother's schooling raise child's health in developing countries?: evidence from Morocco. J Hum Res 34:124-159.

Gorman KS and Pollitt E (1992): Relationship between weight and body proportionality at birth, growth during the first year of life, and cognitive development at 36, 48, and 60 months. Infant Behav Dev 15:279-296.

Gorter AC, Snadiford P, Pauw J, Morales P, Pérez RM and Alberts H (1998): Hygiene behaviour in rural Nicaragua in relation to diarrhoea. Int J Epidemiol 27:1090-1100.

Grantham-McGregor SM, Powell CA, Walker SP and Himes JH (1991): Nutritional supplementation, psychosocial stimulation, and mental development of stunted children: the Jamaican study. Lancet 338:1-5.

Grantham-McGregor SM, Walker SP, Chang SM and Powell CA (1997): Effects of early childhood supplementation with and without stimulation on later development in stunted Jamaican children. Am J Clin Nutr 66:247-253.

Griffiths M (2000): The need for strategic planning, not a technological fix. Food Nutr Bull 21:73-75.

Gryboski K (1996): Maternal and non-maternal time-allocation to infant care, and care during infant illness in rural Java, Indonesia. Soc Sci Med 43:209-219.

Guldan GS, Zeitlin MF, Beiser AS, Super CM, Gershoff SN and Datta S (1993a): Maternal education and child feeding practices in rural Bangladesh. Soc Sci Med 36:925-935.

Guldan GS, Zhang M, Zhang YP, Hong JR, Zhang HX, Fu SY and Fu NS (1993b): Weaning practices and growth in rural Sichuan infants: a positive deviance study. J Trop Pediatr 39:168-175.

Guldan GS, Fan H-C, Ma X, Ni Z-Z, Xiang X and Tang M-Z (2000): Culturally appropriate nutrition education improves infant feeding and growth in rural Sichuan, China. J Nutr 130:1204-1211.

Ha PB, Bentley ME, Pachon H, Sripaipan T, Caulfield LE, Marsh DR and Schroeder DG (2002): Caregiver styles of feeding and child acceptance of food in rural Viet Nam. Food Nutr Bull 23:95-100.

Hasan KZ, Briend A, Aziz KMA, Hoque BA, Patwary MY and Huttly SRA (1989): Lack of impact of a water and sanitation intervention on the nutritional status of children in rural Bangladesh. Eur J Clin Nutr 43:837-843.

Heaton TB, Forste R, Hoffman JP and Flake D (2005): Cross-national variation in family influences on child health. Soc Sci Med 60:97-108.

Hoddinott J, Maluccio JA, Behrman JR, Flores R and Martorell R (2008): Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults. Lancet 371:411-416.

Hoppe C, Andersen GS, Jacobsen S, Mølgaard C, Friis H, Sangild PT and Michaelsen KF (2008): The use of whey or skimmed milk powder in fortified blended foods for vulnerable groups. J Nutr 138:145S-161S.

Hotz C and Gibson RS (2001): Complementary feeding practices and dietary intakes from complementary foods amongst weanlings in rural Malawi. Eur J Clin Nutr 55:841-849.

Hotz C and Gibson RS (2005): Participatory nutrition education and adoption of new feeding practices are associated with improved adequacy of complementary diets among rural Malawian children: a pilot study. Eur J Clin Nutr 59:226-237.

Howard M and Millard AV (1997): Hunger and shame: child malnutrition and poverty on Mount Kilimanjaro. Routledge, London.

Islam MM, Peerson JM, Ahmed T, Dewey KG and Brown KH (2006): Effects of varied energy density of complementary foods on breast-milk intakes and total energy consumption by healthy, breastfed Bangladeshi children. Am J Clin Nutr 83:851-858.

Islam MM, Khatun M, Peerson JM, Ahmed T, Mollah MAH, Dewey KG and Brown KH (2008): Effects of energy density and feeding frequency of complementary foods on total daily energy intakes and consumption of breast milk by healthy breastfed Bangladeshi children. Am J Clin Nutr 88:84-94.

Izurieta LM and Larson-Brown LB (1995): Child feeding practices in Guatemala. Ecol Food Nutr 33:249-262.

Joshi AR (1994): Maternal schooling and child health: a preliminary analysis of the intervening mechanisms in rural Nepal. Health Trans Rev 4:1-26.

Kalanda BF, Verhoeff FH and Brabin BJ (2006): Breast and complementary feeding practices in relation to morbidity and growth in Malawian infants. Eur J Clin Nutr 60:401-407.

Kaltenthaler EC and Drasar BS (1996): Understanding of hygiene behaviour and diarrhea in two villages in Botswana. J Diarrhoeal Dis Res 14:75-80.

Kare MR and Beauchamp GK (1985): The role of taste in the infant diet. Am J Clin Nutr 41:418-422.

Kazembe LN and Namangale JJ (2007): A Bayesian multinomial model to analyse spatial patterns of childhood co-morbidity in Malawi. Eur J Epidemiol 22:546-556.

Kimmons JE, Dewey KG, Haque E, Chakraborty J, Osendarp SJM and Brown KH (2005): Low nutrient intakes among infants in rural Bangladesh are attributable to low intake and micronutrient density of complementary foods. J Nutr 135:444-451.

Krahenbuhl JD, Schutz Y and Jéquier E (1998): High fat versus high carbohydrate nutritional supplementation: a one year trial in stunted rural Gambian children. Eur J Clin Nutr 52:213-222.

Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, Wei R, Curtin LR, Roche AF and Johnson CL (2002): 2000 CDC growth charts for the United States: methods and development. Vital Health Stat 11(246):1-190.

Kuusipalo H, Maleta K, Briend A, Manary M and Ashorn P (2006): Growth and change in blood haemoglobin concentration among underweight Malawian infants receiving fortified spreads for 12 weeks: a preliminary trial. J Pediatr Gastroenterol Nutr 43:525-532.

Lamontagne JF, Engle PL and Zeitlin MF (1998): Maternal employment, child care, and nutritional status of 12-to-18-month-old children in Managua, Nicaragua. Soc Sci Med 46:403-414.

Lartey A, Manu A, Brown KH, Peerson JM and Dewey KH (1999): A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micronutrient status of Ghanaian infants from 6 to 12 months of age. Am J Clin Nutr 70:381-404.

Li H, Barnhart HX, Stein AD and Martorell R (2003): Effects of early childhood supplementation on the educational achievement of women. Pediatr 112:1156-1162.

Lin CA, Manary MJ, Maleta K, Briend A and Ashorn P (2008): An energy-dense complementary food is associated with a modest increase in weight gain when compared with a fortified porridge in Malawian children aged 6-18 months. J Nutr 138:593-598.

Lindtjorn B, Alemu T and Bjovatn B (1992): Child health in arid areas of Ethiopia: longitudinal study of morbidity in infectious diseases. Scand J Infect Dis 24:369-77.

López de Romaña G (2000): Experience with complementary feeding in the FONCODES Project. Food Nutr Bull 23:43-48.

Lutter CK, Mora JO, Habicht JP, Rasmussen KM, Robson DS, Sellers SG, Super CM and Herrera MG (1989): Nutritional supplementation: effects on child stunting because of diarrhea. Am J Clin Nutr 50:1-8.

Lutter CK, Mora JO, Habicht JP, Rasmussen KM, Robson DS and Herrera MG (1990): Age-specific responsiveness of weight and length to nutritional supplementation. Am J Clin Nutr 51:359-364.

Mabilia M (1996): Beliefs and practices in infant feeding among the Wagogo of Chigongwe (Dodoma Rural District) Tanzania II. weaning. Ecol Food Nutr 35:209-217.

Maleta K, Virtanen SM, Espo M, Kulmala T and Ashorn P (2003a): Childhood malnutrition and its predictors in rural Malawi. Paediatr Perinat Epidemiol 17:384-390.

Maleta K, Virtanen S, Espo M, Kulmala T and Ashorn P (2003b): Timing of growth faltering in rural Malawi. Arch Dis Child 88:574-578.

Maleta K, Virtanen SM, Espo M, Kulmala T and Ashorn P (2003c): Seasonality of growth and the relationship between weight and height gain in children under three years of age in rural Malawi. Acta Paediatr 92:491-497.

Maleta K, Kuittinen J, Duggan MB, Briend A, Manary M, Wales J, Kulmala T and Ashorn P (2004): Supplementary feeding of underweight, stunted Malawian children with a ready-to-use food. J Pediatr Gastroenterol Nutr 38:152-158.

Manun'Ebo M, Cousens S, Haggerty P, Kalengaie M, Ashworth A and Kirkwood B (1997): Measuring hygiene practices: a comparison of questionnaires with direct observation in rural Zaire. Trop Med Int Health 2:1015-1021.

Manary MJ, Ndekha Mj, Ashorn P, Maleta K and Briend A (2004): Home-based therapy for severe malnutrition with ready-to-use food. Arch Dis Child 89:557-561.

Martorell R (1999): The nature of childhood malnutrition and its long-term implications. Food Nutr Bull 20:288-292.

Martorell R, Habicht J-P, Yarbrough C. Lechtig A, Klein RE and Western KA (1975): Acute morbidity and physical growth in rural Guatemalan children. Am J Dis Child 129:1296-1301.

Martorell R, Yarbrough C, Yarbrough S and Klein RE (1980): The impact of ordinary illnesses on the dietary intakes of malnourished children. Am J Clin Nutr 33:345-350.

Martorell R, Khan LK and Schroeder DG (1994): Reversibility of stunting: epidemiological findings in children from developing countries. Eur J Clin Nutr 48(Suppl 1):S45-S57.

Martorell R, Mendoza F and Castillo R (1988): Poverty and stature in children. In: Linear growth retardation in less developed countries, pp. 57-73. Ed. JC Waterlow, Raven Press, New York.

Mata LJ, Urrutia JJ, Albertazzi C, Pellecer O and Arellano E (1972): Influence of recurrent infections on nutrition and growth of children in Guatemala. Am J Clin Nutr 25:1267-1275.

Mata LJ, Kromal RA, Urrutia JJ and Garcia B (1977): Effect of infection on food intake and the nutritional state: perspectives as viewed from the village. Am J Clin Nutr 30:1215-1227.

Matilsky DK, Maleta K, Castleman T and Manary MJ (2009): Supplementary feeding with fortified spreads results in higher recovery rates than a corn/soy blend in moderately wasted children. J Nutr 139:773-778.

McLennan JD and Spady DW (1994): Infant feeding practices in a poor district of Santo Domingo. Ecol Food Nutr 32:167-179.

Mendez MA and Adair LS (1999): Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. J Nutr 129:1555-1562.

Moore AC, Akhter S and Aboud FE (2006): Responsive complementary feeding in rural Bangladesh. Soc Sci Med 62:1917-30.

Moore SR, Lima AAM, Conaway MR, Schorling JB, Soares AM and Guerrant RL (2001): Early childhood diarrhoea and helminthiases associate with long-term linear growth faltering. Int J Epidemiol 30:1457-1464.

Mora JO, Herrera MG, Suescun J, de Navarro L and Wagner M (1981): The effects of nutritional supplementation on physical growth of children at risk of malnutrition. Am J Clin Nutr 34:1885-1892.

Moursi M, Mbemba F and Trèche S (2003): Does the consumption of amylase-containing gruels impact on the energy intake and growth of Congolese infants? Pub Health Nutr 6:249-257.

Muhe L, Byass P, Freij L, Sandstrom A and Wall S (1995): A one-year community study of under-fives in rural Ethiopia: patterns of morbidity and public health risk factors. Public Health 109:99-109.

Munthali AC (2002): Change and continuity: perceptions about childhood diseases among the Tumbuka of northern Malawi. PhD thesis. Rhodes University, Grahamstown, South Africa.

National Statistics Office (NSO) [Malawi] and ORC Macro (2005): Malawi Demographic and Health Survey 2004. NSO and ORC Macro, Calverton, Maryland.

Oelofse A, Van Raaij JMA, Benade AJS, Dhansay MA, Tolboom JJM and Hautvast JGAJ (2003): The effect of micronutrient-fortified complementary food on micronutrient status, growth and development of 6- to 12-month-old disadvantage urban South African infants. Int J Food Sci Nutr 54:399-407.

Olney DK, Kariger PK, Stoltzfus RJ, Khalfan SS, Ali NS, Tielsch JM, Sazawal S, Black R, Allen LH and Pollitt E (2009): Development of nutritionally at-risk young children is predicted by malaria, anemia, and stunting in Pemba, Zanzibar. J Nutr 139:763-772.

Oni GA, Brown KH, Bentley ME, Dickin KL, Kayode B and Alade I (1991): Infant feeding practices and prevalence of hand feeding of infants and young children in Kwara State, Nigeria. Ecol Food Nutr 25:209-219.

Oni GA, Schumann DA and Oke EA (1991b): Diarrhoeal disease morbidity, risk factors and treatments in a low socioeconomic area of Ilorin, Kwara State, Nigeria. J Diarr Dis Res 9:250-257.

Owino VO, Kasonka LM, Sinkala MM, Wells JK, Eaton S, Darch T, Coward A, Tomkins AM and Filteau SM (2007): Fortified complementary foods with or without α-amylase treatment increase hemoglobin but do not reduce breast milk intake of 9-mo-old Zambian infants. Am J Clin Nutr 86:1093-1103.

PAHO/WHO (2003): Guiding principles for complementary feeding of the breastfed child. Pan American Health Organization, Washington, DC.

Patel MP, Sandige HL, Ndekha MJ, Briend A, Ashorn P and Manary MJ (2005): Supplemental feeding with ready-to-use therapeutic food in Malawian children at risk of malnutrition. J Health Popul Nutr 23:351-357.

Paul KH, Dickin KL, Ali NS, Monterrosa EC and Stoltzfus RJ (2008): Soy- and rice-based processed complementary food increases nutrient intakes in infants and is equally acceptable with or without added milk powder. J Nutr 138:1963-1968.

Pelletier DL, Frongillo EA and Habicht JP (1993): Epidemiologic evidence for a potentiating effect of malnutrition on child mortality. Am J Public Health 83:1130-1133.

Pelletier DL, Frongillo EA, Schroeder DG and Habicht JP (1995): The effects of malnutrition on child mortality in developing countries. Bull World Health Organ 73:443-448.

Pelto GH, Levitt E and Thairu L (2003): Improving feeding practices: current patterns, common constraints, and the design of interventions. Food Nutr Bull 24:45-82.

Penny ME, Creed-Kanashiro HM, Robert RC, Rocio Norro M, Caulfield LE and Black RE (2005): Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: a cluster-randomised controlled trial. Lancet 365:1863-1872.

Phuka JC (2009): Efficacy of complementary food supplementation with lipid-based nutrient supplements on growth of Malawian children.

PhD dissertation, Acta Universitatis Tamperensis 1451, Tampere University Press, Tampere, Finland.

Phuka JC, Maleta K, Thakwalakwa C, Cheung YB, Briend A, Manary MJ and Ashorn P (2008): Complementary feeding with fortified spread and incidence of severe stunting in 6- to 18-month-old rural Malawians. Arch Pediatr Adolesc Med 162:691-626.

Phuka JC, Maleta K, Thakwalakwa C, Cheung YB, Briend A, Manary MJ and Ashorn P (2009): Supplementary feeding with fortified spread among moderately underweight 6-18-month-old rural Malawian children. Matern Chi Nutr 5:159-170.

Piwoz EG, Black RE, Lopez de Romana G, de Kanashiro HC and Brown KH (1994): The relationship between infants' preceeding appetite, illness, and growth performance and mothers subsequent feeding decisions. Soc Sci Med 39:851-860.

Prentice AM and Paul AA (2000): Fat and energy needs of children in developing countries. Am J Clin Nutr 72:159-172,

Quinn V, Chiligo M and Gittinger JP (1990): Malnutrition, household income and food security in rural Malawi. Health Policy Plan 5:139-148.

Reed BA, Habicht JP and Niameogo C (1996): The effects of maternal education on child nutritional status depend on socio-environmental conditions. Int J Epidemiol 25:585-592.

Rivera JA and Habicht J-P (2002): Effect of supplementary feeding on the prevention of mild-to-moderate wasting in conditions of endemic malnutrition in Guatemala. Bull World Health Organ 80:926-932.

Rivera JA, Sotres-Alvarez D, Habicht J-P, Shamah T and Villalpando S (2004): Impact of the Mexican program for education, health, and nutrition (Progresa) on rates of growth and anemia in infants and young children: a randomized effectiveness study. JAMA 291:2563-2570.

Rondó Schilling P (1990): Supplementary feeding programs: a critical analysis. Rev Saude publ 24:412-419.

Rousham EK, Northrup-Clewes CA and Lunn PG (1998): Maternal reports of child illness and the biochemical status of the child: use of morbidity interviews in rural Bangladesh. Br J Nutr 80:451-456.

Rowland MGM. Cole TJ and Whitehead RG (1977): A quantitative study into the role of infection in determining nutritional status in Gambian village children. Br J Nutr 37:441-50.

Rowland MGM, Goh Rowland SGJ and Cole TJ (1988): Impact of infection on the growth of children from 0 to 2 years in an urban west African community. Am J Clin Nutr 47: 134-38.

Roy SK, Fuchs GJ, Mahmud Z, Ara G, Islam S, Shafique S, Akter SS and Chakraborty B (2005): Intensive nutrition education with or without supplementary feeding improves the nutritional status of moderately-malnourished children in Bangladesh. J Health Popul Nutr 23:320-330.

Ruel MT and Menon P (2002): Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the Demographic and Health Surveys. J Nutr 132:1180-1187.

Ruel MT, Habicht JP, Pinstrup-Andersen P and Gröhn Y (1992): The mediating effect of maternal nutrition knowledge on the association between maternal schooling and child nutritional status in Lesotho. Am J Epidemiol 15:904-914.

Ruel MT, Levin CE, Armar-Klemesu M, Maxwell D and Morris SS (1999): Good care practices can mitigate the effects of poverty and low maternal schooling on children's nutritional status: evidence from Accra. Food Consumption and Nutrition Division (FCND) Discussion Paper no. 62. International Food Policy and Research Institute, Washington, DC.

Sakisaka K, Wakai S and Wongkhomthong S-A (2002): Domestic hygiene behaviour of mothers with children aged 0-5 years old in Tayabo village, Nueva Ecija, the Philippines. Asia Pac J Public Health 14:91-98.

Sanchez-Griñan MI, Peerson JM and Brown KH (1992): Effect of dietary energy density on total ad-libitum energy consumption by recovering malnourished children. Eur J Clin Nutr 46:197-204.

Santos IS, Gigante DP, Coitinho DC, Haisma H, Valle NCJ and Valente G (2005): Evaluation of the impact of a nutritional program for undernourished children in Brazil. Cad Saude Publica 21:776-785.

Schroeder DG, Martorell R, Rivera JA, Ruel MT and Habicht JP (1995): Age differences in the impact of nutritional supplementation on growth. J Nutr 125:1051S-1059S.

Schroeder DG, Pachón H, Dearden KA, Ha TT, Lang TT and Marsh DR (2002): An integrated child nutrition intervention improved growth of younger, more malnourished children in northern Viet Nam. Food Nutr Bull 23:50-58.

Scrimshaw NS and SanGiovanni JP (1997): Synergism of nutrition, infection, and immunity: an overview. Am J Clin Nutr 66:464S-477S.

Scrimshaw NS, Taylor CE and Gordon JE (1968): Interactions of nutrition and infection. World Health Organization, Geneva.

Semba RD, de Pee S, Sun K, Sari M, Akhter N and Bloem MW (2008): Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study. Lancet 371:322-328.

Shrimpton R, Victor CG, de Onis M, Lima FC, Blössner M and Clugston G (2001) : Worldwide timing of growth faltering : implications for nutritional interventions. Pediatrics 107:e75.

Siegel EM, Stoltzfus Rj, Kariger PK, Katz J, Khatry SK, LeClerq SC, Pollitt E and Tielsch JM (2005): Growth indices, anemia and diet independently predict motor milestone acquisition of infants in South Central Nepal. J Nutr 135:2840-2844.

Sigman M, Neumann C, Baksh M, Bwibo N and McDonald MA (1989): Relationship between nutrition and development in Kenyan toddlers. J Pediatr 115:357-364.

Silventoinen K, Haukka J, Dunkel L, Tynelius P, Rasmussen F (2008a): Genetics of pubertal timing and its associations with relative weight in childhood and adult height: the Swedish young male twins study. Pediatrics 121:885-891.

Silventoinen K, Pietiläinen KH, Tynelius P, Sorensen TI, Kaprio J, Rasmussen F (2008b): Genetic regulation of growth from birth to 18 years of age: the Swedish young male twins study. Am J Hum Biol 20:292-298.

Simondon KB and Simondon F (1995): Infant feeding and nutritional status: the dilemma of mothers in rural Senegal. Eur J Clin Nutr 49:179-188.

Smith LC and Haddad L (2000): Explaining child malnutrition in developing countries: a cross-country analysis. International Food Policy Research Institute, Washington, DC.

Stanton BF, Clemens JD, Aziz KMA and Rahman M (1987): Twenty-four-hour recall, knowledge-attitudes-practice questionnaires, and direct observations of sanitary practices: a comparative study. Bull World Health Organ 65:217-222.

Stanton BF, Clemens JD and Khair T (1988): Educational intervention for altering water-sanitation behavior to reduce childhood diarrhea in urban Bangladesh: impact on nutritional status. Am J Clin Nutr 48:1166-1172.

Stein AD, Wang M, Martorell R, Norris SA, Adair LS, Bas I, Sachdev HS, Bhargawa SK, Fall CH, Gigante DP, Victora CG on behalf of the Cohorts Group (2009): Growth patterns in early childhood and final attained stature: data from five birth cohorts from low- and middle-income countries. Am J Hum Biol 23:epub ahead of print.

Sternin M, Sternin J and Marsh D (1998): Designing a community-based nutrition program using the hearth model and the positive deviance approach – a field guide. Save the Children Federation, Westport, Connecticut.

Tanner JM (1990): Fetus into man: physical growth from conception to maturity. Harvard University Press, Cambridge, Massachussetts.

The PLoS Medicine Editors (2008): Scaling up international food aid: food delivery alone cannot solve the malnutrition crisis. PLoS Med 5:e235.

Thomas D, Strauss J and Henriques MH (1990): How does mother's education affect child height? J Hum Res 26:183-211.

Tse WY, Hindmarsh PC, Brook CG (1989): The infancy-childhood-puberty model of growth: clinical aspects. Acta Paediatr Scand Suppl 356:38-43.

UNICEF (1990): Strategy for improved nutrition of children and women in developing countries. The United Nations Children's Fund, New York.

UNICEF (2006a): Progress for children – what is undernutrition? Accessed at: www.unicef.org/progressforchildren/2006n4/index_undernutrition.html on December 15, 2009.

UNICEF (2006b): The State of the World's Children 2007. The United Nations Children's Fund, New York.

UNICEF (2008): The State of the World's Children 2009. The United Nations Children's Fund, New York.

United States Public Health Service, Health Resources Administration. (1976): NCHS growth charts. U.S. Public Health Service (HRA 76-1120, 25, 3), Rockville, Maryland.

Vaahtera M, Kulmala T, Maleta K, Cullinan T, Salin M-L and Ashorn P (2000): Epidemiology and predictors of infant morbidity in rural Malawi. Paediatr Perinat Epid 14:363-71.

Vaahtera M, Kulmala T, Hietanen A, Ndekha M, Cullinan T, Salin M-L and Ashorn P (2001): Breastfeeding and complementary feeding practices in rural Malawi. Acta Paediatr 90:328-332.

Van Breugel JWM (2001): Chewa traditional religion. Kachere Monograph No. 13. Christian Literature Association in Malawi, Blantyre.

Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, Sachdev HS for the Maternal and Child Undernutrition Study Group (2008): Maternal and child undernutrition: consequences for adult health and human capital. Lancet 371:340-357.

Wachs TD (2008): Multiple influences on children's nutritional deficiencies: a systems perspective. Phys Behav 94:48-60.

Walker SP, Chang SM, Powell CA and Grantham-McGregor SM (2005): Effects of early childhood psychosocial stimulation and nutritional supplementation on cognition and education in growth stunted Jamaican children: prospective cohort study. Lancet 366:1804-1807.

Wamani H, Astrom AN, Peterson S, Tylleskar T and Tumwine JK (2005): Infant and child child feeding in Western Uganda: knowledge, practices, and socio-economic correlates. J Trop Pediatr 51:356-361.

Webb P and Block S (2004): Nutrition information and formal schooling as inputs to child nutrition. Econ Dev Cult Change 52:801-820.

Wollinka O, Keeley E, Burkhalter BR and Bashir N (eds.) (1997): Hearth nutrition model: applications in Haiti, Vietnam, and Bangladesh. BASICS, Arlington, Virginia.

WHO (1995): The World Health Organization's infant-feeding recommendation. WHO Weekly Epidemiol Record 17:117-220.

WHO (2006): WHO child growth standards: length/height-for-age, weight-for-age, weight-for length, weight-for-height and body mass index-for-age: methods and development. World Health Organization, Geneva.

WHO Multicentre Growth Reference Study Group (2006): Assessment of differences in linear growth among populations in the WHO

Multicentre Growth Reference Study. Acta Pediatr 450(Suppl.):56-65.

WHO Working Group (1986): Use and interpretation of anthropometric indicators of nutritional status. Bull World Health Organ 64:929-941.

World Health Organization/World Food Program/United Nations Standing Committee on Nutrition/United Nations Children's Fund (2007): Community-based management of severe acute malnutrition. World Health Organization, Geneva.

Zeitlin M, Ghassemi H and Mansour M (1990): Positive deviance in child nutrition – with emphasis on psychosocial and behavioural aspects and implications for development. United Nations University Press, Tokyo.

Zulu EM (1996): Social and cultural factors affecting reproductive behaviour in Malawi. PhD thesis. University of Pennsylvania, Philadelphia.

Zumrawi FY, Dimond H and Waterlow JC (1987): Effects of infection on growth in Sudanese children. Hum Nutr Clin Nutr 41:453-61.

ORIGINAL PUBLICATIONS

Original Article

Feeding patterns of underweight children in rural Malawi given supplementary fortified spread at home

Valerie L. Flax*†, Ulla Ashorn*[1], John Phuka†‡, Kenneth Maleta‡[2], Mark J. Manary§[3] and Per Ashorn†¶

**School of Public Health, Tampere University, Tampere, Finland, †Department of International Health, Tampere University Medical School, Tampere, Finland, ‡College of Medicine, University of Malawi, Blantyre, Malawi, §Washington University School of Medicine, St. Louis, MO, USA, and ¶Department of Paediatrics, Tampere University Hospital, Tampere, Finland*

Abstract

Fortified spread (FS), containing dry food particles embedded in edible fat, offers a convenient means for nutrition rehabilitation. To describe how caregivers feed FS to their undernourished children at home, and how FS use affects other feeding patterns, we conducted a longitudinal observational study in rural Malawi. Sixteen 6- to 17-month-old underweight children (weight-for-age z-score < –2.0; –3.0 < weight-for-height z-score < 0) received FS for 12 weeks. Twelve-hour observations were conducted before supplementation and during weeks 1, 4, 8 and 12 of FS use. FS was fed to children about two times per day; each serving was 15–20 g. The spread was first used mainly alone as a between-meal snack, and then became integrated into the typical complementary feeding pattern by being mixed with porridge. Introduction of FS reduced the number of plain porridge meals, but did not decrease the total number of meals or breastfeeds per day and did not change the daily mean time caregivers spent on feeding. Children accepted the FS well, but more FS was wasted when it was offered mixed with porridge than when given alone (23.6% vs. 1.2%, 95% CI for the difference 13.2% to 31.6%). FS supplementation is feasible for community-based nutrition interventions in Malawi because it easily becomes part of the feeding routine, does not replace other foods and does not take extra caregiver time. To limit wastage, caregivers should be advised to serve FS plain or to mix it with only a small quantity of porridge.

Keywords: child, underweight, supplementary feeding, fortified spread, feeding patterns, sub-Saharan Africa.

Correspondence: Ms Valerie L. Flax, Department of International Health, Tampere University Medical School, Finn-Medi 3 Building, FIN-33014 Tampere University, Tampere, Finland. E-mail: valerie.flax@uta.fi

Present address: [1]Ulla Ashorn, School of Public Health, FIN-33014 Tampere University, Finland; [2]Kenneth Maleta, Community Health Department, College of Medicine, University of Malawi, P/Bag 360, Blantyre 3, Malawi; [3]Mark J. Manary, Washington University School of Medicine, Campus Box 8116, 660 S. Euclid Avenue, St. Louis, MO 63110, USA. John Phuka and Per Ashorn same as corresponding author.

Introduction

Undernutrition affects up to 40% of children aged less than 5 years in low-income countries (UNICEF 2000). It causes morbidity and adverse long-term sequelae and contributes to global childhood mortality. Severely undernourished children have the highest risk of morbidity and death from this condition, but mild and moderate undernutrition create a greater health burden at the population level (Pelletier *et al*. 1995). In Malawi, the problem usually develops in children aged 6–17 months, so that by the age of 18 months, 30–50% of all children in rural Malawi are undernourished (Maleta *et al*. 2003).

Supplementary feeding is one possible avenue for improving the feeding and growth of children in poor communities. Efficacy trials of a variety of types of food supplements in different settings and with children of different ages have had variable results, with some studies showing that supplements have a positive impact on growth while others show no change (WHO 1998; Allen & Gillespie 2001). Age, initial nutritional status, food availability and feeding practices may all have an effect on the success of supplementation (WHO 1998). Despite these possible constraints, in locations, such as Malawi, where other interventions, like dietary diversification and fortified complementary foods, are too expensive to reach the poor, supplementary feeding may be a feasible and appropriate option.

Fortified spread (FS), containing dry food particles embedded in edible fat, is food supplement that has proven to be effective in research settings and that offers some clear benefits over milk- or cereal-based supplements. FS is five times more energy dense than cereals, needs no cooking before use, is hygienic because it does not support bacterial growth, and contains adequate quantities of micronutrients (Briend *et al*. 1999; Briend 2001). A therapeutic version of spread, called ready-to-use therapeutic food, has been used successfully for rehabilitating severely undernourished children either in hospital or as outpatients (Collins & Sadler 2002; Diop *et al*. 2003; Manary *et al*. 2004; Sandige *et al*. 2004). Increases in weight and length gain have also been reported among moderately undernourished children supplemented with FS at home (Patel *et al*. 2005; Kuusipalo *et al*. 2006). These studies suggest that different types of spreads may spread a potential avenue for community-level management of undernutrition. To date, there is no published information available on the practical aspects of home spread use, which would be needed to plan larger-scale interventions.

In order to provide data on how FS is used at home, we carried out a longitudinal observational study of feeding patterns among underweight 6- to 17-month-old children in rural Malawi. The aim of this descriptive study was to look at issues such as the size of a typical FS feed, time spent feeding FS, waste of FS, impact of FS on complementary feeds, and changes in FS use over time.

Methods

Setting, design and overview

The study was conducted around Lungwena and Malindi in a rural area in southern Malawi. Participants were provided with FS for a period of 12 weeks. Ten 12-h observations were conducted for each child; observations were carried out on two consecutive days. The first pair of observations was completed before the children received FS (week 0). Children and their caregivers were then observed during weeks 1, 4, 8 and 12 of FS use. A background questionnaire to obtain socio-economic information was completed on the first day of observation. Children's weight and length were measured at enrolment and at the end of the study. Ethical approval for the study was obtained from the College of Medicine Research and Ethics Committee at the University of Malawi, and from the Ethical Committee of the Pirkanmaa Hospital District in Finland.

Participants

Participants were a sample of 16 6- to 17-month-old children selected from six villages. Villages were chosen so as to include possible differences in health-seeking and availability of food (especially fish) based on their distance from health facilities and the lake. Research assistants and village health workers visited the villages to prepare initial lists of children in the age group. The research team then went to each village to measure the children, test for peanut allergy, and verify eligibility [weight-for-age z-score(WAZ) < -2.0; $-3.0 <$ weight-for-height z-score (WHZ) < 0; not participating in another study; looked after by biological mother; no peanut allergy; no chronic illness; and guardian-signed informed consent]. The weight-for-age and weight-for-height criteria for this study were selected to obtain children who were underweight but not wasted and not short and fat. At the time the study was conducted, low weight-for-height (WHZ < -3.0) was the Malawian Ministry of Health's criteria for a child to enter inpatient nutrition rehabilitation. Weight was measured using a UNICEF Salter scale (reading increment 0.10 kg), and length was measured using a length board (Shorr Productions, Olney, MD, USA; reading increment 0.10 cm). Weights and heights were converted into z-scores using the Center for Disease Control and Prevention tables (Kuczmarski *et al*. 2002).

Procedures

Each trained female research assistant was responsible for carrying out all study activities for four children in one or two villages. Research assistants were assigned to observe and visit the same four participants so that they could develop rapport with the families, thereby minimizing their effect on the observations.

The FS used in this study contained peanut butter, milk powder, sugar, oil and vitamin/mineral mix, and a daily dose provided approximately 250 kcal of energy, 7 g protein, 14 g carbohydrates, 17 g fat, and one recommended daily allowance of 17 micronutrients. It was obtained from a local producer in the capital (Project Peanut Butter, Blantyre, Malawi). Research assistants delivered three plastic jars of FS to participants' homes every 2 weeks; each jar contained enough FS for 5 days. At the beginning of the FS feeding period, caregivers were informed that they should feed the study child 7 teaspoons (approximately 50 g) of FS per day, and that the FS was specifically for the study child. No advice about how or when to give FS was offered because the aim of the study was to see how families chose to use FS in practice.

Background questionnaire

A background questionnaire was administered to each caregiver on the first day of observation. The questionnaire contained demographic and economic questions, including the age, education and occupation of the parents, number of family members, and food availability.

Observations of feeding

On each day of observation, a research assistant visited the family from approximately 6 AM to 6 PM. First, the research assistant asked the caregiver if either she or the child was ill. If so, the research assistant inquired about the kind of illness. Then the research assistant sat near the child and recorded the type of food and duration of all feeding episodes (including breast milk). Research assistants also used a semi-structured form to collect information about caregiver–child interactions during meals, including who fed the child, what utensil was used, and how many bites were offered and eaten.

The study's principal investigator conducted 25% of observation visits with research assistants and independently recorded the data. This allowed us to estimate interobserver reliability for individual variables using Pearson's correlation coefficient and Cohen's κ statistic. On feeding logs, κ was 0.99 for type of food and r was 0.86 for length of episode. On feeding interaction forms, r ranged from 0.84 to 0.98 for variables counting teaspoons of food offered and eaten, and κ was 0.98 for primary feeders and 0.97 for primary utensils. Because interobserver reliability was high, all analyses presented below use data collected by research assistants.

Method of analysis

Data were entered into a self-designed Microsoft Access database, extracted to Microsoft Excel tables and analysed with SPSS (version 11.5) and STATA (version 9.2). Linear regression analysis was used to calculate means and to test for differences between some subgroups. The analysis was adjusted for within-subject correlation by the Huber-White robust standard error (Binder 1983). Binomial regression was used to analyse proportions (Spiegelman & Hertzmark 2005), with statistical inference based on the robust standard error to allow for correlated data.

In the analysis, foods listed in feeding logs and interaction forms were divided into seven types defined as follows: porridge (made from maize, rice or maize/soy; approximately 10% dry matter); FS alone (spread given straight from the jar); FS mixed (spread mixed with porridge); nsima (dough made from maize; approximately 28% dry matter) and relish (most often green vegetables, fish or beans); other meals (rice or boiled pumpkin); snacks (such as bananas, bread or roasted maize); and breast milk. When breast milk and food were recorded on the same line on feeding logs, only the type of food was used in the analysis. This procedure led to a slight underestimation of the number of breast milk episodes.

Table 1. Background characteristics of children and their families

Mean (SD) age of child at enrolment	13 (3) months
Proportion female	63%
Mean (SD) anthropometric measurements	
Weight	7.5 (0.8) kg
Length	69.8 (3.9) cm
Weight-for-age *z*-score	–2.6 (0.3)
Height-for-age *z*-score	–1.8 (0.7)
Weight-for-height *z*-score	–1.2 (0.9)
Mean (SD) age of mother	26 (7) years
Mother's occupation (%)	
Housewife/farmer	75
Small business owner	19
Other	6
Mother's education (%)	
None	6
1–3 years	44
4–6 years	19
7–9 years	12
10 or more years	19
Father lives with family (%)	50
Mean (SD) number of household members	5 (2)
Mean (SD) number of children < 5 years	2 (1)
Mean (SD) birth order of study children	4 (2)

Results

A total of 228 children were identified in initial screening; 200 (87.7%) of them were measured by the research team. Of those measured, 177 were not eligible for the following reasons: 119 not underweight, 38 not correct age, 18 in another study, 1 chronically ill, and 1 whose mother was deceased. Out of 23 eligible children, 16 were selected. In four villages, all eligible children ($n = 8$) were enrolled. In the other two villages, four children were selected randomly (8 children in total). At enrolment, all caregivers were mothers. The background characteristics of the children and their families are shown in Table 1.

Of the planned 160 days of observation, 155 days were completed. The length of most observations was approximately 12 h; however, 11 observation days (7%) were shorter (usually 4–8 h) due to visits away from home (to health centre, traditional healer, fields, funeral or maize mill) by participants.

Table 2 describes the number and duration of different meal types before FS was provided (week 0) and during FS use (weeks 1–12). All children, except one, were breastfed. In the absence of FS, the typical daily feeding pattern was: breast milk 11 times, porridge one to two times, nsima one time, and snacks three times. When FS was introduced, the mean times per day children ate plain porridge decreased (from 1.5 to 0.3, 95% CI for the difference 0.8 to 1.6, $P < 0.001$), while the mean times they had all other food types, including breast milk, remained the same. The duration of breastfeeding episodes did not change when children received the spread.

FS was generally well accepted by children in this study. It was fed to children two times per day on average, and it comprised or was included in 31% of meals and snacks. There was a large difference in the mean time it took to feed FS alone and FS mixed with porridge (5.4 vs. 14.5 min, 95% CI for the difference 5.6 to 12.5, $P < 0.001$). Fifteen per cent (19/124) of observation days during weeks 1–12 included no FS feedings; approximately half of these were because the child's FS supply was already finished. The recommended dose of 7 teaspoons of FS per day was

Table 2. Number and duration of feeding episodes before and during FS supplementation

	Porridge	FS mixed	FS alone	Nsima and relish	Other meals	Snacks	Breast milk
Mean (95% CI) times per day							
Before FS	1.5 (1.1, 1.9)	–	–	1.0 (0.7, 1.4)	0.3 (0.1, 0.5)	2.7 (1.2, 2.8)	11.1 (8.2, 14.1)
During FS	0.3 (0.2, 0.4)	0.9 (0.5, 1.2)	0.7 (0.4, 0.9)	1.0 (0.8, 1.3)	0.2 (0.1, 0.3)	2.0 (1.3, 4.1)	10.1 (6.8, 13.5)
Mean (95% CI) minutes per episode							
Before FS	14.5 (11.6, 17.3)	–	–	17.2 (13.2, 21.3)	22.0 (14.1, 29.9)	6.6 (5.6, 7.5)	6.0 (4.9, 7.2)
During FS	11.8 (7.0, 16.6)	14.5 (11.7, 17.2)	5.4 (3.5, 7.2)	14.3 (12.2, 16.4)	16.8 (8.5, 24.9)	4.9 (4.1, 5.7)	6.6 (5.0, 8.1)

This table is based on data from feeding logs. Means and confidence intervals were adjusted for within-subject correlation. Before FS (fortified spread) = week 0. During FS = weeks 1, 4, 8 and 12. Porridge = maize, rice or maize/soy, approximately 10% dry matter; FS mixed = spread mixed with porridge; FS alone = spread given straight from the jar; nsima = dough made from maize, approximately 28% dry matter, and relish = side dish made of green vegetables, fish or beans; other meals = rice or boiled pumpkin; snacks = small quantities of food eaten between meals (such as banana, bread, roasted maize).

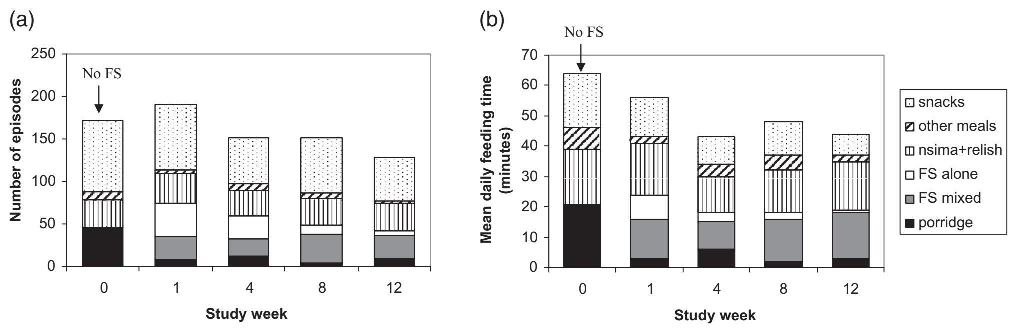

Fig. 1. Number of food episodes and mean daily feeding time by study week.
Figure 1a,b is based on data from feeding logs. In Fig. 1a, the sum of the number of feeding episodes during each study week is presented. In Fig. 1b, the mean daily feeding time for each type of food during each study week was adjusted for within-subject correlation. During week 0, no FS (fortified spread) was provided to participants. FS was available to participants during weeks 1, 4, 8 and 12. Porridge = maize, rice or maize/soy, approximately 10% dry matter; FS mixed = spread mixed with porridge; FS alone = spread given straight from the jar; nsima = dough made from maize, approximately 28% dry matter, and relish = side dish made of green vegetables, fish or beans; other meals = rice or boiled pumpkin; snacks = small quantities of food eaten between meals (such as banana, bread, roasted maize).

offered to children during 27% of visits (34/124); at least 5 teaspoons of FS were offered during 47% of visits (58/124).

The way in which the feeding patterns changed during the course of the study is shown in detail in Fig. 1a. The number of porridge meals was greatest during week 0 (no FS). Most porridge episodes were replaced by FS episodes (alone and mixed) when the children started receiving FS. Both the total number of FS episodes and the number of FS alone episodes were greatest during week 1 and decreased until the end of the study, while the number of FS mixed episodes remained fairly stable throughout the study. During weeks 8 and 12, the combined number of episodes of FS alone, FS mixed and porridge were approximately equal to the number of porridge episodes during week 0 visits.

The daily mean time spent feeding the children decreased when FS was introduced (week 1) and continued to decrease during the rest of the study (Fig. 1b). The mean time spent feeding breast milk, nsima and FS mixed remained fairly constant throughout the study, while the mean time spent feeding porridge and FS alone decreased greatly. Starting from week 4, the combined mean times for feeding porridge, FS alone and FS mixed were less than the mean time spent feeding porridge only during week 0.

Table 3. Teaspoons of FS offered and eaten per episode by study week

	Week 1	Week 4	Week 8	Week 12	Total
Mean (95% CI) teaspoons of FS offered					
FS alone	2.7 (1.7, 3.6)	2.3 (1.4, 3.1)	3.9 (1.8, 6.0)	2.6 (– 1.5, 6.7)	2.7 (2.0, 3.4)
FS mixed	2.8 (2.2, 3.5)	2.8 (2.3, 3.4)	3.2 (2.4, 4.0)	3.0 (2.3, 3.7)	3.0 (2.6, 3.4)
Mean (95% CI) teaspoons of FS eaten					
FS alone	2.7 (1.7, 3.6)	2.2 (1.2, 3.2)	3.9 (1.8, 6.0)	2.6 (– 1.5, 6.7)	2.7 (2.0, 3.4)
FS mixed	2.1 (1.4, 2.8)	2.2 (1.6, 2.7)	2.4 (1.6, 3.2)	2.4 (1.6, 3.3)	2.3 (1.7, 2.8)
Proportion lost (95% CI) during feeding					
FS alone	0.0% (–)	3.9% (–3.1, 9.9)	0.0% (–)	0.0% (–)	1.2% (–1.3, 3.8)
FS mixed	27.0% (11.8, 42.3)	22.6% (15.1, 30.1)	24.8% (8.3, 41.2)	20.0% (8.1, 31.9)	23.6% (14.0, 33.3)

This table is based on data from observations of feeding episodes. Means were calculated using linear regression and proportions were calculated using binomial regression. All calculations were adjusted for within-subject correlation. FS (fortified spread) alone = spread given straight from the jar; FS mixed = spread mixed with porridge. (–) = same value for upper and lower confidence limits.

Data about the amount of FS offered and eaten, as well as the proportion lost or wasted, are presented in Table 3. One teaspoon equals approximately 7 g of FS; so on average, children ate 15–20 g of FS per episode. More of the FS was wasted when it was offered mixed with porridge than when it was given alone (23.6% vs. 1.2%, 95% CI for the difference 13.2% to 31.6%, $P < 0.001$).

To describe who fed the children and what type of utensil was used, proportions were calculated using a feeding episode as the unit of analysis. Caregivers were the primary feeders during 95% (57/60) of FS alone, 88% (66/75) of porridge, 78% (85/109) of FS mixed, and 59% (89/151) of nsima episodes. Children fed themselves 92% (22/24) of snacks and 63% (20/32) of other meals. A spoon was used to feed children during 91% (68/75) of porridge, 88% (53/60) of FS alone, and 83% (91/109) of FS mixed episodes. Children's and caregivers' hands were used during 88% (21/24) of snacks and 64% (96/151) of nsima meals, respectively. For those types of food that were fed to children throughout the study (i.e. porridge, nsima, other meals and snacks), there was little change in the proportions of feeders and utensils before and during FS use.

During the 12-week follow-up, the mean (SD) gain in weight was 1.0 (0.5) kg and in length was 3.8 (1.3) cm. Mean (SD) gains in anthropometric indices were 0.3 (0.6), 0.0 (0.4), and 0.3 (0.5) z-score units for WAZ, height-for-age z-score and WHZ, respectively. At the end of the study, 81% of the participants still had WAZ < -2.0.

Discussion

This study was conducted to learn about patterns of home FS use for underweight young children and how its use modified other complementary feeding patterns. On average, children in this study had breast milk 11 times, nsima one time, porridge one or two times, and snacks three times per day. When FS was added to the diet, it was fed to the children about two times per day; each serving was 15–20 g (1 teaspoon = 7 g). FS was first used mainly alone as a between-meal snack, but was then integrated into the usual feeding pattern by being mixed with porridge. The use of FS did not affect the number of times the child was fed per day, the number or duration of breastfeeds, or the amount of caregiver time spent feeding.

Among the Yao people and in other cultures in the region, porridge is a food that caregivers cook specifically for young children until they are old enough to participate in family meals (Cosminsky *et al*. 1993; Mabilia 1996; Hotz & Gibson 2001). The importance of porridge as a 'baby food' may explain why caregivers rarely used FS to replace meals, and why the number of meals and breastfeeds a child had per day did not decrease when FS was introduced. Because caregivers did not see FS as a replacement for porridge, mixing FS with porridge during regular meals, rather than serving FS alone as a snack, minimized the time they spent feeding the child FS. This strategy meant that the use of supplementary FS did not add to the mean time per day caregivers spent feeding the children.

Observations and discussions with caregivers indicated that the difference in the amount of FS wasted when mixed with porridge vs. plain was related to caregivers' divergent approaches to FS used in these two ways. Caregivers typically offered plain porridge or porridge mixed with FS until the child rejected it or appeared full, and some porridge often remained in the bowl at the end of a feeding session. In contrast, when FS was fed alone, caregivers usually fed it to the children until the supplement they offered was finished. They rarely returned leftover plain FS to the jar or fed it to another family member.

A number of other studies have investigated child feeding with a similar observational methodology to that used here; however, all of these focused only on complementary feeding (Bentley *et al*. 1991; Brown *et al*. 1992; Guldan *et al*. 1993; Izurieta & Larson-Brown 1995; Engle & Zeitlin 1996; Gittelsohn *et al*. 1997). Supplementary feeding studies either collect no data on breastfeeding and food intake, or obtain such information through 24-h recalls. Single or widely spaced recalls are not likely to be as reliable as multiple observations in providing information on what was actually eaten during the entire supplementation period. In addition, such studies have seldom looked at wastage of supplement, or have measured it only when the supplement is supplied at a central location or by a field assistant. We could not identify any published data on time spent feeding supplement.

Our study results agree with findings from Colombia (Mora *et al*. 1981) that breastfeeding frequency remains the same during supplementation, but contrast with data from India (Bhandari *et al*. 2001) showing a decrease. Both of these studies, as well as a study in Jamaica (Walker *et al*. 1991), found that energy intake from regular foods was less during supplementation, whereas data collected from 3- to 4-year-old Malawian children supplemented with FS showed that energy intake from regular foods was unchanged on average (Maleta *et al*. 2004). Our study did not attempt to calculate energy intake, but showed that the number of regular food episodes remained the same before and during supplementation.

The differences between existing studies and ours regarding breastfeeding frequency and regular food consumption during supplementation are probably due to the way in which people from different cultures adopt a supplementary food into child feeding patterns and the type of supplementary food that was provided. If the supplement is similar to foods children are typically fed (e.g. cereal-based food), it is more likely that it will be used in place of regular meals, whereas a supplement like FS may be added to cereals to make an 'improved' food or may be given as a snack. This theory is supported by data from our research group and from a study in Gambia that compared supplementation with FS to maize-soy porridge and high-fat to high-carbohydrate supplements, respectively (Krahenbuhl *et al*. 1998; Maleta *et al*. 2004).

Because FS easily becomes part of the feeding routine, does not replace other foods and does not take extra caregiver time, we believe it could be integrated into community-based nutrition interventions in rural Malawi. The amount of FS wasted when it is mixed with porridge might, however, reduce the population impact of any intervention. To limit wastage, caregivers should be advised to offer FS plain or to mix it with a small quantity of porridge that the child can finish. Other issues, such as the means of identifying appropriate children to receive FS, mode of delivery of FS, and cost of the supplement, should be investigated before undertaking large-scale interventions using this product.

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References

Allen L.H. & Gillespie S.R. (2001) *What Works? A Review of the Efficacy and Effectiveness of Nutrition Interventions*. United Nations Administrative Committee on Coordination/Sub-committee on Nutrition in collaboration with the Asian Development Bank: Manila.

Bentley M.E., Stallings R.Y., Fukumoto M. & Elder J.A. (1991) Maternal feeding behavior and child acceptance of food during diarrhea, convalescence, and health in the central Sierra of Peru. *American Journal of Public Health* **81**, 43–47.

Bhandari N., Bahl R., Nayyar B., Khokhar P., Rohde J.E. & Bhan M. (2001) Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. *Journal of Nutrition* **131**, 1946–1951.

Binder D.A. (1983) On the variances of asymptotically normal estimators from complex surveys. *International Statistical Review* **51**, 279–292.

Briend A. (2001) Highly nutrient-dense spreads: a new approach to delivery multiple micronutrients to high-risk groups. *British Journal of Nutrition* **85** (Suppl. 2), 175–179.

Briend A., Lacsala R., Prudhon C., Mounier B., Grellety Y. & Golden M.H. (1999) Ready-to-use therapeutic food for treatment of marasmus. *Lancet* **353**, 1767–1768.

Brown L.V., Zeitlin M.F., Peterson K.E. *et al.* (1992) Evaluation of the impact of weaning food messages on infant feeding practices and growth in rural Bangladesh. *American Journal of Clinical Nutrition* **56**, 994–1003.

Collins S. & Sadler K. (2002) Outpatient care for severely malnourished children in emergency relief programmes: a retrospective cohort study. *Lancet* **360**, 1824–1830.

Cosminsky S., Mhloyi M. & Ewbank D. (1993) Child feeding practices in a rural area of Zimbabwe. *Social Science and Medicine* **36**, 937–947.

Diop el H.I., Dossou N.I., Ndour M.M., Briend A. & Wade S. (2003) Comparison of the efficacy of a solid ready-to-use food and a liquid milk-based diet for the rehabilitation of severely malnourished children: a randomized trial. *American Journal of Clinical Nutrition* **78**, 302–307.

Engle P.L. & Zeitlin M. (1996) Active feeding behavior compensates for low interest in food among young Nicaraguan children. *Journal of Nutrition* **126**, 1808–1816.

Gittelsohn J., Thapa M. & Landman L.T. (1997) Cultural factors, caloric intake and micronutrient sufficiency in rural Nepali households. *Social Science and Medicine* **44**, 1739–1749.

Guldan G.S., Zeitlin M.F., Beiser A.S., Super C.M., Gershoff S.N. & Datta S. (1993) Maternal education and child feeding practices in rural Bangladesh. *Social Science and Medicine* **36**, 925–935.

Hotz C. & Gibson R.S. (2001) Complementary feeding practices and dietary intakes from complementary foods amongst weanlings in rural Malawi. *European Journal of Clinical Nutrition* **55**, 841–849.

Izurieta L.M. & Larson-Brown L.B. (1995) Child feeding practices in Guatemala. *Ecology of Food and Nutrition* **33**, 249–262.

Krahenbuhl J.D., Schutz Y. & Jequier E. (1998) High fat versus high carbohydrate nutritional supplementation: a one year trial in stunted rural Gambian children. *European Journal of Clinical Nutrition* **52**, 213–222.

Kuczmarski R.J., Ogden C.L., Guo S.S. *et al.* (2002) 2000 CDC growth charts for the United States: methods and development. *Vital Health Statistics* **11**, 1–190.

Kuusipalo H., Maleta K., Briend A., Manary M. & Ashorn P. (2006) Growth and change in blood haemoglobin concentration among underweight Malawian infants receiving fortified spreads for 12 weeks. A preliminary trial. *Journal of Pediatric Gastroenterology and Nutrition* **43**, 525–532.

Mabilia M. (1996) Beliefs and practices in infant feeding among the Wagogo of Chigongwe (Dodoma rural district) Tanzania, II. Weaning. *Ecology of Food and Nutrition* **35**, 209–217.

Maleta K., Virtanen S.M., Espo M., Kulmala T. & Ashorn P. (2003) Childhood malnutrition and its predictors in rural Malawi. *Paediatric and Perinatal Epidemiology* **17**, 384–390.

Maleta K., Kuittinen J., Duggan M.B. *et al.* (2004) Supplementary feeding of underweight, stunted Malawian children with a ready-to-use food. *Journal of Pediatric Gastroenterology and Nutrition* **38**, 152–158.

Manary M.J., Ndekha M., Ashorn P., Maleta K. & Briend A. (2004) Home-based therapy for severe malnutrition with ready-to-use food. *Archives of Disease in Childhood* **89**, 557–561.

Mora J.O., Herrera M.G., Suescun J., de Navarro L. & Wagner M. (1981) The effects of nutritional supplementation on physical growth of children at risk of malnutrition. *American Journal of Clinical Nutrition* **34**, 1885–1892.

Patel M.P., Sandige H.L., Ndekha M.J., Briend A., Ashorn P. & Manary M. (2005) Supplemental feeding with ready-to-use therapeutic food in Malawian children at risk of malnutrition. *Journal of Health, Population and Nutrition* **23**, 351–357.

Pelletier D.L., Frongillo E.A., Schroeder D.G. & Habicht J.P. (1995) The effects of malnutrition on child mortality in developing countries. *Bulletin of the World Health Organization* **73**, 443–448.

Sandige H., Ndekha M.J., Briend A., Ashorn P. & Manary M.J. (2004) Home-based treatment of malnourished

Malawian children with locally produced or imported ready-to-use food. *Journal of Pediatric Gastroenterology and Nutrition* **39**, 141–146.
Spiegelman D. & Hertzmark E. (2005) Easy SAS calculations for risk or prevalence ratios and differences. *American Journal of Epidemiology* **162**, 199–200.
United Nations Children's Fund (UNICEF) (2000) *The State of the World's Children 2001: Early Childhood*. Oxford University Press: Oxford.
Walker S.P., Powell C.A., Grantham-McGregor S.M., Himes J.H. & Chang S.M. (1991) Nutritional supplementation, psychosocial stimulation, and growth of stunted children: the Jamaican study. *American Journal of Clinical Nutrition* **54**, 642–648.
World Health Organization (1998) *Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge.* World Health Organization: Geneva.

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LETTER-TO-THE-EDITOR

Intake of Lipid-based Nutrient Supplements during Illness and Convalescence among Moderately-underweight Malawian Children

Sir,

The effect of infections and other illnesses on the nutritional status of a child depends on the type and severity of the illness, initial nutritional status of the individual, and food intake during illness and convalescence (1). In practice, illnesses in children are often associated with reduced appetite and decreased food intake (2,3). Although short-term nutritional losses can be overcome (4), illnesses predispose children in resource-poor settings to weight loss and development of malnutrition (2).

Lipid-based nutrient supplements (LNS) are ready-to-use foods that have been used for treating children with severe acute malnutrition and for preventing malnutrition and linear growth failure (5,6). Because of their high energy and nutrient content, LNS could be used for supplementation during and soon after illness to mitigate the impact of illness-associated anorexia on the nutritional status of children. To date, little is known about the acceptability of LNS during and after common childhood illnesses. This longitudinal study provides preliminary comparative information on LNS intake by children on ill, convalescent and healthy days.

The study was conducted around Lungwena and Malindi, a rural area in southern Malawi.

Subjects were 16 moderately-underweight (weight-for-age *z*-score <-2) children aged 6-17 months participating in a study on the incorporation of LNS into home diets. Details of the selection criteria are published elsewhere (7).

During the 12 weeks of supplementation, research assistants delivered three 250-g plastic jars of LNS to homes of the participants fortnightly. They visited the study families five evenings per week to weigh LNS jars and used a semi-structured questionnaire to obtain information on child morbidity. Caregivers were advised to feed the child seven teaspoons (≈50 g) of LNS per day. The LNS, produced in Blantyre, Malawi, was made of peanut butter, milk powder, sugar, oil, and vitamin/mineral mix.

The analysis initially compared LNS intake on days when children were reported to be ill versus not ill. The categories 'ill' and 'not ill' were then further subdivided. Mutually-exclusive groups were developed to categorize illnesses: fever was given the first priority in forming the groups, followed by diarrhoea, as these have the largest effect on food intake of children (2,3). Fever was defined as fever only or in combination with any other symptom; diarrhoea was defined as diarrhoea only or in combination with any symptom other than fever; cough was defined as cough only or cough together with 'other' illnesses; and 'other' illnesses contained only symptoms in the 'other' category, including sores, pus from ears, vomiting, and prolonged crying.

Days when children were reported 'not ill' were coded into three categories: early convalescence (day 1-7 following illness), late convalescence (day 8-14 following illness), and healthy (other days). Convalescent days were coded starting from the first day the child was not reported to be ill and continuing until the next reported illness (if any). The first days of data collection were omitted for children who were reported to be 'not ill' either until they were reported to be ill or until the eighth day, at which point they were counted as healthy. When no information was available, the health status of the child was assumed to be identical to the first day when data were available again.

Linear regression analysis was used for calculating the mean LNS intake and to test for the difference in LNS intake on 'ill' versus 'not ill' days. Means and confidence intervals for LNS intake were adjusted for within-subject correlation by the Huber-White robust standard error.

Correspondence and reprint requests should be addressed to:
Ms Valerie L. Flax
Department of International Health
University of Tampere Medical School
Finn-Medi 3 Building
FIN-33014 University of Tampere
Finland
Email: valerie.flax@uta.fi

At enrollment, the mean (standard deviation [SD]) age of the participants was 13 (3) months, the mean (SD) weight-for-age *z*-score was -2.6 (0.3), the height-for-age *z*-score was -1.8 (0.7), and the weight-for-height *z*-score was -1.2 (0.9). The children lived in households with a mean (SD) of 5 (2) members, and their median birth-order was 3.

Data were collected from all the 16 participants during the first eight weeks that LNS was provided. One child moved away after the eighth week, and the remaining children provided information during the final four weeks of follow-up. In total, 845 days of data were collected (63% of the days when LNS was available). Thirteen (1.5%) of these days were excluded from the analysis because the daily measurements were suggestive of food-sharing (LNS use >150 g/day).

Illness was reported on 142 (17%) days. Of these days, 57 (40%) were classified as fever, 30 (21%) as diarrhoea, 44 (31%) as cough, and 11 (8%) as other illness days. Fifteen children were ill on at least one day; the child who moved away during the study had no reported illness.

The mean LNS intake was 43.4 g (≈230 kcal) on 'ill' and 50.6 g (≈268 kcal) on 'not ill' days (difference=7.2 g, 95% CI 0.6-13.8 g, p<0.034). The mean consumption of LNS for different types of illness is shown in the table. Compared to days when children were not reported ill, the mean daily LNS intake was 14% (≈38 kcal) lower on ill days, ranging from <1% (≈2 kcal) on 'other' illness days to 25% (≈65 kcal) on fever days. On an individual level, 12 of 15 participants had a higher mean LNS intake on days when they were not reported to be ill than on those when they were.

Of the 690 days when children were reported to be 'not ill', 32 days were omitted from the analysis of convalescent and healthy days because the timing of the last illness before the study began was unknown. During a two-week period of convalescence from illness, consumption of LNS was similar to the mean for healthy days (Table).

Findings of this preliminary study suggest that young children readily eat LNS during illness and convalescence. The accuracy of measuring child illness and the use of supplementary food are two possible limitations of the study, but these are unlikely to affect the internal validity of or the general picture obtained from these data. Maternal reports of child illness in low-income countries have been validated, even for two-week periods (8). This study minimized caregiver's recall bias by asking about a 24-hour period. Some food-sharing may have occurred within households. However, the pattern of lower LNS intake during illness, with a larger reduction in intake during fever, is similar to the pattern of food intake found in other studies of sick children (2,3) and suggests that most of supplement was consumed by the intended beneficiaries.

The World Health Organization recommends that caregivers continue to feed children during illness and increase intake thereafter (9). Identifying foods or supplements, such as LNS, that underweight children accept when they are ill or recovering and that are easy to use, may help caregivers follow feeding recommendations and prevent a worsening of the nutritional status of children (1,2). The results of this small pilot study suggest that LNS is well-accepted by ill and convalescing children and, as such, might offer the possibility for short-term feeding interven-

Table. Quantity of LNS consumed daily by health status

Health status	Mean (g)	95% CI	1st quartile	3rd quartile
Days when reported ill				
Fever (n=10)	38.2	26.8, 49.6	20.0	52.5
Diarrhoea (n=9)	45.6	33.6, 57.6	29.8	64.0
Cough (n=11)	47.0	37.8, 56.2	27.5	58.8
Other (n=6)	50.5	35.1, 65.8	36.0	76.0
Days when reported not ill				
Early convalescence (n=15) (1-7 day(s) after illness)	50.4	46.8, 54.1	29.0	65.0
Late convalescence (n=150 (8-14 days after illness)	52.3	49.1, 55.5	34.0	69.3
Healthy (n=16) (>14 days after illness)	49.6	47.1, 52.0	31.0	64.5

CI=Confidence Interval; LNS=Lipid-based nutrient supplement tions. This hypothesis could be tested in a randomized trial where young children are allocated to receive supplementary LNS regularly over a defined age-range or as 2-3-week auxiliary treatment during and after acute illnesses.

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REFERENCES

1. Scrimshaw NS, SanGiovanni JP. Synergism of nutrition, infection, and immunity: an overview. *Am J Clin Nutr* 1997;66:464S-477S.
2. Mata LJ, Kromal RA, Urrutia JJ, Garcia B. Effect of infection on food intake and the nutritional state: perspectives as viewed from the village. *Am J Clin Nutr* 1977;30:1215-27.
3. Brown KH, Stallings RY, Creed de Kanashiro H, Lopez de Romana G, Black RE. Effects of common illnesses on infants' energy intakes from breast milk and other foods during longitudinal community-based studies in Huascar (Lima), Peru. *Am J Clin Nutr* 1990;52:1005-13.
4. Hoare S, Poppitt SD, Prentice AM, Weaver LT. Dietary supplementation and rapid catch-up growth after acute diarrhoea in childhood. *Br J Nutr* 1996;76:479-90.
5. Manary MJ, Ndkeha MJ, Ashorn P, Maleta K, Briend A. Home-based therapy for severe malnutrition with ready-to-use food. *Arch Dis Child* 2004;89:557-61.
6. Adu-Afarwuah S, Lartey A, Brown KH, Zlotkin S, Briend A, Dewey KH. Home fortification of complementary foods with micronutrient supplements is well accepted and has positive effects on infant iron status in Ghana. *Am J Clin Nutr* 2008;87:929-38.
7. Flax VL, Ashorn U, Phuka J, Maleta K, Manary MJ, Ashorn P. Feeding patterns of underweight children in rural Malawi given supplementary fortified spread at home. *Matern Child Nutr* 2008;4:65-73.
8. Rousham EK, Northrop-Clewes CA, Lunn PG. Maternal reports of child illness and the biochemical status of the child: the use of morbidity interviews in rural Bangladesh. *Br J Nutr* 1998;80:451-6.
9. Dewey K. Guiding principles for complementary feeding of the breastfed child. Washington, DC: Pan American Health Organization, 2003. 37 p.

Valerie L. Flax[1,2], Kenneth Maleta[3], Ulla Ashorn[1], Mark J. Manary[4], André Briend[5], and Per Ashorn[2,6]

[1]School of Public Health, University of Tampere, Finland, [2]Department of International Health, University of Tampere Medical School, Finland, [3]College of Medicine, University of Malawi, Blantyre, Malawi, [4]Washington University School of Medicine, St. Louis, USA, [5]IRD, Département Sociétés et Santé, Paris, France, and [6]Department of Paediatrics, University of Tampere Hospital, Finland

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Research report

Malawian mothers' attitudes towards the use of two supplementary foods for moderately malnourished children

Valerie L. Flax [a,b,*], Chrissie Thakwalakwa [b], John Phuka [b], Ulla Ashorn [a,b], Yin Bun Cheung [c], Kenneth Maleta [d], Per Ashorn [b,e]

[a] School of Public Health, 33014 University of Tampere, Finland
[b] Department of International Health, University of Tampere Medical School, 33014 University of Tampere, Finland
[c] Singapore Clinical Research Institute, Nanos #02-01, 31 Biopolis Way, Singapore 138669, Singapore
[d] Department of Community Health, College of Medicine, University of Malawi, Private Bag 360, Blantyre 3, Malawi
[e] Department of Paediatrics, Tampere University Hospital, 33014 University of Tampere, Finland

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ABSTRACT

The efficacy of lipid-based nutrient supplements (LNS) versus corn–soy blend (CSB) in promoting the growth of moderately malnourished children is currently being tested, but information about maternal attitudes towards the two supplements is lacking. This research studied 504 Malawian mothers' attitudes about LNS and CSB through exit interviews completed at the end of three 12-week clinical trials and compared differences between the groups. Exploratory analyses of factors associated with withholding of supplements during fever, diarrhea, and cough were performed using logistic regression. Mothers generally had similar, positive attitudes towards LNS and CSB. Both supplements were said to be highly acceptable, children learned to eat them within two weeks, and mothers were willing to use them again. Mothers in the LNS group were reportedly more likely to withhold supplements from their children during cough, due to its sweetness, and were willing to pay more for a one-week supply of supplement than mothers in the CSB group. Maternal literacy was negatively and child's weight-for-height *z*-score was positively associated with withholding of supplements during illness. Our results indicate that the sweetness in LNS should be reduced, and programs using supplements in Malawi could include advice on appropriate feeding of supplements during illness.

Introduction

Moderate malnutrition affects a large number of children younger than five years in low-income countries (United Nations Children's Fund, 2008), and contributes to child mortality and disease burden (Black et al., 2008). It is also associated with increased morbidity (Mata, Kromal, Urrutia, & Garcia, 1977; Scrimshaw & SanGiovanni, 1997), and if left untreated may progress to severe acute malnutrition. Supplementary feeding programs to treat moderately malnourished children have existed for decades, and have typically used micronutrient-fortified corn–soy blend (CSB) (Dijkhuizen, 2000; Hoppe et al., 2008). Similar types of fortified cereal or cereal/legume mixtures tested in Africa and Asia have had inconsistent effects on child growth (Bhandari et al., 2001; Dewey & Adu-Afarwuah, 2008; Lartey, Manu, Brown, Peerson, & Dewey, 1999; Oelofse et al., 2003; Owino et al., 2007).

Lipid-based nutrient supplements (LNS) are ready-to-use foods that are attractive food supplements for malnourished children because they can supply adequate nutrients in a hygienic form that requires no cooking (Briend, 2002). LNS are effective for treating severe acute malnutrition in children at home (Manary, Ndekha, Ashorn, Maleta, & Briend, 2004; World Health Organization/World Food Programme/United Nations System Standing Committee on Nutrition/The United Nations Children's Fund, 2007), and some evidence that LNS improves the growth of moderately malnourished children is now available (Adu-Afarwuah et al., 2007; Matilsky, Maleta, Castleman, & Manary, 2009; Phuka et al., 2008). There is strong interest in the international community in the possibility of using LNS for the prevention and treatment of moderate malnutrition in children (The PLoS Medicine Editors, 2008). Large trials comparing different versions of LNS to CSB or other supplements in this target group are underway, but information about similarities or differences in maternal attitudes towards the two foods is lacking.

* Corresponding author at: Department of International Health, University of Tampere Medical School, Finn-Medi 3 Building, FIN-33014 University of Tampere, Finland.
E-mail address: valerie.flax@uta.fi (V.L. Flax).

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Because mothers often have the main responsibility for feeding young children, data on maternal attitudes towards a new food for children are essential for designing interventions to incorporate it into a particular social and cultural setting (Bentley et al., 1991; Kanashiro et al., 1991). No published data on maternal attitudes towards CSB are available. Maternal attitudes towards LNS have been reported in only one study, which found that mothers had similar and generally positive attitudes towards LNS and two non-food micronutrient supplements (Adu-Afarwuah et al., 2008). Additional information on maternal attitudes towards LNS is needed from different locations and as compared to another food-based supplement, like CSB. An understanding of the reasons or factors underlying maternal attitudes towards supplements may also be helpful to programs.

The main aim of this study was to determine if maternal attitudes towards a new supplementary food (LNS) were similar to those of a well-known and widely available supplement (CSB). As a secondary focus, this research identified predictors of particular maternal attitudes, especially use of supplements during illness.

Methods

Study area and timing

The data used in this paper were taken from three community-based clinical trials conducted in the rural areas around seven health centers in Mangochi district, southern Malawi. The total population of the catchment areas covered by the health centers was approximately 215,000. The people living in the area are subsistence farmers and fisherman, mainly from the Yao ethnic group. The studies took place during the following periods: Study 1 (March–July 2005); Study 2 (January–May 2007); and Study 3 (November 2007–April 2008). The primary results of Study 1 have been published (Phuka et al., 2009) and those of Studies 2 and 3 are currently being analyzed.

Eligibility, enrollment, and randomization of participants

The eligibility criteria for the three studies were the same. Inclusion criteria were as follows: 6–14 months of age; weight-for-age *z*-score (WAZ) <-2.0; guardian-signed informed consent; and residence in the area throughout the study period. Because the age of greatest growth faltering in the target population is 6–18 months of age, participants were selected so that they completed the study before they reached the upper limit of this age range. Children were excluded if they had weight-for-height *z*-score (WHZ) <-3.0, presence of edema, severe illness warranting hospital referral on the day of enrollment, peanut allergy, or if they were already participating in another clinical trial. Details of the processes for enrolling and randomizing participants in Study 1 have been reported elsewhere (Phuka et al., 2009), and similar processes were used in Studies 2 and 3.

Interventions and follow-up

In all three studies, the follow-up period was 12 weeks and participants received one of the two food supplements – CSB or LNS – or they received no supplements (controls). Because the present paper is focused on maternal attitudes towards supplement use, controls were not included.

CSB was packed in 500 g bags (supplied by Rab Processors, Blantyre, Malawi) and contained corn and soy flours, sugar, and micronutrients. LNS was packed in 50 g foil packets (produced by Nutriset, Malaunay, France) in Study 1 and in 300 g plastic jars (produced by Project Peanut Butter, Blantyre, Malawi) in Studies 2 and 3. LNS contained peanut butter, milk powder, cooking oil, sugar, and micronutrients. The nutrient composition of the CSB and LNS used in these studies can be found in Phuka et al. (2009).

In Study 1, participants received either 71 g/day (282 kcal) of CSB or 50 g/day (256 kcal) of LNS. In Studies 2 and 3, there were three intervention groups: no supplement (controls), 71 g/day CSB, and 43 g/day (220 kcal) LNS. The quantities of supplements participants received were selected so that the caloric value of the two supplements was roughly comparable and the logistics of supplying supplements was simple (e.g., 1 bag of CSB or 1 jar of LNS per week). Supplements were delivered to participants' homes weekly in Studies 1 and 2, whereas participants in Study 3 obtained their supplements from the health center monthly. During weekly home visits in Study 1, mothers in both study groups reported that supplements were shared $<$1% of the time and 4.9% of CSB and 6.5% of LNS had not been consumed (Phuka et al., 2009).

CSB must be cooked as porridge, but mothers could choose whether to feed the child LNS plain or mixed with porridge. Mothers were provided with spoons. In Study 1, they were advised to give their child either porridge containing 12 spoons of CSB or 1 packet of LNS per day. In Studies 2 and 3, they were told to give their child porridge containing 4–5 spoons of CSB or 2–3 spoons of LNS 2–3 times per day. All mothers were encouraged to continue breastfeeding on demand.

Sample size

Sample sizes for the individual studies were calculated based on comparison of weight gain between intervention groups. Pooling exit interviews from three trials ($n = 250$ per supplementation group), the present study has a precision level (width of 95% confidence interval) of $\pm$6% for estimation of proportions in each supplementation group for binary variables, such as those used in the main analysis, that have maximum variability. Precision is higher for less evenly distributed binary variables.

Data collection and processing

The exit interview used in these three studies was originally developed for a pilot study in which caregivers of 16 children who had received LNS for 12 weeks were asked open-ended questions during tape-recorded interviews. These questions were then modified into a semi-structured questionnaire that was administered by research assistants to caregivers at their homes at the end of Study 1. Following the completion of Study 1, a few questions were slightly modified and some questions were dropped to produce the questionnaire that was used in Studies 2 and 3. In this paper, only those questions that were the same or similar in all studies were analyzed.

The exit interview questionnaire contained both open- and closed-ended questions. Closed-ended questions were asked about whether supplements were food or medicine; whether supplements should be given during fever, diarrhea, or cough; how easy or difficult it was for the child to eat the supplement; willingness to use supplements again; and willingness to buy supplements. Responses to these questions were dichotomized either by dropping the 'don't know' category or by dividing a 5-point scale so that the two highest categories (e.g., very and somewhat willing) were placed in one group and the other three categories (e.g., neutral, somewhat and very unwilling) were combined in a second group. Open-ended questions were used to assess: positive aspects of supplements; aspects of supplements mothers disliked; changes noticed in the child; how long it took the child to adapt to eating the supplement; the most convenient place to obtain supplements; possible frequency of travel to health center to obtain supplements; reasons why supplements are food or medicine; and reasons why mothers would or would not give supplements during illness. One author (VF), who was blinded to the type of supplement assigned to participants, coded responses to open-ended questions using content analysis to identify themes. Each theme for a given attitude was reviewed to determine whether the content or intensity differed between the CSB and LNS groups, and proportions of all themes for each open-ended question were calculated by study group. Due to the similar content and proportions of themes in both groups, for the main analysis, responses were then dichotomized so that the largest response category or a cluster of related responses represented the mothers' main attitude regarding a particular issue and other responses were combined to form a second category. For example, on the question about changes noticed in the child, responses describing positive changes formed the main category and neutral or negative responses were combined into a second category.

A description of the methods used to obtain anthropometric data for Study 1 is provided in Phuka et al. (2009); similar methods were used in the other two studies. Briefly, weight, height, and mid-upper arm circumference were measured by a researcher (JP) blinded to the participants' study allocation. Anthropometric indices (weight-for-age *z*-score, height-for-age *z*-score, and weight-for-height *z*-score) were calculated using the CDC 2000 growth reference. In all studies, background information on the participants' families, including family assets and maternal literacy, was obtained through questionnaires administered by research assistants during the first visit to the health center.

Data analysis

The data were entered to a Microsoft Access database and analyzed using Stata (version 9.2). For the primary analysis, responses to all questions were placed in two categories and proportions for each food group were obtained. The difference between the proportions and its 95% confidence limit and *p*-value were then calculated. *p*-values were obtained with Fisher's exact test. After excluding 'don't know' replies, numerical responses (from about 91% of participants) to an open-ended question about how much mothers are willing to pay for a one-week supply of supplement were used to calculate the mean price per study group and the difference was tested using *t*-test.

Secondary, exploratory analyses were conducted to gain an understanding of possible factors underlying specific maternal attitudes. Multiple logistic regression models were constructed to detect associations between health and socioeconomic factors selected *a priori* and mothers' perception of the supplement as food not medicine as well as maternal reports of withholding the supplement during fever, diarrhea, and cough. The type of supplement was included in the models to control for differences between study groups. An asset index was created based on a set of assets by using principal components analysis to assess long-term economic welfare in households of participating children (Filmer & Pritchet, 2001). The asset index, child's age at the start of the study, and child's weight-for-height *z*-score (WHZ) at the start of the study were included in the models as continuous explanatory variables. WHZ was chosen because it indicates the level of the child's thinness or wasting, which mothers can easily identify. Maternal literacy represented whether or not mothers could write their names and was entered in the models as a binary variable. In a sub-sample with known maternal age ($n = 234$), maternal age had no association with belief that the supplement was food ($p = 0.159$) or with withholding the supplement during fever ($p = 0.820$), diarrhea ($p = 0.405$), or cough ($p = 0.809$), and was excluded in the models so that the full sample could be used. The correlations between the regression coefficients for each of the final models were examined and none of the predictors were found to be strongly correlated with one another.

Ethics

Ethical approval for these studies was obtained from the College of Medicine Research and Ethics Committee at the University of Malawi and from the Ethical Committee of the Pirkanmaa Hospital District in Finland. Details of the protocols were provided to the clinical trials registry of the National Library of Medicine, Bethesda, MD, USA (http://www.clinicaltrials.gov, trial identification numbers NCT00131222, NCT00420368, NCT00420758).

Results

Background characteristics

In total, 1278 children were invited to the enrollment session, 667 individuals met the inclusion criteria, and 522 of these were randomized to the CSB and LNS groups (Fig. 1). Of the 506 participants who completed the follow-up, exit interviews were obtained from 504 (CSB 255, LNS 249). There were no significant differences in the socioeconomic and demographic characteristics of the two study groups (Table 1).

Maternal attitudes towards supplements

To check for errors in recording open-ended responses given in the local language onto data collection forms in English, we compared the open-ended responses in this large sample to those from tape-recorded exit interviews in our pilot study. We found no differences in the main themes and types of responses.

Overall, most maternal attitudes about CSB and LNS were quite similar (Table 2), as were the tone and content of their replies to open-ended questions. Consequently, quotes from open-ended questions are used here only to illustrate differences between the groups or clarify possible programmatic issues. Key themes from open-ended questions and the proportion of participants who provided these responses in each study group are reported in the text below.

The majority of mothers in both groups described positive aspects of the supplement, said there was nothing they disliked about the supplement, and noticed positive changes in the child at the end of the study (Table 2). When mothers in both groups were asked about the positive aspects of supplements, they most frequently mentioned that the child liked the sweetness of the food (CSB 32%, LNS 34%), that the supplement improved the child's health or growth (CSB 17%, LNS 19%), or that the child liked eating the supplement (CSB 16%, LNS 15%). A small proportion of mothers in each group (12%) named something they disliked about the supplements. They most frequently said there were problems with the contents or preparation of supplements. The types of problems

Table 1
Selected demographic and socioeconomic characteristics of participants who completed the exit interviews, by group.

Characteristics	Study group	
	CSB	LNS
Number (%) of participants	255 (51%)	249 (49%)
Number (%) of males	134 (53%)	120 (48%)
Mean (SD) age at start of study (months)	11.3 (2.7)	11.0 (2.6)
Mean (SD) number of family members	4.8 (1.8)	4.6 (1.8)
Number (%) of mothers who are literate	72 (28%)	87 (35%)
Housing materials		
Burned brick	43 (17%)	42 (17%)
Unburned brick	177 (69%)	173 (69%)
Other (less expensive than bricks)	35 (14%)	34 (14%)
Mean (SD) weight-for-height *z*-score at start of study	−1.1 (0.9)	−1.2 (0.9)

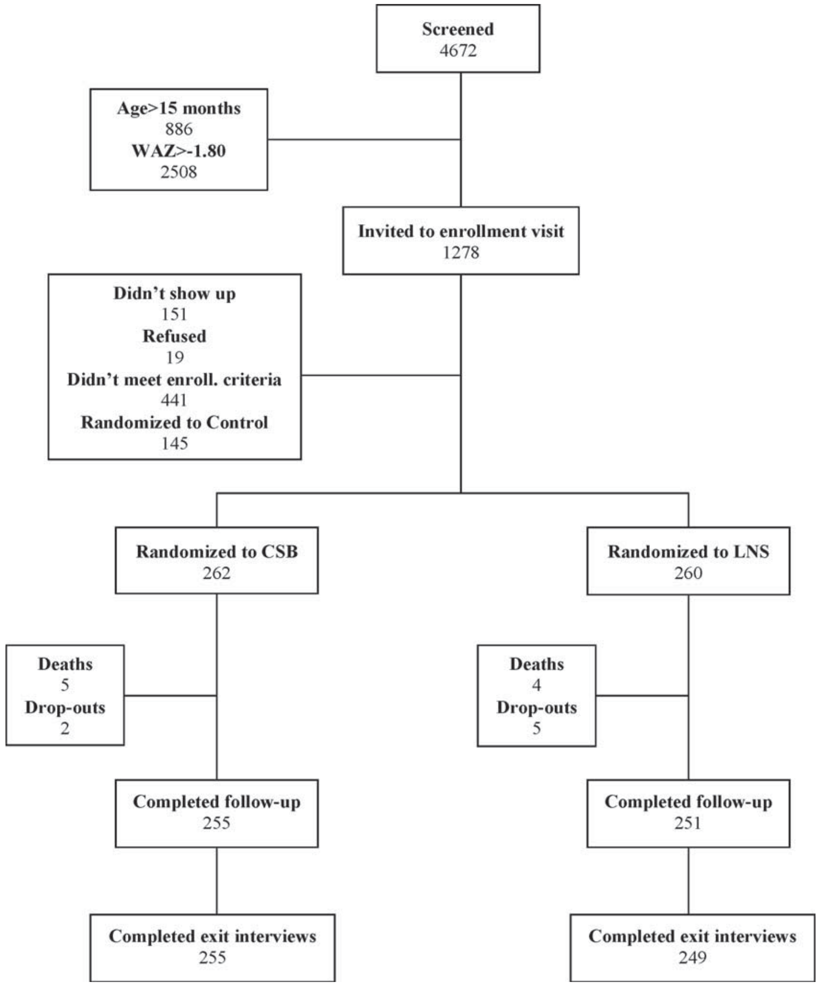

Fig. 1. Profile of the three studies. CSB, corn–soy blend; LNS, lipid-based nutrient supplements.

described differed between the groups. Mothers in the CSB group who disliked something about the supplement raised issues such as CSB does not have enough sugar or it is difficult to cook, whereas mothers in the LNS group most often said that LNS contained too much sugar or they disliked the taste of the cooking oil in it. Changes mothers noticed in their child at the end of the intervention included: the child looked healthier (CSB 51%, LNS 59%), had gained weight (CSB 29%, LNS 22%), or got sick less often (CSB 10%, LNS 8%).

Table 2
Maternal attitudes towards supplements, by study group[a].

Maternal attitudes	CSB	LNS	Difference between groups (95% CI)	*p*-value
Percentage of mothers who reported[b]				
Supplement had positive aspects	97%	97%	0% (−3%, 3%)	0.800
Supplement did not have negative aspects	87%	88%	1% (−5%, 6%)	0.783
There were positive changes in child after feeding supplement for 12 weeks	92%	93%	1% (−4%, 5%)	0.863
It was easy for child to eat supplement compared to usual foods (acceptability)	95%	93%	−2% (−6%, 3%)	0.469
Child learned to eat supplement within the first two weeks	86%	85%	−1% (−8%, 5%)	0.690
Supplement is food rather than medicine	70%	69%	−1% (−9%, 7%)	0.845
Supplement should NOT be given to child during				
Fever	23%	22%	−1% (−9%, 6%)	0.828
Diarrhea	19%	25%	6% (−1%, 14%)	0.101
Cough	25%	38%	13% (5%, 21%)	0.002
They are willing to use supplement again if provided for free	96%	94%	−2% (−6%, 2%)	0.310
They are willing to travel to health center for free supplement	99%	98%	−1% (−3%, 1%)	0.278
They are willing to buy supplement if for sale	96%	94%	−2% (−6%, 2%)	0.292
Health center is the most convenient place to buy supplement	56%	52%	−4% (−13%, 5%)	0.402
Price evaluation[c]				
Mean (SD) amount willing to pay (in Malawian kwacha) for one week of supplement	42 (35)	53 (48)	11 (3, 19)	0.011

[a] CSB, micronutrient-fortified corn–soy blend; LNS, lipid-based nutrient supplements.
[b] Responses to all questions were dichotomized and 'don't know' responses were excluded from the analysis. *p*-value for difference in proportions by Fisher's exact test.
[c] *p*-value for difference between means obtained by *t*-test, non-numeric responses were excluded from the analysis. The average exchange rate during the studies was 136 Malawian kwacha = 1 US$. 2007 GDP per capita = 36,800 Malawian kwacha (IMF World Economic Outlook Database, http://www.imf.org).

Most mothers in both food groups said that it was easy for the child to eat the supplement as compared to usual food. The majority also reported that the child learned to eat the supplement during the first two weeks of the study (Table 2), including those who found it easy to eat the supplement from the beginning of the study period (CSB 62%, LNS 59%) and children for whom it became easier during the first or second week of the study (CSB 24%, LNS 26%). Among those who had difficulty adapting to eating the supplement, different reasons emerged. Some children took longer to learn the new taste and a few never learned, others got used to eating the study food only when they recovered from initial illnesses, while still others were described as being poor eaters. The following quotes highlight these issues:

> "During the first three weeks, he refused to eat it and I was forcing him. After that, he ate it well until the end of the study." (CSB)

> "She started eating it well during the second month of the study, when she was not suffering from cough, fever, and diarrhea anymore." (CSB)

> "Since she was born, she was reluctant to eat any kind of food. It was the same with LNS." (LNS)

The majority of mothers in both groups said that the supplement is food, not medicine (Table 2). Among mothers who considered the supplement to be food, the main reasons were that it was edible and satisfied the child's hunger (CSB 47%, LNS 49%), it looked like food or contained ingredients that are food (CSB 33%, LNS 26%), or it improved the child's health (CSB 11%, LNS 9%). Like the latter group of mothers who said that the supplement is food, mothers who said that the supplement is medicine also believed it was so because it improved the child's health, either by helping the child's nutritional status or by curing or preventing illness (CSB 68%, LNS 79%). Most mothers did not name a specific illness that could be prevented or cured by the supplement, but a few mentioned that their child's diarrhea stopped after starting to eat the supplement. Mothers who said that the supplement is medicine appeared to recognize that it is food but think that it contains medicine or to believe that it has aspects of both food and medicine. Excerpts from mothers' responses illustrate these opinions:

> "In this food there are substances that I believe are medicine." (LNS)

> "[It is medicine] because there is a mixture of vitamins in the porridge." (CSB)

> "At first my child was sick, but now she is fine. That is why it is medicine. It is also food because it gives my child energy." (LNS)

When asked about feeding the supplement to the child during illness, a significantly greater proportion of mothers whose child received LNS than CSB stated that they would withhold the supplement when the child had a cough (Table 2). Although the difference was not significant, a larger proportion of mothers in the LNS than CSB group also said they would not give the supplement during diarrhea, while similar proportions of mothers in both groups reported withholding of supplements during fever. Among mothers who would withhold supplements during illness, the reasons were similar in the two study groups. Loss of appetite was named as a reason for withholding of supplements during fever (CSB 81%, LNS 80%), diarrhea (CSB 56%, LNS 51%), and cough (CSB 27%, LNS 28%). In both groups, mothers who said they would withhold the supplement during cough stated that the sugar in the supplement made the cough worse and/or caused vomiting (CSB 73%, LNS 72%). A mother whose child received LNS explained, "It is not good because this food has a lot of sugar, which can cause high cough that results in the child vomiting." Some mothers stated that they would not give the supplement during diarrhea because it makes diarrhea worse or causes vomiting (CSB 23%, LNS 24%). Mothers in the LNS group mentioned more serious effects of the supplement when used during diarrhea than those in the CSB group, and there was a larger proportion of mothers in the LNS group who said they would not give the supplement during diarrhea because they believed or suspected it caused the diarrhea (CSB 3%, LNS 16%). A mother whose child received LNS gave a typical explanation for this group, "It is not good because it makes the child have fast diarrhea that doesn't stop." In contrast, mothers whose children had CSB generally said that the child vomits if given CSB during diarrhea or that "the diarrhea might continue."

Nearly all mothers in both groups stated that if supplements were provided for free they would be willing to use supplements again and to travel to the health center to get them (Table 2). Approximately three-quarters of the mothers reported they could go to the health center to pick up supplements at least once per month (CSB 74%, LNS 72%). When asked who or what would facilitate their going to the health center for free supplements, most mothers mentioned transportation issues: either they could go to the health center by foot because it was nearby (CSB 40%, LNS 31%) or they would need a bicycle or money for transport because the distance was too far (CSB 20%, LNS 27%). About half of the mothers in both groups stated that the most convenient place to buy supplements was the health center (Table 2), other commonly mentioned locations were markets or groceries (CSB 16%, LNS 21%) or in the village (CSB 10%, LNS 11%).

Of the mothers who gave numerical replies (405/446 = 91%) when asked how much they were willing to pay for a one-week supply of the supplement, the mean price mothers in the LNS group were willing to pay was higher than that of the CSB group (Table 2). The prices suggested by mothers ranged from 5 to 200 kwacha in both study groups. The median prices were 40 and 50 kwacha in the CSB and LNS groups, respectively, and the interquartile range was the same in both groups (20, 50 kwacha). Proportions of different types of non-numeric responses to the price question were similar between the groups (willing to pay (CSB 8%, LNS 8%), cannot buy it (CSB 1%, LNS 2%)).

The majority of mothers in both groups (CSB 88%, LNS 85%) said that they controlled the use of the supplement in their family (not shown in table). When mothers discussed the supplement with someone else, they most frequently talked about it with their husbands (CSB 49%, LNS 56%) or their own mothers (CSB 25%, LNS 17%).

Factors associated with specific maternal attitudes

Exploratory analyses were carried out to determine if selected maternal, child, and socioeconomic factors were associated with the maternal belief that the supplement is food, not medicine and with mothers' reports that they would withhold the supplement if the child has fever, diarrhea, or cough. Several factors were entered at one time into separate logistic regressions models for each of these maternal attitudes. Child's age at the start of the study, child's WHZ score at the start of the study, maternal literacy, and socioeconomic status (using an asset index) were not associated with mother's belief that the supplement is food (Table 3). In models for mothers' reports that they would withhold the supplement during illness, use of LNS was positively associated with withholding during cough and less strongly associated with diarrhea (Table 3). Maternal literacy was negatively associated while the child's WHZ at the start of the study was positively associated with withholding during fever, diarrhea, and cough.

Table 3
Multivariable logistic regression analyses of factors associated with mothers' beliefs about supplements and their practices related to supplement use during child illness.

Predictor variables	Odds ratio (95% CI)			
	Mothers believe supplement is food not medicine	Mothers report they would withhold supplement if child has fever	Mothers report they would withhold supplement if child has diarrhea	Mothers report they would withhold supplement if child has cough
Participation in LNS group	0.94 (0.64, 1.38)	1.01 (0.66, 1.57)	1.53 (0.97, 2.38)*	2.03 (1.36, 3.05)‡
Child's age at start of study	1.01 (0.93, 1.08)	1.00 (0.92, 1.08)	0.94 (0.86, 1.02)	1.02 (0.95, 1.11)
Child's WHZ at start of study	0.89 (0.71, 1.11)	1.31 (1.02, 1.68)†	1.39 (1.08, 1.79)†	1.39 (1.10, 1.74)‡
Maternal literacy	1.18 (0.77, 1.80)	0.46 (0.28, 0.78)‡	0.55 (0.33, 0.92)†	0.54 (0.34, 0.85)‡
Asset index	1.07 (0.92, 1.24)	0.98 (0.83, 1.16)	1.07 (0.90, 1.27)	0.99 (0.85, 1.16)

WHZ, weight-for-height *z*-score; Asset index is a proxy for socioeconomic status and was calculated using principal components analysis.
* $p < 0.10$.
† $p < 0.05$.
‡ $p < 0.01$.

Discussion

The main aim of this research was to compare Malawian mothers' attitudes towards two types of food supplements for moderately malnourished children. We found that mothers' attitudes towards LNS and CSB were positive and quite similar. Most mothers in both study groups reported that supplements were highly acceptable, the child learned to eat the supplement within two weeks, and they would be willing to buy supplements and use them again. Mothers in the LNS group were reportedly more likely to withhold supplements from their children during cough and were willing to pay more for a one-week supply of the supplement than mothers in the CSB group. The variability in responses from both study groups regarding belief in supplements as food versus medicine and withholding during illness was greater than for other questions studied here. As such issues might be of programmatic importance, we explored possible predictors of these particular beliefs and practices. We were not able to identify any significant predictors of mothers' belief that supplements were food, but we found that use of LNS was associated with the attitude that the supplement should not be given during cough and less strongly associated with diarrhea. In addition, child's WHZ at the start of the study was positively associated while maternal literacy was negatively associated with withholding during fever, cough, and diarrhea.

The main strengths of this study were a large total sample size taken from randomized clinical trials with few drop-outs and the use of CSB, a common supplement, as the comparison group. Although we chose to present a summary of themes, illustrated with quotes, rather than a detailed qualitative analysis, collecting qualitative data on maternal attitudes towards supplements was beneficial because we obtained culturally appropriate information that helped explain responses to some of the closed-ended questions.

This study had some limitations. Because our data were collected at the end of intervention trials comparing the effects of supplements on child growth, mothers used only one supplement—either CSB or LNS. We cannot be certain that mothers' attitudes towards the supplements would be similar if they had had the opportunity to try them both before responding to the questions (see Paul, Dickin, Ali, Monterrosa, & Stoltzfus, 2008). Another possible limitation was the lack of data on other predictors that might be important in the regression models, such as maternal age and food security. Information on maternal age was available for a sub-sample within our data set, but was not significantly associated with the any of the outcomes and was excluded in the final models to allow the use of the full sample. Although seasonal differences in levels of food security are marked in Malawi (Maleta, Virtanen, Espo, Kulmala, & Ashorn, 2003), data on food security were not collected during these studies as each took place within a short time period when the general level of food security would have been similar for the participants. Given these possible limitations and the exploratory nature of the regression analyses, the models presented here should be interpreted cautiously, but could provide preliminary evidence to guide future research.

The positive quality and similarity in attitudes found in this study of LNS and CSB mirror results for LNS and two non-food micronutrient supplements in Ghana (Adu-Afarwuah et al., 2008). There were, however, a few important differences between the study groups, and some issues that may be of programmatic importance were identified. We found that the majority of mothers believed that LNS and CSB were food, not medicine. In fact, some mothers who said that the supplement was medicine explained that it had aspects of both food and medicine or that it was food that contained medicine, indicating that our closed-ended question (*Is the supplement food or medicine?*) did not capture the nuances of mothers' perceptions. Similar types of problems have been noted in other surveys in Malawi (Launiala, 2009), and this may explain, in part, why we were not able to identify any predictors of this belief in a regression model. The issue of whether supplements are seen as food or medicine is important because it may affect how they are used within households and could influence whether they are shared. Supplementary feeding studies have frequently dealt with food sharing either by controlling the distribution and consumption of supplements or by providing supplementary food to the whole family (Durnin, Aitchison, Beckett, Husaini, & Pollitt, 2000; Krahenbuhl, Schutz, & Jequier, 1998; Manary et al., 2004; Owino et al., 2007; Rivera & Habicht, 2002; Simondon et al., 1996), but these methods are not feasible on a population level. An alternative approach was taken in one study in Malawi where mothers were told at enrollment that LNS and CSB were medical treatments for their moderately wasted children (Matilsky et al., 2009). While focusing on the "medicinal" qualities of supplements might prevent sharing in a short trial, during longer periods of supplementation it could have the unintended consequence of making mothers think they can discontinue use when their child no longer has symptoms or looks better, as has occurred when other health-related products were marketed as medicine (Bentley, 1988). Further research on Malawian mothers' conceptions of the terms "food" and "medicine" is needed before selecting the most appropriate approach for promoting supplements, and other possible avenues for preventing supplement sharing should be explored.

We have focused part of this research on the use of supplements during illness because children in low-income countries are frequently ill and illness is associated with child nutritional status (Mata et al., 1977; Scrimshaw & SanGiovanni, 1997). The design of our questionnaire did not allow us to determine whether use of supplements during illness was a major concern for mothers. However, the continued consumption of supplements could well be important for maintaining children's nutrient intake during illness (Brown, 2001), and, consequently, for programs promoting supplements. In this study, mothers whose children received LNS were about 1.5 and 2 times more likely than those who received CSB to say that they would withhold the supplement during diarrhea and cough. The differences between the study groups in relation to diarrhea are probably explained by mothers' opinions about the stronger effect of LNS on diarrhea symptoms. The greater likelihood of withholding LNS than CSB during cough was related to its sweeter taste and to the belief that sweet food makes a cough worse, suggesting that this version of LNS may be too sweet. This conclusion should be considered in light of the finding that sweetness was the most frequently mentioned positive aspect of both supplements. Having some sugar in supplements is supported by research showing that children have a preference for sweet food from early in life (Kare & Beauchamp, 1985) and that mothers liked the sweetness of a processed complementary food for their children (Paul et al., 2008). Our results regarding sweetness of supplements highlight the importance of listening to mothers' opinions related to new foods for their children and balancing positive and negative aspects to get a product that is acceptable and likely to be used appropriately (Bentley et al., 1991; Kanashiro et al., 1991).

We identified several factors that are associated with mothers' reports of withholding of supplements during illness, particularly maternal literacy and child's WHZ at the start of the study. Maternal education is known to be associated with child feeding and caring practices (Engle, Menon, & Haddad, 1997), such as more frequent initiation of child feeding (Guldan et al., 1993) and a more nurturing style of feeding (LeVine et al., 1991), which supports our finding that literate mothers are less likely to withhold supplements during illness. Our detection of an association between child's nutritional status and maternal feeding practices is consistent with reports of preferential feeding of thin or poorly growing children (Piwoz, Black, Lopez de Romana, de Kanashiro, & Brown, 1994; Simondon & Simondon, 1995). Mothers' feeding behaviors, in general and during illness, might also be influenced by the undesirability in Malawian cultures of having a child who is too thin because it indicates that parents are not following culturally prescribed rules of abstinence (Bezner Kerr, Dakishoni, Shumba, Msachi, & Chirwa, 2008; Munthali, 2002).

In conclusion, this study found that mothers' attitudes towards a new type of supplementary food, LNS, are comparable to those towards a widely used supplement, CSB, suggesting that mothers of target children in this setting would likely be able to adopt LNS and adapt to using it, if it replaced CSB in supplementary feeding programs. Our results indicate that the sweetness in LNS should be reduced to make it more acceptable for use during cough, and future research and programs using supplements in Malawi could include advice on appropriate feeding of supplements during illness. Additional information on how the labeling of supplements as food or medicine affects their long-term use is needed.

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References

Adu-Afarwuah, S., Lartey, A., Brown, K. H., Zlotkin, S., Briend, A., & Dewey, K. H. (2007). Randomized comparison of 3 types of micronutrient supplements for home fortification of complementary foods in Ghana: effects on growth and motor development. *American Journal of Clinical Nutrition, 86*(2), 412–420.

Adu-Afarwuah, S., Lartey, A., Brown, K. H., Zlotkin, S., Briend, A., & Dewey, K. H. (2008). Home fortification of complementary foods with micronutrient supplements is well accepted and has positive effects on infant iron status. *American Journal of Clinical Nutrition, 87*(4), 929–938.

Bentley, M. E. (1988). The household management of childhood diarrhea in rural north India. *Social Science and Medicine, 27*(1), 75–85.

Bentley, M. E., Dickin, K. L., Mebrahtu, S., Kayode, B., Oni, G. A., Verzosa, C. C., et al. (1991). Development of a nutritionally adequate and culturally appropriate weaning food in Kwara State, Nigeria: an interdisciplinary approach. *Social Science and Medicine, 33*(10), 1103–1111.

Bezner Kerr, R., Dakishoni, L., Shumba, L., Msachi, R., & Chirwa, M. (2008). "We grandmothers know plenty": breastfeeding, complementary feeding and the multifaceted role of grandmothers in Malawi. *Social Science and Medicine, 66*(5), 1095–1105.

Bhandari, N., Bahl, R., Nayyar, B., Khokhar, B., Rohde, J., & Bhan, M. K. (2001). Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. *Journal of Nutrition, 131*(7), 1946–1951.

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., et al. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet, 371*, 243–260.

Briend, A. (2002). Possible use of spreads as a FOODlet for improving the diets of infants and young children. *Food and Nutrition Bulletin, 23*(3), 239–243.

Brown, K. H. (2001). A rational approach to feeding infants and young children with acute diarrhea. In C. H. Lifschitz (Ed.), *Pediatric gastroenterology and nutrition in clinical practice*. New York: Marcel Dekker Inc.

Dewey, K. G., & Adu-Afarwuah, S. (2008). Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Maternal and Child Nutrition, 4*(Suppl. 1), 24–85.

Dijkhuizen, P. (2000). Processed complementary foods in the World Food Programme. *Food and Nutrition Bulletin, 21*(1), 62–64.

Durnin, J. V. G. A. , Aitchison, T. C., Beckett, C., Husaini, M., & Pollitt, E. (2000). Nutritional intake of an undernourished infant population receiving an energy and micronutrient supplement in Indonesia. *European Journal of Clinical Nutrition, 54*(Suppl. 2), S43–S51.

Engle, P. L., Menon, P., & Haddad, L. (1997). *Care and nutrition: concepts and measurement*. Washington, DC: International Food Policy Research Institute.

Filmer, D., & Pritchet, L. H. (2001). Estimating wealth effects without expenditure data-or tears: an application to educational enrollments in states of India. *Demography, 38*(1), 115–132.

Guldan, G. S., Zeitlin, M. F., Beiser, A. S., Super, C. M., Gershoff, S. N., & Datta, S. (1993). Maternal education and child feeding practices in rural Bangladesh. *Social Science and Medicine, 36*(7), 925–935.

Hoppe, C., Andersen, G. S., Jacobsen, S., Molgaard, C., Friis, H., Sangild, P. T., et al. (2008). The use of whey or skimmed milk powder in fortified blended foods for vulnerable groups. *Journal of Nutrition, 138*(1), 145S–161S.

Kanashiro, H. C., Fukumoto, M., Bentley, M. E., Jacoby, E., Verzosa, C., & Brown, K. H. (1991). Use of recipe trials and anthropological techniques for the development of a home-prepared weaning food in the central highlands of Peru. *Journal of Nutrition Education, 23*(1), 30–35.

Kare, M. R., & Beauchamp, G. K. (1985). The role of taste in the infant diet. *American Journal of Clinical Nutrition, 41*(2 Suppl.), 418–422.

Krahenbuhl, J. D., Schutz, Y., & Jequier, E. (1998). High fat versus high carbohydrate nutritional supplementation: a one year trial in stunted rural Gambian children. *European Journal of Clinical Nutrition, 52*(3), 213–222.

Lartey, A., Manu, A., Brown, K. H., Peerson, J. M., & Dewey, K. G. (1999). A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micronutrient status of Ghanaian infants from 6 to 12 months of age. *American Journal of Clinical Nutrition, 70*(3), 391–404.

Launiala, A. (2009). How much can a KAP survey tell us about people's knowledge, attitudes and practices? Some observations from medical anthropology research on malaria in pregnancy in Malawi. *Anthropology Matters, 11*(1), 1–13.

LeVine, R. A., LeVine, S. E., Richman, A., Uribe, F. M. T., Sunderland-Correa, C., & Miller, P. M. (1991). Women's schooling and child care in the demographic transition: a Mexican case study. *Population and Development Review, 17*(3), 459–496.

Maleta, K., Virtanen, S. M., Espo, M., Kulmala, T., & Ashorn, P. (2003). Seasonality of growth and relationship between weight and height gain in children under three years of age in rural Malawi. *Acta Paediatrica, 92*(4), 491–497.

Manary, M. J., Ndekha, M., Ashorn, P., Maleta, K., & Briend, A. (2004). Home-based therapy for severe malnutrition with ready-to-use food. *Archives of Disease in Children, 89*(6), 557–561.

Mata, L. J., Kromal, R. A., Urrutia, J. J., & Garcia, B. (1977). Effect of infection on food intake and the nutritional state: perspectives as viewed from the village. *American Journal of Clinical Nutrition, 30*(8), 1215–1227.

Matilsky, D. K., Maleta, K., Castleman, T., & Manary, M. J. (2009). Supplementary feeding with fortified spreads results in higher recovery rates than with a corn/soy blend in moderately wasted children. *Journal of Nutrition, 139*(4), 773–778.

Munthali A. C. (2002). *Change and continuity: perceptions about childhood diseases among the Tumbuka of Northern Malawi*. Ph.D. thesis. Grahamstown, South Africa: Rhodes University.

Oelofse, A., Van Raaij, J. M., Benade, A. J., Dhansay, A. M., Tolboom, J. J., & Hautvast, J. G. (2003). The effect of a micronutrient-fortified complementary food on micronutrient status, growth and development of 6- to 12-month-old disadvantaged South African infants. *International Journal of Food Sciences and Nutrition, 54*(5), 399–407.

Owino, V. O., Kasonka, L. M., Sinkala, M. M., Wells, J. K., Eaton, S., Darch, T., et al. (2007). Fortified complementary food increases growth and hemoglobin independently of α-amylase treatment, without reducing breastmilk intake of 9-month old Zambian infants. *American Journal of Clinical Nutrition, 86*(4), 1094–1103.

Paul, K. H., Dickin, K. L., Ali, N. S., Monterrosa, E. C., & Stoltzfus, R. J. (2008). Soy- and rice-based processed complementary food increases nutrient intakes in infants and is equally acceptable with or without added milk powder. *Journal of Nutrition, 138*(10), 1963–1968.

Phuka, J. C., Maleta, K., Thakwalakwa, C., Cheung, Y. B., Briend, A., Manary, M. J., et al. (2008). Complementary feeding with fortified spread and incidence of severe stunting in 6- to 18-month-old rural Malawians. *Archives of Pediatric and Adolescent Medicine, 162*(7), 619–626.

Phuka, J. C., Maleta, K., Thakwalakwa, C., Cheung, Y. B., Briend, A., Manary, M. J., et al. (2009). Supplementary feeding with fortified spread among moderately underweight 6–18-month-old rural Malawian children. *Maternal and Child Nutrition, 5*(2), 159–170.

Piwoz, E. G., Black, R. E., Lopez de Romana, G., de Kanashiro, H. C., & Brown, K. H. (1994). The relationship between infants' preceding appetite, illness, and growth performance and mothers' subsequent feeding practice decisions. *Social Science and Medicine, 39*(6), 851–860.

Rivera, J. A., & Habicht, J.-P. (2002). Effect of supplementary feeding on the prevention of mild-to-moderate wasting in conditions of endemic malnutrition in Guatemala. *Bulletin of the World Health Organization, 80*(12), 926–932.

Scrimshaw, N. S., & SanGiovanni, J. P. (1997). Synergism of nutrition, infection, and immunity: an overview. *American Journal of Clinical Nutrition, 66*(2), 464S–477S.

Simondon, K. B., Gartner, A., Berger, J., Cornu, A., Massamba, J.-P., & San Miguel, J.-L. (1996). Effect of early, short-term supplementation on weight and linear growth of 4–7-mo-old infants in developing countries: a four-country randomized trial. *American Journal of Clinical Nutrition, 64*(4), 537–545.

Simondon, K. B., & Simondon, F. (1995). Infant feeding and nutritional status: the dilemma of mothers in rural Senegal. *European Journal of Clinical Nutrition, 49*(3), 179–188.

The PLoS Medicine Editors. (2008). Scaling up international food aid: food delivery alone cannot solve the malnutrition crisis. *PLoS Medicine, 5*(11), e235.

United Nations Children's Fund. (2008). *The state of the world's children 2009*. New York: United Nations Children's Fund.

World Health Organization/World Food Programme/United Nations System Standing Committee on Nutrition/The United Nations Children's Fund. (2007). *Community-based management of severe acute malnutrition*. Geneva: World Health Organization.

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Research report

Feeding patterns and behaviors during home supplementation of underweight Malawian children with lipid-based nutrient supplements or corn-soy blend

Valerie L. Flax [a,b,*], John Phuka [b,e], Yin Bun Cheung [b,c,d], Ulla Ashorn [a,b], Kenneth Maleta [e], Per Ashorn [b,f]

[a] School of Public Health, 33014 University of Tampere, Finland
[b] Department of International Health, University of Tampere Medical School, Lääkärinkatu 1, Arvo building, 33014 University of Tampere, Finland
[c] Singapore Clinical Research Institute, Nanos #02-01, 31 Biopolis Way, Singapore 138669, Singapore
[d] Office of Clinical Sciences, Duke-NUS Graduate Medical School, 8 College Road, Singapore 169857, Singapore
[e] Department of Community Health, College of Medicine, University of Malawi, Private Bag 360, Blantyre 3, Malawi
[f] Department of Paediatrics, Tampere University Hospital, 33014 University of Tampere, Finland

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A B S T R A C T

The way caregivers use supplementary food for undernourished children and integrate it into feeding patterns may influence the benefits achieved by supplementation. We studied feeding patterns and behaviors in 170 underweight 6–17-month-olds who received either lipid-based nutrient supplements (LNS) ($n = 85$) or corn-soy blend (CSB) ($n = 85$) during a 12-week intervention trial in southern Malawi. Observational data were collected during one 11 h home visit per participant. Differences were assessed by study group and by mode of serving LNS. Associations between selected caregiver behaviors and child growth were also tested. We found no difference between the CSB and LNS groups in mean number of feeding episodes per day or mean daily feeding time. Caregivers fed the child with a spoon, washed their hands before feeding, and there were leftovers significantly more often in the CSB than LNS group and when LNS mixed with porridge and plain LNS were compared. This suggests that differences between the groups were linked to the mode of serving LNS. Presence of leftovers was negatively associated with change in child's WAZ. Programs promoting LNS in Malawi should consider behaviors related to mode of serving and provide advice to caregivers in order to minimize leftovers during supplement use.

1. Introduction

Supplementary feeding programs for undernourished young children in low-income countries have typically used micronutrient-fortified cereal-legume mixtures, such as corn-soy blend (CSB) (Hoppe et al., 2008). There is little or no evidence that CSB promotes child growth, and results with other types of cereal or cereal-legume blends have been inconsistent (Bhandari et al., 2001; Lartey, Manu, Brown, Peerson, & Dewey, 1999; Dewey & Adu-Afarwuah, 2008; Oelofse et al., 2003; Owino et al., 2007). A new class of supplements for children, lipid-based nutrient supplements (LNS), which contain dry food particles embedded in edible fats, has been available for several years (Briend, 2002). LNS are ready-to-use and have generally proven to be beneficial for the home treatment of severely and moderately wasted children (Ciliberto et al., 2005; Diop el, Dossou, Ndour, Briend, & Wade, 2003; Manary, Ndekha, Ashorn, Maleta, & Briend, 2004; Matilsky et al., 2009; Patel et al., 2005; Sandige, Ndekha, Briend, Ashorn, & Manary, 2004). There is some evidence that LNS may be useful for the prevention of childhood undernutrition (Adu-Afarwuah et al., 2007; Phuka et al., 2008). Large trials studying the effects of LNS compared to CSB or other supplements on child growth are ongoing, but little is known about how the two supplements affect child feeding patterns or caregiver feeding behaviors. This type of information is important because caring behaviors during feeding can have an impact on the benefits that might be achieved by supplementation.

Although several studies have described caring practices during complementary feeding (Bentley, Stallings, Fukumoto, & Elder, 1991b; Dearden et al., 2009; Engle & Zeitlin, 1996; Gittelsohn et al., 1998; Guldan et al., 1993; Moore, Akhter, & Aboud, 2006), published research on behaviors related to use of supplements is sparse. We previously conducted a study in Malawi to learn about typical feeding patterns of 6–17-month-old children, the integration of LNS into the pattern, and changes in supplement use during a 12-week period (Flax et al., 2008). The study provided descriptive information about home use of LNS, but its small sample and lack of control group limited generalizations that could

* Corresponding author at: Department of International Health, University of Tampere Medical School, Lääkärinkatu 1, Arvo Building, FIN-33014 University of Tampere, Finland.
E-mail address: valerie.flax@uta.fi (V.L. Flax).

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be made from the data. The present study took place within the context of a supplementary food trial comparing the effects of LNS and CSB on the growth of moderately to severely underweight children. It used the same observational methods as the earlier study, but had a larger sample and included corn-soy blend for comparison.

The main aim of this study was to compare child food consumption patterns and caregiver and child feeding behaviors in the two study groups. We also examined behaviors related to the use of plain LNS versus LNS mixed with porridge. The aspects of feeding that we observed were based on the behavioral dimensions of complementary feeding outlined in Pelto, Levitt, and Thairu (2003), including *how*, *when*, and *where* food is fed and *who* is feeding the child, and on specific issues, such as leakage, that might influence the impact of supplementary feeding on growth. Our secondary purpose was to test whether selected behaviors, such as feeding frequency, hand washing before feeding episodes, and presence of leftover supplements, were associated with the growth of study participants.

2. Methods

2.1. Study area and timing

The present study was part of a trial testing the effects of supplementation with either LNS or CSB on the growth of underweight children. The trial took place from April to July 2005 in Mangochi district, southern Malawi, an area populated mainly by subsistence farmers and fishermen from the Yao ethnic group. The trial documented no statistically significant difference in the mean weight and length gain between the two intervention groups (Phuka et al., 2009).

2.2. Ethics

Ethical approval for the study was obtained from the College of Medicine Research and Ethics Committee at the University of Malawi and from the Ethical Committee of the Pirkanmaa Hospital District in Finland. The trial protocol was registered with the National Library of Medicine, Bethesda, MD, USA (http://www.clinicaltrials.gov, trial identification number NCT00131222).

2.3. Eligibility, enrollment and randomization of participants

Children could be included in the study if they were 6–14 months of age; had weight-for-age *z*-score (WAZ) <-2.0; had guardian-signed informed consent; and were resident in the area throughout the study period. They were excluded if they had weight-for-length *z*-score (WLZ) <-3.0, edema, severe illness warranting hospital referral on the day of enrollment, peanut allergy, or they were participating in another clinical trial. Details of the processes for enrolling and randomizing participants have been reported elsewhere (Phuka et al., 2009).

2.4. Interventions and follow-up

The follow-up period for the clinical trial was 12 weeks, during which participants received either 71 g/day (282 kcal) of CSB or 50 g/day (256 kcal) of LNS delivered to their homes weekly. CSB was packed in 500 g bags (supplied by Rab Processors, Blantyre, Malawi) and contained corn and soy flours and micronutrients. It was supplied as dry flour that had to be cooked as porridge. LNS were packed in 50 g foil packets (produced by Nutriset, Malaunay, France) and contained peanut butter, milk powder, cooking oil, sugar, and micronutrients. LNS were ready-to-use and could be given either plain or mixed with regular porridge. Caregivers were provided with spoons and advised to feed their child either porridge containing 12 spoons of CSB or 1 packet of LNS per day. Neither study group was given instructions about how many times per day to feed the child the supplement, nor, in the case of LNS, in what form it should be served (plain or mixed with porridge). Caregivers were encouraged to continue breastfeeding on demand.

2.5. Sample size

The sample size was calculated based on expected values for the primary outcome (weight gain) of the clinical trial. A sample size of 84 children per group was required to achieve 80% power and 95% confidence, assuming a standard deviation of 0.39 kg per group during 12 weeks and a mean gain difference of 0.17 kg between groups (CSB and LNS). The target enrollment was 88 children per group to allow for 5% attrition. This gives a power of about 80% for detecting a difference of 0.4 SD in quantitative variables, which is considered a small-to-moderate effect size by Cohen (1988).

2.6. Data collection and measurement of outcome variables

Six trained research assistants collected the data. They were required to achieve at least 80% agreement with the trainer (VF) on five consecutive practice observations before the study began. Agreement between observers was >85% for length of feeding episode and caregiver hand washing and >95% for all other variables studied.

Research assistants made a 1-day visit (6:30 a.m. to 5:30 p.m.) to each participant's home between the 5th and 11th study week. They recorded the date and exact start and end times of the observation visit. This was used together with the enrollment date and dates of supplement delivery to determine the following for each participant: timing of the observation visit within the trial follow-up period, number of days after supplement delivery when the observation took place, and length of observation. The day when supplement was received was counted as zero and the days were numbered consecutively until the next supplement delivery.

At the beginning of each observation, the research assistant introduced herself then sat near the child and recorded on a log form the start and end times and the type of food given during all feeding episodes, including breastmilk. Feeding episodes were counted as separate if there were at least 15 min between the end of one episode and the beginning of another. Food recorded on logs was divided into six categories: plain porridge, nsima and relish, CSB, LNS plain, LNS mixed, and snacks. Plain porridge was made of corn or rice and contained approximately 10% dry matter. Nsima was stiff corn porridge, approximately 28% dry matter, and relish was a sauce, usually made of beans, green vegetables, or fish. CSB was porridge made from corn-soy blend. LNS plain were LNS served as such. LNS mixed were LNS combined with corn porridge. Snacks were small quantities of food served between meals. During the season when the study was conducted, snacks were usually fruit, sugar cane, sweet potato, cassava, banana, or bread.

The number of episodes of each type of food was calculated and these were added to get the total number of episodes per day for each participant. The total number of breastfeeding episodes was slightly underestimated because breastfeeding during a meal or snack was not counted as a separate episode. The length of a feeding episode in minutes was determined by subtracting the start from the end time. The daily time for each type of food was calculated for each participant and the total time was obtained by adding the length of all feeding episodes per child.

Research assistants used a semi-structured form to collect information about child and caregiver behavior during supplement feeding episodes. They recorded the child's main position during the feeding episode and the number of bites of food offered to and eaten by the child, which were used to calculate the proportion accepted. The position of the child was marked as sitting on the caregiver's lap, sitting on the floor, standing, or walking/crawling. Because they occurred infrequently, standing and walking/crawling were combined in the analysis.

Caregivers' behaviors measured included: hand washing before the feeding episode, person feeding the child, utensil used, whether supplement was shared, whether there was any leftover at the end of the feeding episode, and the proportion shared and leftover. Caregivers were counted as washing their own hands and/or their child's hands if they were rinsed with water before the feeding episode. The person feeding the child was noted as the mother, the child him or herself, or another person (usually a grandmother, aunt, or father). Mother and other person were used if they fed the child during the whole meal. If the child fed him or herself at least part of the time, this was recorded as self-feeding. Self-feeding was counted even when it was partial to detect possible differences in child autonomy depending on the type of supplement. The main utensil used during the meal was recorded as: spoon, LNS packet, or hand (caregiver's or child's). The LNS packet was considered as the utensil if the supplement was fed by squeezing it from the packet directly into the child's mouth. Sharing supplement was defined as consumption of the supplement by a person other than the participant during the meal. The proportion of the supplement meal shared was estimated based on the quantity of food presented to the participant that was eaten by someone else. CSB and LNS mixed with porridge were considered to be leftover if the feeding episode had ended but some food remained in the bowl, whether it was eaten by someone else or discarded. Plain LNS were leftover if the remaining part of the packet was given to someone else to eat after the study child had already finished eating. The proportion leftover was recorded as the amount of the original portion that remained in the bowl or was eaten by someone else from the packet after the feeding episode.

Whether supplement feeding episodes were offered as a meal or snack was determined from feeding logs. A supplement episode was considered to be a meal if no other meal of the same type (e.g., breakfast) was offered during that period of the day, and it was counted as a snack if it was offered between meals. Use of the supplement as a meal or snack was included with other caregiver behaviors.

Measurements of weight, height, and mid-upper arm circumference were obtained from unclothed children at the beginning and end of the study by a researcher (JP) blinded to the participants' study allocation. Weight was measured using an electronic child scale (SECA 834, Chasmors Ltd., London, UK) with a 0.1 g increment. Anthropometric indices, including WAZ, were calculated using the CDC 2000 growth reference, which was the latest reference available at the time of enrollment. Background information on the participants' families was obtained through a questionnaire administered by research assistants during a home visit.

2.7. Data analysis

The data were entered to a Microsoft Access database and analyzed using Stata (version 9.2). All comparisons between the CSB and LNS groups were by intention to treat. Means were calculated for each study group for the following variables: study week when observation was conducted, day after supplement delivery when observation was conducted, hours of observation, number of feeding episodes (total and by type of food), daily feeding time (total and by type of food), proportion of offered supplement accepted by the child, proportion of supplement shared, and proportion leftover. The means were compared and the hypothesis that there was no difference between the study groups was tested using *t*-test.

Proportions for each study group were determined for participants who did not eat supplements during observations, participants who were reported to have no supplements left, whether the supplement was offered as a meal or snack, where supplement feeding episodes took place (veranda/yard and earth surface/mat), caregiver and child hand washing, child's main position, feeder, utensil used, supplement sharing, and presence of leftovers. For the analysis of caregiver behavior, only the first supplement feeding episode of the day was included for each participant. The majority of participants had one or fewer supplement feeding episodes (CSB 82%, LNS 87%), and limiting the analysis to the first one allowed us to compare proportions between the study groups without adjusting for intra-individual correlation. The hypothesis that there was no difference between the proportions of behaviors in the two study groups was tested using Fisher's exact test. There were two variables that could have had an influence on behaviors during supplement use–age of the child at observation and whether the supplement was given as a meal or snack. We used logistic regression to determine if controlling for these variables had an effect on our results.

As there was no difference in the growth of the children in the two study groups, we used the full sample to detect whether selected caregiver behaviors were associated with child growth. Using multivariable linear regression analysis with change in child's WAZ during the study as the outcome, we entered the following explanatory variables into a single model: number of feedings, caregiver hand washing, supplement sharing, and presence of leftovers. The child's initial WAZ and age at observation were also included as covariates. Number of feedings was defined as the total number of complementary and supplementary feeding episodes observed. It was entered in the model because a higher number of feeds have been linked with higher total energy intake (Islam et al., 2008), which would be expected to influence growth. Caregiver hand washing was selected because better hygiene decreases incidence of diarrhea in children (Ejemot, Ehiri, Meremikwu, & Critchley, 2008), and diarrhea may have a negative impact on child growth (Black, Brown, & Becker, 1984; Checkley et al., 2008). Supplement sharing and presence of leftover supplement were included to determine the effect of limited supplement consumption on weight gain. Correlations between the regression coefficients were examined, and none of the variables were strongly correlated with one another.

3. Results

In total, 280 children were invited to the enrollment session and 88 were randomized to each study group (Fig. 1). Of these, 85 who received CSB and 86 who received LNS had observation visits. One child in the LNS group with indeterminate information about the type of supplement consumed was excluded. Two children in the CSB group ate LNS and one child in the LNS group ate CSB, but these children did not consume their assigned supplement on the day of observation. There were no statistically significant differences between the study groups in background characteristics (Table 1) or proportions of children reported to be ill on the day of observation (CSB 19/85 = 22%, LNS 14/85 = 16%, difference (95% CI) 6% (−6%, 18%), $p = 0.438$).

Timing of observations and failure to consume supplements on the day of observation did not differ between the study groups (Table 2). Nearly all children were observed during the second half of the follow-up period and most were visited between the first and fifth day after supplement delivery. Seven observation days (CSB 3, LNS 4) were cut short by two or more hours, usually because the child was sick and the mother took him or her to the health center. The main reason for not eating supplements during observation was that the participant had no supplement left

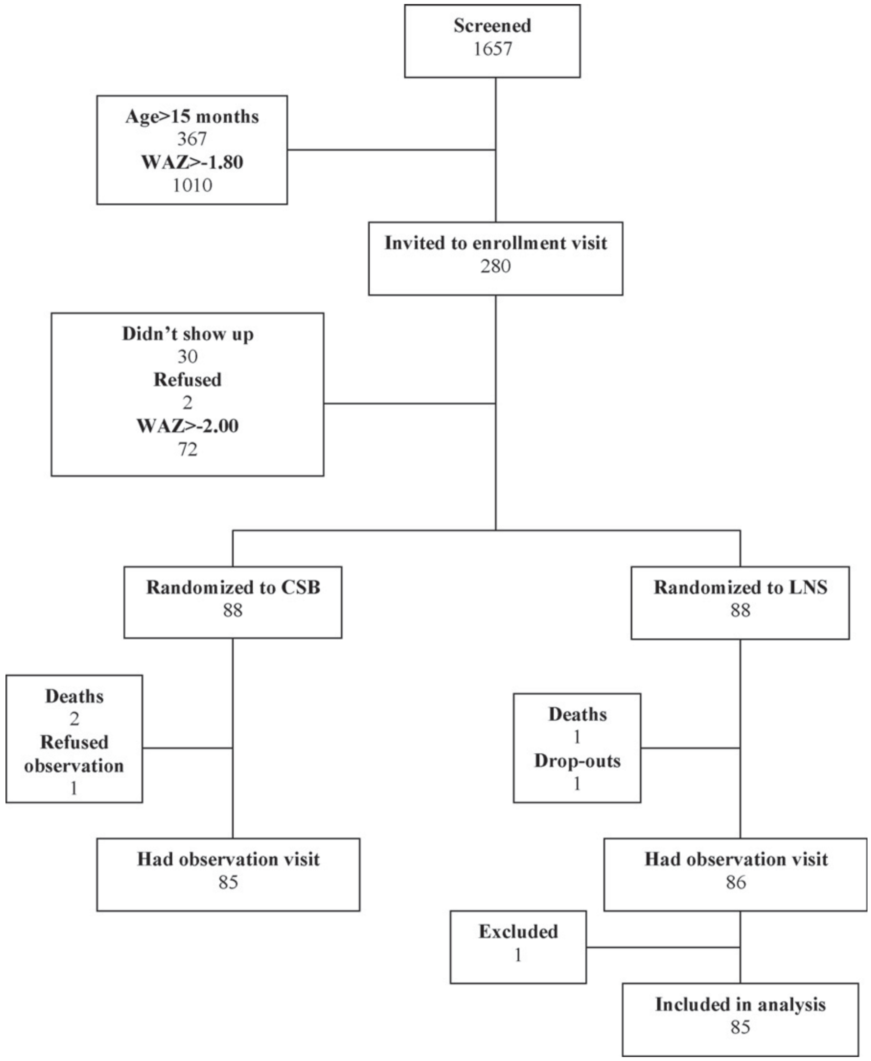

Fig. 1. Study profile. CSB, corn-soy blend; LNS, lipid-based nutrient supplement. WAZ, weight-for age *z*-score.

(Table 2). Among those reporting no supplement remaining, there was no difference between the study groups in the number of days after supplement delivery when the observation took place (CSB 3.5 ± 0.7 days, LNS 2.7 ± 0.9 days, difference (95% CI) 0.8 (−1.6, 3.2), $p = 0.479$). Other reasons for not eating the supplement during observation included: child refuses to eat the supplement in general or due to illness (CSB 4, LNS 2) and mother was away so no supplement was cooked or offered to the child (CSB 2, LNS 1).

Table 1
Selected demographic and socioeconomic characteristics of participants at enrollment.

Characteristics	Study group	
	CSB ($n = 85$)	LNS ($n = 85$)
Number (%) of males	48 (56%)	42 (49%)
Mean (SD) child age at observation (months)	13.6 (2.7)	13.7 (2.4)
Mean (SD) weight-for-age *z*-score at start of study	−3.1 (0.8)	−2.9 (0.7)
Mean (SD) birth order of study child	3.5 (2.1)	3.3 (2.3)
Mean (SD) maternal age (years)	28 (7)	26 (7)
Maternal education		
None	48 (57%)	41 (48%)
1–3 years	13 (15%)	18 (21%)
4–6 years	13 (15%)	16 (19%)
7 or more years	11 (13%)	10 (12%)
Housing materials		
Brick	60 (71%)	58 (68%)
Mud and poles	24 (28%)	23 (27%)
Other	1 (1%)	4 (5%)

CSB, corn-soy blend; LNS, lipid-based nutrient supplements.

There was no difference between the study groups in the total mean number of feeding episodes per day and total mean daily feeding time (Table 3). When specific types of food were examined, the mean number of supplement meals was significantly higher in the LNS group, while the mean daily time spent feeding nsima and relish was significantly higher in the CSB group. Nearly all participating children were still breastfed (CSB 85/85 = 100%, LNS 83/85 = 98%), and the breastfeeding frequency and time spent breastfeeding were similar in both groups. Among those participants who were served LNS during observation, most were offered the supplement plain (47/74 = 64%) rather than mixed with porridge (20/74 = 27%), while a small proportion (7/74 = 9%) were given LNS both plain and mixed. The mean minutes per episode for children who ate each type of food were: CSB (12.4 ± 5.5), LNS mixed with porridge (13.1 ± 7.4), and plain LNS (8.9 ± 4.9).

We detected some similarities and several differences in child and caregiver behaviors in the CSB and LNS groups (Table 4). Children accepted both of the supplements well. Similar numbers of bites of the two supplements were offered to the children, but the mean proportion of the offered supplement that was eaten by participants was slightly higher in the LNS group (CSB 94%, LNS 98%, difference (95% CI) 4% (1%, 7%), $p = 0.003$). There was no

Table 2
Timing of observations and failure to consume supplements during observations.

Characteristics	Study group		Difference between study groups (95% CI)	p-value
	CSB (n = 85)	LNS (n = 85)		
Mean (SD) study week when observation conducted	8.8 (1.8)	8.7 (1.9)	0.1 (−0.4, 0.7)	0.618
Mean (SD) day after supplement delivery when observation conducted	3.0 (2.4)	2.9 (2.3)	0.1 (−0.6, 0.8)	0.720
Mean (SD) hours of observation	10.6 (0.8)	10.3 (1.4)	0.3 (0, 0.6)	0.082
Proportion of participants who did not eat supplement during observation	22%	12%	10% (1, 22)	0.102
Proportion of participants who did not have supplement left during observation	15%	8%	7% (−3, 17)	0.233

CSB, corn-soy blend; LNS, lipid-based nutrient supplements. Difference in means by *t*-test. Difference in proportions by Fisher's exact test.

Table 3
Mean number of feeding episodes and mean daily feeding time by study group and type of food.

Type of food	Mean (SD) number of episodes per day		Mean difference (95% CI)	p-Value	Mean (SD) daily feeding time (min)		Mean difference (95% CI)	p-value
	CSB (n = 85)	LNS (n = 85)			CSB (n = 85)	LNS (n = 85)		
All feeding episodes	16.4 (4.0)	15.9 (4.1)	0.6 (−0.6, 1.8)	0.394	102 (62)	90 (52)	12 (−5, 30)	0.157
Breastmilk	12.4 (4.2)	11.5 (4.2)	0.9 (−0.3, 2.2)	0.121	63 (57)	54 (47)	9 (−7, 25)	0.251
Plain porridge	0.3 (0.5)	0.4 (0.6)	−0.1 (−0.3, 0)	0.130	3 (6)	4 (8)	−1 (−4, 1)	0.180
Nsima & relish	1.0 (0.4)	0.9 (0.4)	0.1 (0, 0.2)	0.107	14 (9)	11 (6)	3 (1, 6)	0.004
Supplement	0.8 (0.5)	1.0 (0.5)	−0.2 (−0.3, 0)	0.035	11 (8)	11 (8)	0 (−2, 2)	0.961
Snacks	1.8 (1.4)	1.9 (1.5)	−0.1 (−0.6, 0.3)	0.599	12 (14)	10 (10)	2 (−2, 5)	0.403

Porridge, corn or rice porridge; Nsima & relish, stiff corn porridge & sauce; Supplement, corn-soy blend or lipid-based nutrient supplements; snacks, small quantities of food (most frequently fruit, sugar cane, sweet potato or cassava, banana, and wheat or corn bread) served between meals. Difference in mean number of episodes and mean daily feeding time by *t*-test.

difference between the groups in the location of the feeding episodes or the child's position during them. Although children in both groups were usually fed supplements by their mothers, those in the LNS group were more likely to have other people feed them the supplement than those in the CSB group. Caregivers in the CSB group were significantly more likely than those in the LNS group to serve the supplement as meal, wash their hands before feeding, and feed the child with a spoon. Outright sharing of supplements was observed relatively infrequently and there was no difference between the groups in the occurrence of sharing or the mean proportion shared (CSB 4%, LNS 1%, difference (95% CI) 3% (−1%, 6%), $p = 0.128$). There were significantly more instances of leftovers and the mean proportion leftover was higher in the CSB than the LNS group (CSB 19%, LNS 6%, difference (95% CI) 12% (9%, 15%), $p < 0.001$). We observed approximately one-quarter of the leftovers being eaten by someone else. Shared supplements and those leftovers that were observed being eaten were most often consumed by the child's siblings or cousins (CSB 76%, LNS 73%). Statistical adjustment for age and use of the supplement as a meal versus snack did not make a difference in the comparison of behaviors in the two study groups (details not shown).

Our sub-group comparisons of behaviors related to the use of LNS mixed and plain generally mirrored the results of CSB compared to LNS (Table 5). Children ate similar proportions of

Table 4
Child and caregiver behavior during supplement feeding episodes.

Child and caregiver behavior	CSB (n = 66)		LNS (n = 75)		Difference in proportions (95% CI)	p-value
	n	%	n	%		
Offered as meal not snack	64	97%	54	72%	25% (14, 36)	<0.001
Location						
On veranda not yard	36	55%	40	54%	1% (−15, 17)	1.00
On earth surface not mat	38	58%	53	70%	−12% (−28, 4)	0.157
Hand washing before feeding						
Caregiver washed own hands	42	64%	27	37%	27% (11, 43)	0.002
Caregiver washed child's hands	17	26%	10	13%	13% (−1, 25)	0.085
Sitting on lap	42	65%	52	69%	−4% (−20, 11)	0.592
Sitting on floor	21	32%	18	24%	8% (−7, 23)	0.345
Standing, walking or crawling	2	3%	5	7%	−4% (−11, 3)	0.450
Person feeding						
Mother all of the time	57	86%	59	79%	7% (−5, 20)	0.274
Self part or all of the time	8	11%	8	12%	−1% (−12, 9)	0.797
Other person all of the time	1	2%	8	11%	−9% (−17, −2)	0.037
Utensil						
Spoon	61	92%	36	48%	44% (31, 57)	<0.001
LNS packet	1	1%	34	45%	−44% (−55, −32)	<0.001
Caregiver's or child's hand	4	6%	5	7%	−1% (−9, 7)	1.00
Supplement sharing	10	15%	4	5%	10% (0, 19)	0.088
Part of food was leftover	33	50%	16	21%	29% (13, 44)	<0.001

CSB, corn-soy blend; LNS, lipid-based nutrient supplements. Difference in proportions by Fisher's exact test. Analysis based on the first supplement meal of the day per child. Types of supplement meals within the LNS group were: plain LNS (n = 50), LNS mixed with porridge (n = 24), and CSB (n = 1).

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Table 5
Child and caregiver behavior during LNS feeding episodes.

Child and caregiver behavior	LNS mixed with porridge (*n* = 24)		LNS plain (*n* = 50)		Difference in proportions (95% CI)	*p*-value
	n	%	*n*	%		
Offered as meal not snack	24	100%	28	57%	43% (29, 57)	<0.001
Location						
On veranda not yard	15	62%	25	51%	11% (−12, 35)	0.455
On earth surface not mat	14	56%	38	77%	−21% (−44, 11)	0.065
Hand washing before feeding						
Caregiver washed own hands	16	69%	11	22%	47% (25, 69)	<0.001
Caregiver washed child's hands	6	25%	4	8%	17% (−2, 35)	0.068
Child's main position						
Sitting on lap	19	76%	32	65%	11% (−11, 32)	0.431
Sitting on floor	6	24%	12	24%	0% (−2, 2)	1.00
Standing, walking or crawling	0	0%	5	10%	−10% (−19, 17)	0.160
Person feeding						
Mother all of the time	21	87%	37	74%	13% (−4, 31)	0.238
Self part or all of the time	1	4%	7	14%	−10% (−22, 3)	0.262
Other person all of the time	2	8%	6	12%	−4% (−18, 10)	1.00
Utensil						
Spoon	24	96%	13	26%	70% (55, 84)	<0.001
LNS packet	0	0%	34	68%	−68% (−81, −57)	<0.001
Caregiver's or child's hand	1	4%	3	6%	−2% (−12, 8)	1.00
Supplement sharing	1	4%	3	6%	−6% (−12, 1)	1.00
Part of food was leftover	14	56%	2	4%	52% (32, 72)	<0.001

Difference in proportions by Fisher's exact test. Analysis based on the first supplement meal of the day per child. The child in the LNS group who was observed eating CSB was excluded.

the offered LNS whether it was served mixed with porridge or plain (LNS mixed 97%, LNS plain 99%, difference (95% CI) 2% (−1%, 4%), $p = 0.225$). The location of feeding and the child's position did not differ between the sub-groups. Caregivers were significantly more likely to serve LNS mixed with porridge than plain LNS as a meal and wash their own hands before feeding. LNS mixed with porridge was usually fed with a spoon, while plain LNS was frequently fed directly from the packet. There was no difference in supplement sharing or the mean proportion shared (LNS mixed 1%, LNS plain 1%, difference (95% CI) 0% (−2%, 2%), $p = 0.567$) based on the way LNS were served. There were more frequently leftovers and the mean proportion leftover was larger for LNS mixed with porridge than for plain LNS (LNS mixed 15%, LNS plain 1%, difference (95% CI) 14% (8%, 21%), $p < 0.001$). Statistical adjustment for age and use of the supplement as a meal or snack did not have an impact on comparisons between LNS plain and mixed (details not shown).

Presence of leftovers after supplement feeding episodes was negatively associated with change in child's WAZ (Table 6). The other explanatory variables entered to the model (number of feedings, caregiver hand washing, and supplement sharing) did not predict change in child's WAZ.

Table 6
Multivariable linear regression analysis of caregiver feeding behaviors during supplementary feeding associated with change in child's WAZ.

Explanatory variables	Change in child's WAZ	
	Regression coefficient (95% CI)	*p*-value
Constant	−0.82 (−1.41, −0.23)	0.007
Age at observation	0.66 (0.03, 0.10)	0.001
Child's WAZ at enrollment	−0.08 (−0.20, 0.04)	0.196
Number of feedings[a]	0.02 (−0.04, 0.08)	0.466
Caregiver hand washing	−0.03 (−0.21, 0.15)	0.760
Supplement sharing	−0.02 (−0.30, 0.28)	0.885
Presence of leftovers	−0.19 (−0.37, −0.01)	0.036

WAZ, weight-for-age *z*-score.
[a] Number of feedings includes complementary and supplementary feeding episodes, but excludes breastmilk.

4. Discussion

The main aim of this study was to compare feeding patterns and behaviors of undernourished children who received either CSB or LNS as food supplements. We found no difference between the groups in total mean number of feeding episodes per day or total mean daily time spent feeding. The mean number of supplement episodes was higher in the LNS group while the mean daily time spent feeding nsima was higher in the CSB group. Caregivers were more likely to serve the supplement as a meal, wash their hands before feeding, and use a spoon in the CSB than the LNS group. There were more frequently leftovers and the proportion leftover was larger among those who had CSB than LNS. The same patterns of caregiver behavior found in comparisons of CSB with LNS were also detected when LNS mixed with porridge was compared to plain LNS. Presence of leftovers was the only predictor associated with change in child's WAZ.

The strengths of this research were a study population taken from a randomized clinical trial with few drop-outs and the use of structured observations to detect feeding patterns and behaviors. Observational methods have frequently been used to study behaviors related to complementary feeding in children (Bentley et al., 1991b; Engle & Zeitlin, 1996; Gittelsohn et al., 1998; Guldan et al., 1993; Moore et al., 2006) and are more accurate than recall or survey methods for obtaining information about food consumption and other household behaviors (Basch et al., 1990; Curtis et al., 1993; Stanton, Clemens, Aziz, & Rahman, 1987).

This study had some limitations, including the possible influence of observers on feeding behavior and the use by three participants of the supplement that was not assigned. Although caregivers could have modified their behaviors in the presence of observers, we believe that reactivity in the present study was reasonably low. Research has shown that reactivity decreases with two or more observations (Cousens, Kanki, Toure, Diallo, & Curtis, 1996; Gorter et al., 1998), and several aspects of feeding studied here were similar to findings from our earlier study, where there were 10 observations per participant (Flax et al., 2008). In addition, the overall feeding pattern in this study was comparable to the number of complementary feeds per day reported elsewhere in southern Malawi (Hotz & Gibson, 2001). In terms of the participants who were observed eating the other supplement, they made up a very small proportion of the study sample (<2%), so their impact on the analysis was minimal.

The overall feeding patterns detected in this research were quite similar in the two study groups, with the majority of participants being fed one supplement meal, one nsima and relish meal, and one to three snacks. Although the frequency of LNS episodes was significantly higher than CSB episodes, the difference between the groups was small and was probably linked to the variation in proportions of children in each group who did not eat the supplement during observation. Since children usually consumed their supplements in the morning and nsima sometime thereafter, differences between the study groups in the amount of time spent feeding nsima could be related to the large disparity in the volume of the supplements consumed due to their different energy densities (Briend, 2002; Phuka et al., 2009). There is evidence that high volume, low density foods (like CSB) can enhance satiety and influence subsequent meals (Rolls, 2009). The other notable aspect of the feeding pattern was the low frequency of plain porridge use in the LNS and CSB groups, which was similar to findings during LNS supplementation in our earlier study (Flax et al., 2008).

In our previous work, we theorized that LNS was integrated into feeding patterns by mixing it with porridge because porridge was an important element of child feeding (Cosminsky, Mhloyi, & Ewbank, 1993; Mabilia, 1996) and because offering it together with porridge, rather than as an additional snack, saved time. In the present study, LNS was more frequently served plain. The differences in LNS use between the two studies suggest that Malawian caregivers can be flexible and adaptive in their child feeding regimes, as has been shown in feeding interventions and trials of improved practices in other settings (Bentley et al., 1991a; Paul, Dickin, Ali, Monterossa, & Stoltzfus, 2008; The Manoff Group, 2007). We suspect that differences in patterns of LNS use in these two studies may be at least partly related to LNS packaging. In our earlier study, LNS were provided in jars containing a one-week supply, while in the present study they were given to participants in foil packets for daily use. The ease of using foil packets and feeding the child directly from them may have encouraged mothers to give children plain LNS more often than when it was provided in a jar and also influenced the type of utensil used to feed it.

Although there is evidence from Nicaragua that some caregiver and child behaviors, such as self-feeding, are different during meals and snacks (Engle & Zeitlin, 1996), feeding the supplement as a meal or snack did not influence self-feeding or other behaviors in this study.

Differences between the study groups in certain behaviors, such as hand washing and leftovers, were associated with specific patterns of behavior related to plain LNS. Our findings with regard to the proportions of caregivers washing their hands before CSB and LNS mixed with porridge feeding episodes are similar to reports of maternal hand washing before child feeding in other developing countries, while those for plain LNS are somewhat lower (Manun'Ebo et al., 1997; Sakisaka et al., 2002).

Non-compliance in feeding the recommended amount of supplement to children may limit the impact on growth. Other studies comparing CSB and LNS in Malawi have reported minimal levels of supplement sharing based on focus group discussions and maternal reports (Matilsky, Maleta, Castleman, & Manary, 2009; Phuka et al., 2008, 2009). In the same sample from which the present study was drawn, mothers indicated during weekly interviews at the time of supplement distribution that <1% of the supplements were diverted to other family members (Phuka et al., 2009). These figures contrast with our direct observations, which documented larger proportions of outright sharing, frequent leftovers, and some children whose weekly supply of supplement was finished early. Similar discrepancies between reported and observed behaviors have been found in research on household hygiene (Manun'Ebo et al., 1997) and indicate that caregivers tend to under-report undesirable behaviors (Curtis et al., 1993). There is very little research on leftover supplements. Results from our earlier study, where we reported the proportion of LNS plain and mixed that was "lost", are comparable and consistent with the proportion leftover in the present research (Flax et al., 2008).

Our finding that leftovers are associated with child growth concurs with some supplementary feeding research showing that when the intake of supplements was inadequate due to sharing or replacement the effect on growth was constrained (Beaton & Ghassemi, 1982; Owino et al., 2007; Santos et al., 2005). The lack of association between sharing and growth in the present study is probably related to the infrequent occurrence of sharing and to the small quantities shared. The mean feeding frequency in this study is in the range recommended by international agencies for children of this age (PAHO/WHO, 2003). This together with the low variability in the number of daily feeding episodes in our sample may explain why we did not detect an association between feeding frequency and growth. Our finding with regard to hand washing and child growth is consistent with research showing that hygiene behaviors cluster (Arimond & Ruel, 2002). It is likely that we detected no association between hygiene before supplement feeding and growth because hand washing alone does not adequately represent the totality of household hygiene practices.

In conclusion, this study found that most differences between the study groups were linked to the way LNS were served (plain vs. mixed with porridge). Programs promoting LNS in Malawi should consider behaviors related to mode of serving and provide appropriate advice to caregivers in order to minimize leftovers. As several types of packaging for LNS are currently in wide use, further research on behaviors associated with specific types of packaging may be warranted.

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References

Adu-Afarwuah, S., Lartey, A., Brown, K. H., Zlotkin, S., Briend, A., & Dewey, K. H. (2007). Randomized comparison of 3 types of micronutrient supplements for home fortification of complementary foods in Ghana: effects on growth and motor development. *American Journal of Clinical Nutrition, 86*, 412–420.

Arimond, M., & Ruel, M. T. (2002). *Assessing care: progress towards the measurement of selected childcare and feeding practices and implications for programs*. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Basch, C. E., Shea, S., Arliss, R., Contento, I. R., Rips, J., Gutin, B., Irigoyen, M., & Zybert, P. (1990). Validation of mothers' reports of dietary intake by four to seven year-old children. *American Journal of Public Health, 80*, 1314–1317.

Beaton, G. H., & Ghassemi, H. (1982). Supplementary feeding programs for young children in developing countries. *American Journal of Clinical Nutrition, 35*, 864–916.

Bentley, M. E., Dickin, K. L., Mebrahtu, S., Kayode, B., Oni, G. A., Verzosa, C. C., Brown, K. H., & Idowu, J. R. (1991). Development of a nutritionally adequate and culturally appropriate weaning food in Kwara State, Nigeria: an interdisciplinary approach. *Social Science & Medicine, 33*, 1103–1111.

Bentley, M. E., Stallings, R. Y., Fukumoto, M., & Elder, J. A. (1991). Maternal feeding behavior and child acceptance of food during diarrhea, convalescence, and health in the Central Sierra of Peru. *American Journal of Public Health, 81*, 43–47.

Bhandari, N., Bahl, R., Nayyar, B., Khokhar, P., Rohde, J. E., & Bhan, M. K. (2001). Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. *Journal of Nutrition, 131*, 1946–1951.

Black, R. E., Brown, K. H., & Becker, S. (1984). Effects of diarrhea associated with specific enteropathogens on the growth of children in rural Bangladesh. *Pediatrics, 73*, 799–805.

Briend, A. (2002). Possible use of spreads as a FOODlet for improving the diets of infants and young children. *Food and Nutrition Bulletin, 23*, 239–243.

Checkley, W., Buckley, G., Gilman, R. H., Assis, A. M. O., Guerrant, R. L., Morris, S. S., Mølbak, K., Valentiner-Branth, P., Lanata, C. F., Black, R. E., & The Childhood Malnutrition and Infection Network. (2008). Multi-country analysis of the effects of diarrhoea on childhood stunting. International Journal of Epidemiology, 37, 816–830.

Ciliberto, M. A., Sandige, H., Ndekha, M. J., Ashorn, P., Briend, A., Ciliberto, H. M., & Manary, M. J. (2005). Comparison of home-based therapy with ready-to-use therapeutic food with standard therapy in the treatment of malnourished Malawian children: a controlled, clinical effectiveness trial. *American Journal of Clinical Nutrition, 81*, 864–870.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd edition). Hillsdale, NJ, USA: Lawrence Erlbaum.

Cosminsky, S., Mhloyi, M., & Ewbank, D. (1993). Child feeding practices in a rural area of Zimbabwe. *Social Science & Medicine, 36*, 937–947.

Cousens, S., Kanki, B., Toure, S., Diallo, I., & Curtis, V. (1996). Reactivity and repeatability of hygiene behaviours: structured observations from Burkina Faso. *Social Science and Medicine, 43*, 1299–1308.

Curtis, V., Cousens, S., Mertens, T., Traore, E., Kanki, B., & Diallo, I. (1993). Structured observations of hygiene behaviors in Burkina Faso: validity, variability, and utility. *Bulletin of the World Health Organization, 71*, 23–32.

Dearden, K. A., Hilton, S., Bentley, M. E., Caulfield, L. E., Wilde, C., Ha, P. B., & Marsh, D. (2009). Caregiver verbal encouragement increases food acceptance among Vietnamese toddlers. *Journal of Nutrition, 139*, 1387–1392.

Dewey, K. G., & Adu-Afarwuah, S. (2008). Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Maternal and Child Nutrition, 4*(Suppl 1), 24–85.

Diop el, H. I., Dossou, N. I., Ndour, M. M., Briend, A., & Wade, S. (2003). Comparison of the efficacy of a solid ready-to-use food and a liquid milk-based diet for the rehabilitation of severely malnourished children: a randomized trial. *American Journal of Clinical Nutrition, 78*, 302–307.

Ejemot, R. I., Ehiri, J. E., Meremikwu, M. M., & Critchley, J. A. (2008). Hand washing for preventing diarrhoea. *Cochrane Database Systematic Reviews, 23*, CD004265.

Engle, P. L., & Zeitlin, M. (1996). Active feeding behavior compensates for low interest in food among young Nicaraguan children. *Journal of Nutrition, 126*, 1808–1816.

Flax, V. L., Ashorn, U., Phuka, J., Maleta, K., Manary, M. J., & Ashorn, P. (2008). Feeding patterns of underweight children in rural Malawi given supplementary fortified spread at home. *Maternal and Child Nutrition, 4*, 65–73.

Gittelsohn, J., Shankar, A. V., West, K. P., Faruque, F., Gnywali, T., & Pradhan, E. K. (1998). Child feeding and care behaviors are associated with xerophthalmia in rural Nepalese households. *Social Science and Medicine, 47*, 477–486.

Gorter, A. C., Sandiford, P., Pauw, J., Morales, P., Pérez, R. M., & Alberts, H. (1998). Hygiene behaviour in rural Nicaragua in relation to diarrhoea. *International Journal of Epidemiology, 27*, 1090–1100.

Guldan, G. S., Zeitlin, M. F., Beiser, A. S., Super, C. M., Gershoff, S. N., & Datta, S. (1993). Maternal education and child feeding practices in rural Bangladesh. *Social Science and Medicine, 36*, 925–935.

Hoppe, C., Andersen, G. S., Jacobsen, S., Molgaard, C., Friis, H., Sangild, P. T., & Michaelsen, K. F. (2008). The use of whey or skimmed milk powder in fortified blended foods for vulnerable groups. *Journal of Nutrition, 138*, 145S–161S.

Hotz, C., & Gibson, R. S. (2001). Complementary feeding practices and dietary intakes from complementary foods amongst weanlings in rural Malawi. *European Journal of Clinical Nutrition, 55*, 841–849.

Islam, M. M., Khatun, M., Peerson, J. M., Ahmed, T., Mollah, M. A. H., Dewey, K. G., & Brown, K. H. (2008). Effects of energy density and feeding frequency of complementary foods on total daily energy intakes and consumption of breast milk by healthy breastfed Bangladeshi children. *American Journal of Clinical Nutrition, 88*, 84–94.

Lartey, A., Manu, A., Brown, K. H., Peerson, J. M., & Dewey, K. G. (1999). A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micronutrient status of Ghanaian infants from 6 to 12 months of age. *American Journal of Clinical Nutrition, 70*, 391–404.

Mabilia, M. (1996). Beliefs and practices in infant feeding among the Wagogo of Chigongwe (Dodoma rural district) Tanzania: II. Weaning. *Ecology of Food and Nutrition, 35*, 209–217.

Manary, M. J., Ndekha, M., Ashorn, P., Maleta, K., & Briend, A. (2004). Home-based therapy for severe malnutrition with ready-to-use food. *Archives of Disease in Children, 89*, 557–561.

Manun'Ebo, M., Cousens, S., Haggerty, P., Kalengaie, M., Ashworth, A., & Kirkwood, B. (1997). Measuring hygiene practices: a comparison of questionnaires with direct observation in rural Zaire. *Tropical Medicine and International Health, 2*, 1015–1021.

Matilsky, D. K., Maleta, K., Castleman, T., & Manary, M. J. (2009). Supplementary feeding with fortified spreads results in higher recovery rates than with a corn/soy blend in moderately wasted children. *Journal of Nutrition, 139*, 773–778.

Moore, A. C., Akhter, S., & Aboud, F. E. (2006). Responsive complementary feeding in rural Bangladesh. *Social Science & Medicine, 62*, 1917–1930.

Oelofse, A., Van Raaij, J. M., Benade, A. J., Dhansay, A. M., Tolboom, J. J., & Hautvast, J. G. (2003). The effect of a micronutrient-fortified complementary food on micronutrient status, growth and development of 6- to 12-month-old disadvantaged South African infants. *International Journal of Food Sciences and Nutrition, 54*, 399–407.

Owino, V. O, Kasonka, L. M., Sinkala, M. M., Wells, J. K., Eaton, S., Darch, T., Coward, A., Tomkins, A. M., & Filteau, S. M. (2007). Fortified complementary food increases growth and hemoglobin independently of α-amylase treatment, without reducing breastmilk intake of 9-month old Zambian infants. *American Journal of Clinical Nutrition, 86*, 1094–1103.

PAHO/WHO. (2003). *Guiding principles for complementary feeding of the breastfed child*. Washington, DC: Pan American Health Organization.

Patel, M. P., Sandige, H. L., Ndekha, M. J., Briend, A., Ashorn, P., & Manary, M. J. (2005). Supplemental feeding with ready-to-use therapeutic food in Malawian children at risk of malnutrition. *Journal of Health Population, and Nutrition, 23*, 351–357.

Paul, K. H., Dickin, K. L., Ali, N. S., Monterossa, E. C., & Stoltzfus, R. J. (2008). Soy- and rice-based processed complementary food increases nutrient intakes in infants and is equally acceptable with or without added milk powder. *Journal of Nutrition, 138*, 163–168.

Pelto, G. H., Levitt, E., & Thairu, L. (2003). Improving feeding practices: current patterns, common constraints, and the design of interventions. *Food and Nutrition Bulletin, 24*, 45–82.

Phuka, J. C., Maleta, K., Thakwalakwa, C., Cheung, Y. B., Briend, A., Manary, M. J., & Ashorn, P. (2008). Complementary feeding with fortified spread and incidence of severe stunting in 6- to 18-month-old rural Malawians. *Archives of Pediatric and Adolescent Medicine, 162*, 619–626.

Phuka, J. C., Maleta, K., Thakwalakwa, C., Cheung, Y. B., Briend, A., Manary, M. J., & Ashorn, P. (2009). Supplementary feeding with fortified spread among moderately underweight 6-18-month-old rural Malawian children. *Maternal and Child Nutrition, 5*, 159–170.

Rolls, B. J. (2009). The relationship between dietary energy density and energy intake. *Physiology and Behavior, 97*, 609–615.

Sakisaka, K., Wakai, S., & Wongkhomthong, S.-A. (2002). Domestic hygiene behaviour of mothers and children aged 0-5 years old in Tayabo village, Nueva Ecija, the Philippines. *Asia-Pacific Journal of Public Health, 14*, 91–98.

Sandige, H., Ndekha, M. J., Briend, A., Ashorn, P., & Manary, M. (2004). Home-based treatment of malnourished Malawian children with locally-prepared or imported ready-to-use food. *Journal of Pediatric Gastroenterology and Nutrition, 39*, 141–146.

Santos, I. S., Gigante, D. P., Coitinho, D. C., Haisma, H., Valle, N. C. J., & Valente, G. (2005). Evaluation of the impact of a nutritional program for undernourished children in Brazil. *Cadernos de Saúde Pública, 21*, 776–785.

Stanton, B. F., Clemens, J. D., Aziz, K. M. A., & Rahman, M. (1987). Twenty-four-hour recall, knowledge-attitudes-practice questionnaires, and direct observations of sanitary practices: a comparative study. *Bulletin of the World Health Organization, 65*, 217–222.

The Manoff Group. (2007). *Trials of improved practices (TIPs): giving participants a voice in program design* [monograph on the internet], Washington, DC, USA: The Manoff Group. Available from: http://www.manoffgroup.com/documents/summarytips.pdf.

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