Infant and young child feeding practices and growth in rural Bangladesh

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Doctor of Philosophy
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Abstract

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Childhood undernutrition contributes significantly to morbidity and mortality in the first few years of life, and increases risk of chronic diseases in adulthood. The majority of growth faltering in children occurs between the ages of 3 and 24 months, likely due to sub-optimal infant and young child feeding (IYCF) practices, recurrent infections and inadequate water and sanitation facilities. Using data from the evaluation of a community-based nutrition program in rural Bangladesh, we identified determinants of IYCF practices and their impact on child growth, and assessed whether providing nutrition messages to care-givers can result in improved growth for children < 2 years old. Twenty-four hundred pregnant women were recruited into a prospective cohort, with follow-up at infant age 3, 9, 16 and 24 months.

Study 1 assessed the relationship between maternal knowledge and attitudes regarding complementary feeding (CF) and timing of CF initiation. We observed that mothers with the most positive attitudes towards CF were less likely to initiate timely CF. Surprisingly, knowledge was not associated with timely CF initiation.

In study 2 we determined the association between household food security (HHFS) and infant diet. We observed that although HHFS was a significant predictor of dietary diversity in infants, diet quality was poor for children from even the more food-secure households.

Our third study focused on the associations between IYCF practices and infant growth. We found that neither exclusive breastfeeding (EBF) at age 3 months, nor timely initiation of CF were associated with subsequent growth. Only quality of diet at age 9 months was significantly associated with infant growth at 9, 16 and 24 months of age.

Our final study assessed the impact of a nutrition program on IYCF practices and infant growth. The program was successful in improving the quality of infant diet at 9 months, but not rates of EBF at 3 months or timely CF initiation. The intervention was also not associated with improvements in infant growth.

Taken together, these studies identify the determinants of age-specific IYCF practices in rural Bangladesh, and contribute to the longitudinal evidence linking these practices to child growth.

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1. Background and significance

Childhood undernutrition, characterized by linear and ponderal growth faltering, is arguably the most important global public health problem, with adverse consequences reaching far beyond the immediate and short term, not only for the individual child, but also for societies and nations as a whole. Two indicators of childhood undernutrition are commonly used: 1) Stunting and 2) Wasting. Stunting is defined as child height-for-age z-score (HAZ) more than 2 standard deviations below the median of World Health Organization (WHO) Child Growth Standards (1, 2), and is considered a marker for long-term nutritional status. Wasting is defined as child weight-for-height z-score (WHZ) more than 2 standard deviations below the median WHO Child Growth Standards (1, 2), and is a measure of acute undernutrition. According to recent estimates, 165 million children < 5 years of age are stunted and 52 million are wasted, in low- and middle-income countries (3). Furthermore, undernutrition, which includes stunting, wasting, and vitamin A and zinc deficiencies, in conjunction with sup-optimal breastfeeding practices, is the underlying cause of 3.1 million child deaths each year (3).

The determinants of childhood undernutrition are multi-layered and varied. Maternal nutritional status plays a pivotal role in fetal development and growth, and birth outcomes, which in turn determine growth in infancy and young childhood (3). Infant and young child feeding (IYCF) practices are another key determinant of child growth (4). Sub-optimal feeding practices result in the majority of childhood growth faltering occurring between the ages of 3 and 24 months (5). Micronutrient deficiencies, especially zinc deficiency, also impact growth negatively (6). Household food security also impacts childhood growth and nutritional status (7, 8), most likely mediated through maternal undernutrition and sub-optimal IYCF practices. Non-nutrition factors, such as frequent and prolonged childhood illnesses and lack of adequate water, sanitation and hygiene (WASH) and sub-clinical conditions, such as environmental enteropathy, also contribute to the burden of childhood undernutrition, especially in low-income settings.

Maternal nutrition

Maternal nutrition is an important determinant of childhood nutrition, especially during early infancy. Maternal nutritional status characterized by her height and weight directly impacts fetal growth. Mothers who are short (height < 145 cm) and underweight (BMI < 18.5 kg) are more likely to give birth to babies who are small-for-gestational-age (SGA; defined as being < 10^{th} percentile for weight of all fetuses at that gestational age) (3). This in turn has implication for child growth; approximately 20% of stunting at 24 months may be attributable to SGA (3). Children born to short mothers (< 145 cm) are also more likely to die in the first five years of life than those born to mothers who were at least 160 cm tall (9). A growing body of evidence also indicates that maternal nutrition affects offspring health in latter’s adult life, especially risk of chronic diseases (10, 11).

Infant and young child feeding practices

IYCF practices are important determinants of nutritional status of children. The WHO recommends exclusive breastfeeding (defined as no other food or drink except for medicines and/or nutritional supplements) for all children up to 6 months of age, followed by introduction of nutritionally adequate and safe complementary foods, while continuing breastfeeding until the child is two years old (12). The prevalence of optimal IYCF practices is very low across the globe. Less than 40% of children are exclusively breastfed (13), leading to increased infant mortality due to frequent and prolonged infections (14).

The lack of exclusive breastfeeding is often accompanied by inappropriate introduction of complementary feeding, the second component of IYCF practices. Timely and adequate introduction of complementary feeding is essential in preventing infant undernutrition (15). Starting from 6 months of age, a range of nutrient- and energy-dense complementary foods should be given frequently to cover the higher nutritional requirements for growing children. However, as with exclusive breastfeeding, complementary feeding practices are also inadequate worldwide. Complementary foods are often introduced too early or too late. Even when they are introduced at the right age, they are most often nutritionally inadequate and unsafe. These sub-optimal feeding practices result in inadequate energy consumption, as well as increased incidence of infant illnesses such as diarrhea and respiratory infections (14), leading to increased infant mortality and morbidity (16).

To facilitate the monitoring of, and improvements in complementary feeding practices, the WHO established population based indicators of complementary feeding practices in 2008 (17). These indicators have been instrumental in raising awareness of the importance of complementary feeding practices for infant growth. They have also become valuable tools for monitoring the success of intervention programs aimed at improving IYCF practices.

Using data from 46 countries, an analysis of these indicators revealed that complementary feeding practices were inadequate in many parts of the world, especially in sub-Saharan Africa and South Asia (18). Analyzing data from the 2011 Nepal Demographic and Health Survey, Khanal et al (19) report that only 30% of Nepalese children received the minimum dietary diversity and only 26% received an acceptable diet, as defined by WHO. In Bangladesh, Kabir et al (20) report that only 42% of children 6-23 months received the minimum dietary diversity recommended by WHO, and 40% received the minimum acceptable diet. These indicators are even worse in India, with only 15% of children aged 6-23 months receiving the adequate dietary diversity, and less than 10% receiving the minimum acceptable diet (21).

Comparing IYCF indicators across five South Asian countries, Senarath et al (22) found that household poverty and low maternal education were the most consistent determinants of sub-optimal feeding practices in this part of the world. In addition, limited exposure to media, lack of antenatal care, and lack of access to trained birth attendants were also associated with inappropriate feeding practices in these populations (22). These findings are consistent with other research looking at determinants of sub-optimal IYCF practices in similar settings (23, 24).

Household food insecurity

Defined as having inadequate physical and economic access to food that meets people's dietary needs as well as their food preferences, (25), household food insecurity has been identified as an important underlying cause of childhood undernutrition (3, 26). However, how household food security impacts IYCF practices is less well understood.

The relationship between household food security, diet and nutritional status of adults and older children has been well-established (27-31). A growing number of studies, especially in recent years, have assessed the relationship of household food insecurity and rates of childhood undernutrition in different parts of the world. Working in eight countries, which were part of the MAL-ED study, Psaki and colleagues (32) observed that household food insecurity (measured via lack of food access) was associated with decrease in HAZ among children aged 24 – 60 months across all MAL-ED sites. Household food insecurity is also associated with childhood stunting and wasting in Bangladesh (33), Pakistan (7), and South Africa (34).

Although the association between household food insecurity and growth faltering in infancy and early childhood has been established, the pathways through which this effect is mediated are not well understood. As sub-optimal complementary feeding practices are highly predictive of childhood undernutrition (35), it is plausible that one of the pathways through which household food insecurity negatively impacts child growth is through inadequate diet quantity, quality and diversity. Limited research has been conducted on how household food security influences infant feeding, especially complementary feeding practices. The study by Saha et al (36), was one of the first to assess this association. Understanding the relationship between household food security and IYCF is essential to assess whether a lack of food or other factors, such as lack of knowledge or cultural issues, need to be addressed in a population. This will have implications for infant nutrition intervention programs.

Environmental factors

Frequent and prolonged childhood diseases, such as diarrhea, are the second immediate cause of undernutrition among children < 5 years of age (26). The link between lack of adequate WASH conditions and increased risk of infectious diseases is well-established, contributing to almost 7% of the global burden of disease and more than 2 million deaths every year (37). Children in low-income countries bear the brunt of this burden.

A growing body of evidence is also linking improvements in WASH conditions to gains in child growth. A recent Cochrane review concluded that WASH interventions can result in improved linear growth among children (38). Working in Ethiopia, Fenn and colleagues (39) observed an improvement of 0.33 HAZ among the group receiving WASH interventions. In India, access to improved sanitation facilities was associated with 16 – 39% reduced odds of stunting among children < 2 years old (40).

The complex interaction between infections and undernutrition is well-established (15). Defined as changes in the gut's flora due to prolonged and persistent exposure to enteric pathogens, environmental enteropathy (EE) is being increasingly identified as a vital link in this relationship (41, 42). One proposed pathway is EE leading to malabsorption of important nutrients, which in turn lead to deficits in growth (43).

Intervention for improving child nutrition

The importance of adequate nutrition during the first 1000 days, from conception to age 2 years, is well-established, and so are the consequences of inadequate nutrition during this critical period (26). Furthermore, the majority of growth faltering in children occurs between the ages of 3 and 24 months (5). Adequate infant diet (measured via WHO's complementary feeding indicators (44)) was associated with reduced risk of childhood stunting and underweight in 14 low-income countries (45). Therefore, it is not surprising that promotion of optimal complementary feeding practices has been identified as vital to improving childhood nutrition around the globe (46).

Maternal knowledge and attitudes are important determinants of infant feeding practices. Low maternal education was a consistent determinant of sub-optimal feeding practices across five South Asian countries (22), and a higher breastfeeding knowledge score was significantly associated with longer duration of exclusive breastfeeding in Indonesia (47).

Providing education to mothers has been effective in improving a host of infant and child health outcomes, including reduced incidence of diarrhea (48), improved childhood immunization rates (49), and decreased prevalence of underweight and morbidity (50). Education of mothers is also an important component of programs aimed at improving IYCF practices and child growth. Maternal nutrition counseling and education can also improve exclusive breastfeeding rates throughout the first six months of infant's life and reduce risk of childhood stunting by improving complementary feeding practices (46).Complementary feeding education has also been shown to improve child growth and development, as well as reduce morbidity (35, 51). Therefore, promoting optimal ICYF practices through provision of nutrition education to mothers is an important avenue for reducing rates of childhood undernutrition, worldwide.

Other interventions that have been successful in improving child nutrition include home-based fortification of complementary foods with micronutrients and better WASH conditions. Home-based fortification with micronutrient powders (MNP) can reduce prevalence of anemia by 31% (52). However, the evidence for the impact of MNP supplementation on child growth is less conclusive. In-home iron supplementation resulted in significant weight gain among Kenyan infants (53), but a recent review of the effectiveness of MNP supplementation, which included 17 studies from 9 countries, did not find an impact on various child anthropometric measures (54).

Situation in Bangladesh

Bangladesh has made remarkable improvements in child survival over the past two decades. Between 1990 and 2013, under-5 mortality decreased from 144 to 51 per 1000 live births, and infant mortality decreased from 100 to 33 per 1000 live births (55). However, childhood undernutrition remains a major public health problem. Bangladesh is one of the 20 countries where 80% of the word's undernourished children live (56). The prevalence of preschool children with height-for-age, weight-for-age, and weight-for-height z-scores less than -2.0 is estimated to be 41%, 36%, and 16%, respectively (57). This high burden of childhood undernutrition occurs concurrently with a high prevalence of inadequate infant feeding practices in the country. Only 64% of infants < 6 months are exclusively breastfed, even though 100% are put to the breast at least once during this time (57).

Sub-optimal feeding practices continue as the child grows older. Complementary feeding is delayed for 33% of infants 6-9 months of age (57). Even for those infants for whom complementary feeding is initiated in a timely manner, the diet is most likely not nutritionally adequate, with less than half the children between the ages of 6-23 months receiving a minimally acceptable diet as defined by the WHO (20). Among children 6-11 months, only 18% receive a minimally acceptable diet (20). Furthermore, inadequate infant feeding practices were prevalent even among households in the richest quintile. Only 31% of children from the wealthiest quintile in the country were receiving a minimally acceptable diet (57). The figure was 11% for children from the lowest quintile (57).

Gaps in literature

Most research assessing the association between IYCF practices and childhood growth has been done using nationally representative, cross-sectional surveys, such as country-specific Demographic and Health Surveys. These studies, although important for establishing the prevalence of a public health problem, are limited in their ability to determine how age-specific IYCF practices impact subsequent child growth. Therefore, there is a need for well-designed, prospective studies to assess these associations, and establish plausible temporality between suboptimal infant feeding practices and subsequent growth.

Second, although many studies have looked at the impact of maternal knowledge and attitudes on breastfeeding practices, fewer studies have been done to evaluate the impact of maternal knowledge and attitudes on other components of IYCF practices, specifically age at initiation of complementary feeding and the quantity and quality of infant dietary intake (46). Research assessing the relationship between household food security and infant feeding practices is also limited. Therefore, identifying the determinant of, and barriers to optimal IYCF practices remains a research priority. It will provide the insight necessary for designing effective, age-appropriate interventions for improving infant feeding practices and growth. Therefore, effectiveness trials and/or evaluation of programs aimed at improving IYCF practices, specifically complementary feeding practice are urgently needed (58).

Dissertation aims

The overarching goal of this dissertation is to identify the determinants of IYCF practices in rural Bangladesh, assess their impact on child growth and determine whether a program that included maternal nutrition education as a significant component resulted in better nutritional outcomes for children less than 2 years of age. This dissertation addresses the identified gaps in research by answering the following four questions:

1. Are maternal knowledge and attitudes regarding IYCF practices significant predictors of timing of CF initiation?
2. Does household food security independently determine quality of infant diet?
3. Do improved IYCF practices in the first year of life result in improved child growth through 2 years of age?
4. Can a nutrition program that included maternal education as a significant component improve IYCF practices and infant growth in rural Bangladesh?

2. Maternal knowledge and attitudes in relation to complementary feeding initiation in rural Bangladesh

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Abstract

Inappropriate complementary feeding (CF) practices are common in Bangladesh. To identify predictors of the timing of introduction of solid/semi-solid/soft foods (CF initiation) in rural Bangladesh, we prospectively interviewed 2073 pregnant women at 28 - 31 weeks' pregnancy and at postnatal months 3 and 9. CF knowledge and attitudes were assessed at the 3 mo visit and score tertiles were created for analysis. CF initiation was characterized as early (≤4 mo), timely (5-6 mo) or late (≥7 mo), based on maternal recall at the 9 mo visit. We used polytomous logistic regression, adjusted for SES, infant gender, maternal age, literacy and parity to identify predictors of early or late vs. timely CF initiation.

CF initiation was early for 7%, timely for 49%, and late for 44% of infants. Only 19% of mothers knew the recommended CF initiation age. A higher knowledge score was not associated with timely CF initiation. Mothers with the least positive attitudes (lowest score tertile) were more likely to initiate early CF compared to those with the most positive attitudes (highest score tertile) (aOR = 0.6, 95% CI: 0.4 – 0.9). Mothers with the most positive attitudes were more likely to initiate late CF compared to those with the least positive attitude (aOR = 1.3, 95% CI: 1.0 – 1.6). Multiparous mothers were also less likely to initiate timely CF compared to those with 1 child (early vs. timely aOR = 1.9; 95% CI: 1.2, 3.1; late vs. timely aOR = 1.3, 95% CI: 1.0, 1.7). SES, infant gender, maternal age and literacy were not associated with age at CF initiation.

Efforts discouraging early CF initiation have been successful but late introduction of foods is still widely prevalent in Bangladesh. Interventions for improving infant nutrition need to promote timely CF initiation.

Introduction

Globally, 165 million children less than five years of age are undernourished, with 52 million suffering from severe malnutrition (3). Undernutrition, which includes stunting, wasting, and vitamin A and zinc deficiencies, along with sup-optimal breastfeeding practices, is the underlying cause of 45% of all child deaths (3). The World Health Organization (WHO) recommends exclusive breastfeeding for all children up to 6 months of age, followed by introduction of nutritionally adequate and safe complementary foods, while continuing breastfeeding until the child is two years old (12). However, worldwide only 39% of infants less than 6 months are exclusively breastfed (13).

Prevalence of the WHO-recommended infant and young child feeding (IYCF) indicator for timely initiation of complementary feeding (59) is similarly dismal, especially in three of the 20 countries where 80% of the world's undernourished children live (56). In Nepal, one-third of children 6-8 months of age do not receive any solid/semi-solid foods (60). In India, complementary feeding is initiated for only 55% of children aged 6-8 months (61). And in Bangladesh, only 67% of children 6-9 receive complementary foods (57).

Suboptimal IYCF practices are a key determinant of childhood undernutrition, especially between the ages of 3 and 24 months (5). Furthermore, inappropriate infant feeding practices during this period have lifelong consequences in the form of deficits in linear growth and cognitive ability (3). Although extensive research has been conducted on identifying predictors of breastfeeding practices, there has been less focus on trying to ascertain the determinants of infant diet beyond exclusive breastfeeding, especially timing of initiation of complementary feeding. The studies that have focused on identifying factors associated with introduction of solid/semi-solid/soft food have used cross-sectional data (22, 62, 63), and are subject to methodological limitations, such as reverse causality. Therefore, well-designed, prospective studies are needed to identify the barriers to timely complementary feeding initiation and isolate those barriers that are modifiable.

Maternal knowledge and attitudes are important determinants of infant feeding practices. Low maternal education was a consistent determinant of sub-optimal feeding practices across five South Asian countries (22), and a higher breastfeeding knowledge score was significantly associated with longer duration of exclusive breastfeeding in Indonesia (47).

Providing education to mothers has been effective in improving a host of infant and child health outcomes, including reduced incidence of diarrhea (48), improved childhood immunization rates (49), and decreased prevalence of underweight and morbidity (50). Maternal nutrition counseling and education can also improve exclusive breastfeeding rates throughout the first six months of infant's life and reduce risk of childhood stunting by improving complementary feeding practices (46).Complementary feeding education has also been shown to improve child growth and development, as well as reduce morbidity (35, 51).

Bangladesh has a very high burden of childhood undernutrition. The prevalence of children less than 5 years of age with height-for-age, weight-for-age, and weight-for-height z-scores less than -2.0 is estimated to be 41%, 36%, and 16%, respectively (57). Suboptimal infant feeding practices are also widespread. Only 18% of infants 6 – 11 months receive a minimally acceptable diet, (as defined by WHO (44)) and complementary feeding is delayed for one-third of infants aged 6 – 8 months (57); however few studies have attempted to ascertain the causes for this delay. Assessing the relationship between maternal knowledge and attitudes regarding complementary feeding/foods and timely initiation of complementary feeding will provide the insight necessary for designing effective, age-appropriate interventions for improving infant feeding practices and nutritional status in this setting. Therefore, the aim of this study is to determine the strength of the association between maternal knowledge and attitudes and infant age at which complementary foods are introduced in the context of rural Bangladesh.

Methods

Study population and setting

The study setting, population and data collection tools have been described in detail elsewhere (64, 65). Briefly, data for this study were collected in the context of evaluation of Window of Opportunity, a community-based nutrition and infant and young child feeding program implemented by CARE in six countries, including Bangladesh, where it was known as *Akhoni Shomay*. *Akhoni Shomay* was carried out in Karimganj, a rural sub-district of Kishoreganj with a population of ~320,000, approximately 120 km north of Dhaka.

An integrated set of individual-, household- and community-level interventions was implemented. This included promotion of optimal IYCF practices through individual counseling for mothers, as well as group counseling for other key influencers of IYCF practices. The program also promoted hand-washing with soap, and home-based fortification of complementary foods using micronutrient powders.

Women living in a second sub-district, Katiadi, served as controls. To evaluate the program, a prospective cohort of ~2400 pregnant women (1200 per sub-district) was recruited between January and September 2011. Pregnant women were recruited in their 7th month of gestation, with follow-up of their offspring scheduled to occur at 3, 9, 16 and 24 months of age.

Variable derivation

<u>Complementary feeding knowledge</u>

Complementary feeding knowledge was assessed via 19 items included in the questionnaire administered at the 3-month follow-up. Questions included recommended age of complementary feeding initiation, techniques for responsive feeding, and types of foods and how to prepare them. A scale of complementary feeding knowledge was created from the sum of correct responses. However, if a mother identified force-feeding an infant as acceptable, 1 point was deducted from her knowledge score.

Attitudes

Attitudes were assessed using 10 items also included in the questionnaire administered at 3-month follow-up. Questions included nutritional importance and cost of complementary foods and nutritional supplements, and ease of continued breastfeeding for the mother. Respondents answered using a 5-point scale ranging from‘1 = Strongly Agree’ to ‘5 = Strongly Disagree’. Positive attitudes were reverse-coded before analysis. Factor analysis using principal-axis factoring method and an orthogonal varimax rotation extracted three factors. Nine of the 10 items had factor loadings of > 0.5. An overall attitude scale was created from the simple sum of scores for these nine items (theoretical range: 9 – 45). A higher score reflected more positive attitudes towards complementary feeding.

Infant age at complementary feeding initiation

Infant age (in months) at complementary feeding initiation was estimated using maternal recall at 9-month follow-up. Complementary feeding was considered early if reported age was ≤ 4 months, timely at 5 – 6 months, and late if reported age was ≥ 7 months.

Other covariates

Information on socio-demographic variables, including household socioeconomic status, maternal age, literacy and parity were abstracted from the questionnaire administered at recruitment into the study at 28 – 31 weeks' pregnancy.

Statistical analysis

Data were imported into Statistical Analysis Software (SAS), version 9.3 for analysis. Median (range) was calculated for continuous variable and frequencies and percentages were calculated for categorical variables. Household socioeconomic status was assessed through residence characteristics and ownership of assets. Principal Component Analysis was used to create an asset based socioeconomic status score using methods described by Filmer and Pritchett (66).

A 3-level categorical variable was created for infant age at complementary feeding initiation, with timely initiation as referent. Tertiles were created for maternal knowledge and attitude scores for analysis at 0 – 7, 8 – 9, and 10 – 15 for the knowledge score and at 19 – 29, 30, and 31 – 39 for the attitudes score. Polytomous logistic regression, adjusted for SES, infant gender, maternal age, literacy, parity, district of residence and timing of enrollment was used to determine the association between maternal knowledge and attitudes and timing of CF initiation. Using a polytomous regression model, instead of ordinal logistic regression, allows for comparisons of 'early' or 'late' versus 'timely' initiation of complementary feeding, separately. The corresponding odds ratios and their 95% confidence intervals are interpreted using 'timely' CF initiation as referent. After collinearity assessment, interactions between maternal knowledge, attitudes and each of the covariates were evaluated. Statistical significance was set at $p < 0.05$.

Ethics

This study was approved by the Research Review Committee (RRC) and the Ethical Review Committee (ERC) of the International Center for Diarrheal Disease Research, Bangladesh (icddr,b). At the time of enrollment, informed consent was provided by each woman. Verbal consent was obtained at each follow-up visit.

Results

The 9-months follow-up was completed by 2073 out of 2400 mother-child dyads. Based on maternal recall, complementary feeding was initiated at ≤ 4 months for 7%, at 5-6 months for 49%, and ≥ 7 months for 44% of infants in our cohort. At age 9 months, complementary feeding had been initiated for all but three infants in our cohort, with 98% also continuing to be breastfed.

Table 2.1 summarizes the maternal knowledge and attitudes regarding complementary feeding prevalent among the mothers in the study. Only 19% of mothers answered correctly when asked about the recommended age of complementary feeding initiation. When asked about methods of responsive feeding, only 36% of respondents were able to identify 3 or more techniques. All but 7 of the mothers interviewed "Agreed" or "Strongly Agreed" that complementary foods in addition to breastmilk were healthy for infants > 6 months of age (a positive attitude), but 97% also "Agreed" or "Strongly Agreed" that feeding their baby food costs more than just breastfeeding (a negative attitude).

Characteristics of study households, stratified by tertiles of maternal knowledge and attitudes towards complementary feeding, are summarized in Tables 2.2 and 2.3 respectively. Maternal age, literacy, parity and SES were similar across these tertiles. Timing of complementary feeding initiation differed significantly by tertiles of maternal attitudes ($p < 0.01$) but not knowledge.

The associations between maternal knowledge and attitudes towards complementary feeding and timing of complementary feeding initiation are summarized in Table 2.4. Maternal knowledge was not associated with the outcome, but maternal attitudes were. Mothers with lowest attitudes tertile were more likely to initiate early complementary feeding compared to mothers with higher attitude tertiles (aOR = 0.6; 95% CI: 0.4 – 0.9). Mothers with highest attitudes tertiles were also more likely to initiate late complementary feeding compared to mothers in the lowest attitude tertile (aOR = 1.3; 95% CI: 1.0 – 1.6). Household socioeconomic status, maternal age, literacy and infant gender were not associated with timing of complementary feeding initiation, but maternal parity was. Mothers with more than one child were significantly less likely to initiate timely complementary feeding compared to mothers with only one child (early vs. timely aOR = 1.9; 95% CI: 1.2, 3.1; late vs. timely aOR = 1.3, 95% CI: 1.0, 1.7)

As there was no evidence of collinearity, we also tested for interactions between maternal knowledge, attitudes and each of the covariates. No significant interactions were observed.

Discussion

Our study assessed the association between maternal knowledge and attitudes regarding complementary feeding and the timing of complementary feeding initiation in rural Bangladesh. We observed that although the prevalence of early initiation is low, a large proportion of mothers are waiting longer than the WHO recommended 6 months before introducing solid/semi-solid/soft foods to infants, and that a higher score on the attitude scale resulted in late initiation of complementary feeding.

Delayed introduction to complementary foods is not unique to our study setting. In several countries with high burden of childhood undernutrition, complementary feeding is initiated too late for a significant proportion of infants (57, 60, 61). Given this fact, as well as the well-established relationship between suboptimal complementary feeding practices and consequences for child health and survival, the focus of most nutrition intervention programs has not been timely complementary feeding promotion as a measurable outcome. Instead these studies have assessed the effect of complementary feeding education on outcomes such as infant growth, morbidity and development (35, 51).Therefore, there is an urgent need for intervention programs and well-designed follow-up studies that also focus on decreasing the prevalence of delayed introduction of complementary foods, in addition to improving frequency, diversity and quantity of CF, especially in low-income, food insecure populations.

We found that better maternal attitudes towards complementary feeding, but not improved maternal knowledge, were associated with the timing of complementary feeding initiation. Specifically, when comparing infants for whom CF was initiated early or on time, mothers with more positive attitudes towards complementary feeding were less likely to initiate early CF. However, when comparing infants for whom CF was initiated too late or on time, mothers with better attitudes were more likely initiate late complementary feeding. This apparent discrepancy may be explained by the nature of the intervention of *Akhoni Shomay,* the nutrition intervention program this study is embedded in. The majority of the behavior change messages regarding IYCF practices were focused on breastfeeding initiation, exclusivity and maintenance. Only two of the nine key behaviors that were promoted as part of *Akhoni Shomay* concentrated on CF practices, with an emphasis on diet quantity, quality, and diversity. Therefore, it is possible that program staff delivering complementary feeding education focused on what foods to feed the infant and how to prepare them, and not on the age at which solid/semi-solid/soft foods should be introduced to the child. As Table 2.1 shows, the majority of mothers in the study identified ≥ 4 WHO recommended food groups and how to prepare them, but less than 20% of mothers knew the correct age at which complementary feeding should be initiated.

Although the association of maternal knowledge, whether context specific or measured via educational attainment, and improved child health outcomes is well-established, we did not observe this association in our study. Neither maternal education as measured by literacy status, nor context specific knowledge regarding IYCF practices was associated with timing of introduction of solid/semi-solid/soft foods. This finding is in contrast to that of other studies that have assessed the factors influencing timing of complementary feeding initiation (62, 63, 67). It is possible that maternal knowledge/education is not the foremost driver of child rearing practices in this particular setting. Working in the same setting, Yu et al (65) did not observe an association between prenatal maternal breastfeeding knowledge and exclusive breastfeeding status at infant age 3 months. Also working with data collected as part of *Akhoni Shomay* evaluation Owais et al [unpublished data] did not find an association between maternal literacy and receipt of minimally acceptable diet (as defined by WHO (44)) at infant age 9 months.

Multiparous mothers in our study were significantly less likely to initiate timely complementary feeding. Even though previous studies did find parity to be significantly associated with timing of complementary feeding initiation, the direction of association in those studies differs from what we observed. In Georgia and northern Ethiopia, mothers with two or more children were more likely to introduce complementary foods at the WHO recommended age, compared to those with one child (62, 63). It is possible that nulliparous mothers in our study setting are more amenable to behavior change, as they don't have other children to take care of, and are likely to have more time to think about and act on the messages being given to them. If this is true, then future intervention programs should focus most on first-time mothers. This strategy may also have the advantage of being sustainable, as these mothers will likely follow the recommended infant feeding practices for all their latter children.

A major strength of our study is the large sample size which increases the power of our analysis. Furthermore, as this was a prospective cohort study, the main exposure was assessed prior to the outcome, which strengthens our ability to make causal inferences. However, as with any other observational study, this one also has some limitations. The outcome is based on maternal recall several months after solid/semi-solid/soft foods were introduced to the infant. This is a potential source of outcome misclassification in the study as infant age at complementary feeding initiation was assigned based on maternal report and not directly observed feeding practices. The time lag may also be a potential source of outcome misclassification as maternal recall may have been affected. However, we did cross-reference the reported age of complementary feeding initiation at the 9-month follow-up with infant diet (based on 24-hour maternal recall) reported at the 3-month follow-up. A discrepancy was present for only 3% of infants included in this study and adjustments to the age at complementary feeding initiation were made accordingly.

In conclusion, this study adds to the literature on determinants of infant and young child feeding practices, especially delayed introduction of complementary foods in resource poor settings. We observed that although efforts discouraging early complementary feeding initiation have been successful, late introduction of foods remains widely prevalent. Our findings imply that interventions, such as educational activities, aimed at improving infant nutritional status need to focus on emphasizing timely complementary feeding initiation. However, identifying barriers to optimal feeding practices should remain a research priority. A better understanding of predictors of behaviors around infant feeding will enable interventions programs to be most effective in modifying these behaviors.

Table 2.1: Complementary feeding knowledge and attitudes among 2073 mothers in 2011-2012 in Kishoreganj, Bangladesh

Knowledge[1]	**%**
Knew recommended age for complimentary feeding initiation	18.8
Identified ≥ 4 WHO recommended food groups for infant diet	89.6
Knew recommended ways to prepare infant's food	73.7
Identified ≥ 3 methods of responsive feeding	35.9
Attitudes[1,2]	
Complementary foods in addition to breastmilk are healthy for infants > 6 months	99.7
Nutritional supplements are affordable and ensure infant has adequate nutrition	28.3
Confident about continued breastfeeding	24.9
Complementary feeding is expensive	96.9

[1] Assessed at infant age 3 months
[2] Proportion includes those who 'Agreed' or 'Strongly Agreed'

Table 2.2: Maternal characteristics[1] and infant feeding practices[2] among 2073 mother-child dyads in 2011-2012 in Kishoreganj, Bangladesh, by maternal knowledge

		Maternal knowledge score[3]			
		0 – 7	8 – 9	10 – 15	
	n	594	699	780	*p*
Maternal characteristics					
Age in years, median (range)		24 (15 – 49)	24 (15 – 47)	24 (14 – 46)	0.18
Literacy, %					0.40
Cannot read at all		36.6	32.9	36.0	
Can read part of a sentence		16.2	16.7	14.1	
Can read a complete sentence		47.2	50.4	49.9	
Parity, %					0.13
1		24.7	28.3	29.5	
≥2		75.3	71.7	70.5	
Socioeconomic status, %					0.07
1st quintile (lowest)		23.4	20.0	16.4	
2nd quintile		20.4	20.0	19.4	
3rd quintile		18.4	18.9	22.0	
4th quintile		19.7	19.3	21.0	
5th quintile (highest)		18.2	21.8	21.2	
Infant feeding practices					
Continued breastfeeding at 9 months, %		98.7	97.6	97.3	0.21
Complementary feeding initiation, %					0.08
Early (≤ 4 months)		8.2	7.3	5.4	
Timely (5 – 6 months)		46.6	46.9	52.2	
Late (≥ 7 months)		45.2	45.8	42.4	

[1]Assessed at baseline

[2]Assessed at infant age 9 months

[3] Assessed at infant age 3 months; categories are tertiles

Table 2.3: Maternal characteristics[1] and infant feeding practices[2] among 2073 mother-child dyads in 2011-2012 in Kishoreganj, Bangladesh, by maternal attitude

	Maternal attitude score[3]			
	19 – 29	30	31 – 39	
n	619	742	712	*p*
Maternal characteristics				
Age in years, median (range)	24 (15 – 46)	24 (14 – 49)	24 (15 – 45)	0.39
Literacy, %				0.32
Cannot read at all	37.8	32.9	35.2	
Can read part of a sentence	16.2	15.8	14.9	
Can read a complete sentence	46.0	51.3	49.9	
Parity, %				0.81
1	27.1	28.6	27.4	
≥ 2	72.9	71.4	72.6	
Socioeconomic status, %				0.37
1st quintile (lowest)	23.3	17.8	18.5	
2nd quintile	18.9	19.7	21.1	
3rd quintile	19.4	21.0	19.4	
4th quintile	19.2	19.9	20.8	
5th quintile (highest)	19.2	21.6	20.2	
Infant feeding practices				
Continued breastfeeding at 9 months, %	93.9	99.1	99.9	<0.01
Complementary feeding initiation, %				<0.01
Early (≤ 4 months)	11.0	4.8	5.3	
Timely (5 – 6 months)	52.2	46.4	48.5	
Late (≥ 7 months)	36.8	48.8	46.2	

[1]Assessed at baseline
[2]Assessed at infant age 9 months
[3] Assessed at infant age 3 months; categories are tertiles

Table 2.4: Association between maternal knowledge and attitudes and complementary feeding initiation[1] in 2011-2012 in Kishoreganj, Bangladesh

	Maternal knowledge score[2]		
	0 – 7	8 – 9	10 – 15
Complementary feeding initiation			
Unadjusted OR (95% CI)			
Early[3] vs. timely[4]	Ref.	0.9 (0.6 – 1.4)	0.6 (0.4 – 0.9)
Late[5] vs. timely[4]	Ref.	1.0 (0.8 – 1.3)	0.8 (0.7 – 1.0)
Adjusted[6] OR (95% CI)			
Early[3] vs. timely[4]	Ref.	1.0 (0.7 – 1.6)	0.8 (0.5 – 1.3)
Late[5] vs. timely[4]	Ref.	1.2 (1.0 – 1.5)	1.1 (0.8 – 1.4)
	Maternal attitude score[2]		
	19 – 29	30	31 – 39
Complementary feeding initiation			
Unadjusted OR (95% CI)			
Early[3] vs. timely[4]	Ref.	0.5 (0.3 – 0.8)	0.5 (0.3 – 0.8)
Late[5] vs. timely[4]	Ref.	1.5 (1.2 – 1.9)	1.4 (1.1 – 1.7)
Adjusted[6] OR (95% CI)			
Early[3] vs. timely[4]	Ref.	0.6 (0.4 – 0.9)	0.6 (0.4 – 0.9)
Late[5] vs. timely[4]	Ref.	1.5 (1.2 – 1.9)	1.3 (1.0 – 1.6)

[1]Assessed at infant age 9 months
[2]Assessed at infant age 3 months; categories are tertiles
[3]Defined as age ≤ 4 months
[4] Defined at age 5 – 6 months
[5] Defined as age ≥ 7 months
[6] Adjusted for SES, maternal age, literacy, parity, infant gender, district and time of enrollment

3. Household food security and infant feeding practices in rural Bangladesh

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Abstract

To determine the association between household food security (HHFS) and infant complementary feeding (CF) practices in rural Bangladesh, we studied pregnant women and their infants followed-up at age 3 and 9 months. Information on socio-demographics, maternal diet, and infant diet and feeding practices were collected by interview. We used two indicators of HHFS at 3 months' follow-up: maternal food composition score (FCS), calculated via the World Food Programme method, and an HHFS index created from an 11-item food security questionnaire. Infant feeding practices were characterized using WHO definitions.

2073 mother-child dyads completed the 9 months follow-up. CF was initiated at age ≤ 4 months for 7%, at 5-6 months for 49%, and ≥7 months for 44% of infants. Based on 24-hour dietary recall, 98% of infants were still breastfeeding at age 9 months, 16% received ≥4 food groups and 16% received ≥4 food groups and ≥4 meals (minimally acceptable diet) in addition to breastmilk. Mothers' diet was more diverse than infants'. The odds of receiving a minimally acceptable diet for infants living in most food secure households, were 3 times those for infants living in least food secure households (adjusted OR: 3.0; 95% CI: 2.1, 4.3).

HHFS and maternal FCS are significant predictors of subsequent infant feeding practices. Nevertheless, even the more food secure households had poor infant diet. Interventions aimed at improving infant nutritional status need to focus on both complementary food provision and education.

Introduction

Infant and young child feeding (IYCF) practices are important determinants of nutritional status of children. The World Health Organization (WHO) recommends exclusive breastfeeding (defined as no other food or drink except for medicines and/or nutritional supplements) for the first six months of life. Even though the benefits of exclusive breastfeeding are well-established, only 39% of infants less than 6 months old are exclusively breastfed worldwide (13).

The lack of exclusive breastfeeding is often accompanied by inappropriate complementary feeding practices, the second component of IYCF. Timely and adequate introduction of complementary feeding is essential in preventing infant undernutrition (15). The WHO recommends introduction of complementary foods from 6 months of age, with continued breastfeeding until the child is two years old. A range of nutrient- and energy-dense complementary foods should be given frequently to cover the higher nutritional requirements for growing children. However, as with exclusive breastfeeding, complementary feeding practices are also inadequate worldwide. Complementary foods are often introduced too early or too late. Even when they are introduced at the right age, they are most often nutritionally inadequate and unsafe. These sub-optimal feeding practices result in inadequate energy consumption, as well as increased incidence of infant illnesses, such as diarrhea and respiratory infections (14), leading to increased infant mortality and morbidity (16).

Bangladesh is one of the 20 countries where 80% of the world’s undernourished children live (56). The prevalence of preschool children with height-for-age, weight-for-age, and weight-for-height z-scores less than -2.0 is estimated to be 41%, 36%, and 16%, respectively (57). This high burden of childhood undernutrition occurs concurrently with a high prevalence of inadequate infant feeding practices in the country. Only 64% of infants < 6 months are exclusively breastfed, even though 100% are put to the breast at least once during this time (57). Sub-optimal feeding practices continue as the child grows older. Complementary feeding is delayed for 33% of infants 6-9 months of age (57). Furthermore, exclusive breastfeeding prevalence has not improved over the past decade (57). Even for those infants for whom complementary feeding is initiated in a timely manner, the diet may not be nutritionally adequate, with less than half the children between the ages of 6-23 months receiving a minimally acceptable diet as defined by the WHO (20). Among children 6-11 months, only 18% receive a minimally acceptable diet (20).

Household food security, defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences, (68) has been identified as an important underlying cause of childhood undernutrition (3, 26). However, how household food security impacts IYCF practices is less well understood.

The relationship between household food security, diet and nutritional status of adults and older children has been well-established (27-31). Substantial research has also been conducted on identifying the predictors of nutritional status of infants and young children (3, 26). And it is no surprise that sub-optimal complementary feeding practices are highly predictive of childhood undernutrition (35). However, fewer studies have attempted to assess the relationship between how food secure a household is and the quality of an infant’s diet. This relationship can have implications for infant nutrition intervention programs, such as whether the appropriate intervention is to rectify lack of food access at the household level or address other barriers to optimal infant diet, such as lack of knowledge or cultural issues.

Presumably more food secure households are more likely to have improved infant diet. However, according to the 2011 Bangladesh Demographic and Health Survey, only 31% of children from the wealthiest, and probably the most food secure quintile in the country were receiving a minimally acceptable diet (57). The figure was 11% for children from the lowest quintile (57). Therefore, the aim of this study is to determine the strength of the association between household food security and infant feeding practices independent of other socio-demographic factors in the context of a food insecure population in rural Bangladesh.

Methods

Study population and setting

The study setting, population and data collection tools have been described in detail elsewhere (64, 65). Briefly, data for this study were collected in the context of evaluation of Window of Opportunity, a community-based nutrition and infant and young child feeding program implemented by CARE in six countries, including Bangladesh, where it was known as *Akhoni Shomay*. *Akhoni Shomay* was carried out in Karimganj. A rural sub-district of Kishoreganj with a population of ~320,000, approximately 120 km north of Dhaka, this is one of the most food insecure regions in Bangladesh.

An integrated set of individual-, household- and community-level interventions was implemented. Women living in a second sub-district, Katiadi, served as controls. To evaluate the program, a prospective cohort of ~2400 pregnant women (1200 per sub-district) was recruited between January and September 2011. Pregnant women were recruited in their 7th month of gestation, with follow-up of their offspring scheduled to occur at 3, 9, 16 and 24 months of age.

Variable derivation

<u>Infant diet quality</u>

To evaluate infant diet quality, our main outcome, we used two indicators developed by WHO. The first, infant dietary diversity, is defined as number of food groups consumed by the infant in the past 24 hours (44). Using maternal recall at the 9-months' follow-up, everything the child ate over the past 24 hours was categorized into one of seven food groups. An infant who consumes ≥ 4 food groups is said to meet WHO's minimum dietary diversity criteria (44). The second index was whether a child received a minimally acceptable diet in the past 24 hours (44). This indicator is derived from the number of food groups as well as the number of meals consumed over a 24 hour period. Furthermore, whether an infant received a minimally acceptable diet or not is also determined by his or her age and breastfed status. For example, a 9 months old breastfed infant should receive ≥ 4 food groups and ≥ 4 meals over 24 hours to be considered having received a minimally acceptable diet.

Household food security

Household food security, our main exposure, was assessed via Food Composition Score (FCS) based on reported maternal diet at 3-months' follow-up. Developed by the World Food Programme, FCS is a composite of dietary diversity, frequency with which food is consumed in the household, and the nutritional importance of food (69). There are seven food groups included in calculating the FCS, which is calculated by multiplying a food-group specific weighting factor with the number of days that food group was consumed over the past seven days and then summed up. Animal source protein and dairy products are assigned the largest weighting factor followed by legumes, grains, fruits and vegetables, and sugars and oil.

We also used a scale developed specifically for rural Bangladesh by Frongillo et al (70). This questionnaire (called HHFS questionnaire henceforth) grades food insecurity based on frequency of food purchases, cooking and meals consumed, as well as management strategies. Of the 11 items included in the questionnaire, 10 were used to create the HHFS score. The question asking, "Have you paid back or do you think you can pay back (food borrowed from others in the last 30 days to make a meal)?" was excluded.

Information on socio-demographic variables, including household socioeconomic status, maternal age, literacy and parity were abstracted from the questionnaire administered at recruitment into the study at gestational age 7 months.

Statistical analysis

Data were imported into Statistical Analysis Software (SAS), version 9.3 for analysis. Median (range) was calculated for continuous variable and frequencies and percentages were calculated for categorical variables. Differences between maternal and infant diet were tested using Fisher's exact test. Household socioeconomic status was assessed through residence characteristics and ownership of assets. Principal Component Analysis was used to create an asset based socioeconomic status score using methods described by Filmer and Pritchett (66).

Binary variables for infant dietary diversity and receipt of minimally acceptable diet were created using WHO cut-offs (44). Quartiles were created for both measures of household food security for analysis. Multivariable logistic regression, adjusted for SES, maternal age, literacy, parity, infant gender, district of residence and timing of enrollment was used to determine the association between household food security and quality of infant diet. After collinearity assessment, interactions between both measures of household food security and each of the covariates were evaluated. Statistical significance was set at $p<0.05$.

Ethics

This study was approved by the Research Review Committee (RRC) and the Ethical Review Committee (ERC) of the International Center for Diarrheal Disease

Research, Bangladesh (icddr,b). At the time of enrollment, informed consent was provided by each woman. Verbal consent was obtained at each follow-up visit.

Results

The 9-months follow-up was completed by 2073 out of 2400 mother-child dyads. Based on maternal recall, complementary feeding was initiated at ≤ 4 months for 7%, at 5-6 months for 49%, and ≥ 7 months for 44% of infants in our cohort. At age 9 months, complementary feeding had been initiated for all but three infants in our cohort, with 98% also continuing to be breastfed. The most common food groups included in infants' diet were grains, roots and tuber (93%), non-vitamin A rich fruits and vegetables (43%), and flesh foods (33%). Dairy products, legumes and nuts, eggs and vitamin A rich fruits and vegetables were consumed by 20%, 17%, 11% and 11% of infants, respectively.

Although 74% of infants in the study received at least 4 meals over a 24-hours period, only 16% of infants in the study met the minimum dietary diversity criteria, and hence were categorized as receiving a minimally acceptable diet over a 24-hours period. The median maternal FCS assessed at 3 months' follow-up was 62 (range: 19.5 – 112) and the median HHFS was 40 (range: 23 – 45). Pearson's correlation estimate between the two scores was 0.38.

Characteristics of study households stratified by maternal diet and household food security score are summarized in Table 3.1 and 3.2, respectively. Maternal age, literacy and parity were similar across food security groups. Infant age at complementary feeding initiation and rates of continued breastfeeding were also similar across groups. However, the quality of infant diet was strongly associated with household food security status. Based on the results from the multivariable logistic model, the odds of receiving a minimally acceptable diet for infants living in most food secure households as measured via maternal diet were 3 times the odds for infants living in least food secure households (adjusted OR = 3.0; 95% CI = 2.1, 4.3; Table 3.3). Results were similar using the HHFS index (Table 3.3). Household socioeconomic status, maternal age, literacy, and infant gender were not associated with infant feeding practices.

We tested for interactions between both measures of household food security and each of the covariates. Interactions for ≥ 4 food groups and minimally acceptable diet could not be assessed due to collinearity issues (see Chapter 3: Appendix). The relationship between household food security and ≥ 4 meals was modified by maternal parity (maternal FCS score: p-interaction = 0.02; HHFS score: p-interaction = 0.048).

We also examined differences between the maternal and infant diets. Table 3.4 summarizes the comparison of maternal and infant dietary diversity. The greatest overlap occurs for grains, roots and tubers, which 93% of mother-child dyads reported consuming over the past 24-hours. The highest discrepancy between maternal and her infant's diet was for flesh foods, with 63% of mothers reporting consuming meat when their infant did not, followed by non-vitamin A rich fruits and vegetables (49%), and legumes and nuts (26%). More than three-quarters of mother-child dyads included in this study reported not consuming eggs (78.7%) and vitamin A rich fruits and vegetables (75.3%). More than half the respondents also reported not consuming dairy products (62.7%) and legumes and nuts (57.8%) for both themselves and their children. We did not observe a difference between maternal and infant dietary diversity by infant gender.

Discussion

Our study assessed the association between household food security and infant feeding practices in a food insecure population. We found that variations in household food insecurity are significantly associated with infant feeding practices in rural Bangladesh. However, maternal diet is more diverse than infant diet in our population.

To our knowledge, this study is one of the first to use the food composition score as an indicator of household food security. Developed by the World Food Programme, the validity of FCS as a method for assessing household food security has been established (69). Although region- or country-specific measures to assess food security contribute to our understanding of how food security is thought of in different cultures, they make cross-country comparisons difficult to conduct. Using a standard measure such as FCS provides the opportunity to compare between settings and studies. That both methods of assessing household food security are similarly associated with infant feeding practices in this study makes it likely that FCS is a valid measure of food security in the context of rural Bangladesh. Additional research is needed to assess whether the validity of FCS as an indicator of food security holds in other settings.

Our study is also one of the few which looked specifically at how household food security drives infant feeding practices. The study by Saha et al (36), was one of the first to assess this association. Their finding, that better HHFS was associated with improved feeding practices for infants 6-12 months old is similar to ours.

As maternal FCS is a direct measure of maternal diet, we can also conclude that maternal diet is strongly associated with infant diet. This finding is similar to those from another study conducted in Bangladesh as well research conducted in Ethiopia and Vietnam (71). However, we also observed discordance between maternal and infant diet. For each of the 7 food groups, whenever there was a discrepancy between their diets, it was in favor of the mother (Table 3.4), meaning that even when the foods were available in the household, they were not being given to the infant. This finding is in contrast to the concept of "maternal buffering" which posits that mothers reduce their own food intake to protect their children from food scarcity (72). Therefore, it is likely that there are more complex processes determining infant diet in rural Bangladesh than how food secure a household is. Understanding these processes will be critical in improving infant feeding practices in this setting.

The amount of schooling completed by mothers is highly associated with improved child health, diet and nutritional outcomes, especially in low-income settings (71, 73-76). Therefore, it is surprising that this association does not hold in our study. This finding may be an indication that improved maternal literacy does not translate directly to better child rearing practices in rural Bangladesh, and interventions for improved child growth and survival in this setting need to be multi-factorial.

A major strength of our study is the large sample size which increases the power of analyses. Furthermore, as this was a prospective cohort study, the main exposure was assessed prior to the outcome. This strengthens our ability to make causal inferences. However, as with any other observational study, this one also has some limitations. First, both the outcome and exposure measures are based on maternal recall of what she and her child ate. However, the time lag between dietary intake and report is comparatively small – 7 days in the case of the mother and only 24 hours for the infant. Second, using minimally acceptable diet as a measure of infant diet a quality has limitation in terms of assessing actual caloric intake. The quantity of food consumed by the infant may be a more relevant measure for studying impact of infant diet on growth outcomes.

In conclusion, this study adds to the body of evidence on how household food security is related to infant feeding practices in low-income settings. We observed that more food secure households employ improved infant feeding practices. Our findings imply that interventions aimed at improving infant nutritional status need to focus on both complementary food provision and education.

Table 3.1: Maternal characteristics[1] and infant feeding practices[2] among 2073 mother-child dyads in 2011-2012 in Kishoreganj, Bangladesh, by maternal food consumption score

	Maternal Food Composition Score[3]				
	19.5–54.5	55–61.5	62–76	76.5–112	
n	531	497	525	520	*p*
Maternal characteristics					
Age in years, median (range)	25 (15 – 49)	24 (16 – 45)	24 (15 – 47)	24 (14 – 46)	0.53
Literacy, %					0.41
Cannot read at all	37.3	31.6	36.0	35.6	
Can read part of a sentence	14.5	17.7	13.9	16.3	
Can read a complete sentence	48.2	50.7	50.1	48.1	
Parity, %					0.85
1	25.8	27.4	29.7	28.1	
2	24.1	23.5	24.0	24.8	
≥ 3	50.1	49.1	46.3	47.1	
Socioeconomic status, %					0.24
1st quintile (lowest)	23.0	16.5	20.4	18.7	
2nd quintile	19.2	18.9	20.2	21.3	
3rd quintile	18.8	21.5	20.2	19.4	
4th quintile	19.8	23.9	17.7	18.8	
5th quintile (highest)	19.2	19.1	21.5	21.7	
Infant feeding practices					
Continued breastfeeding at 9 months, %	97.4	98.8	98.3	96.7	0.11
Age at complementary feeding initiation, %					0.06
≤ 4 months	5.3	5.0	4.8	2.3	
5 – 6 months	48.4	52.1	47.2	54.2	

≥ 7 months	46.3	42.9	48.0	43.5	
Infant diet over past 24 hours, %					
≥ 4 meals	67.6	74.4	77.9	78.1	<0.01
≥ 4 food groups	10.4	16.1	17.7	21.3	<0.01
Minimally acceptable diet[4]	10.4	16.1	17.3	20.6	<0.01

[1] Assessed at baseline
[2] Assessed at infant age 9 months
[3] Assessed via the World Food Programme method; categories are quartiles
[4] ≥ 4 meals *and* ≥ 4 food groups

Table 3.2: Maternal characteristics[1] and infant feeding practices[2] among 2073 mother-child dyads in 2011-2012 in Kishoreganj, Bangladesh, by household food security score

	Household food security score[3]				
	23 – 37	38 – 40	41 – 41	42 – 45	
n	407	789	368	509	*p*
Maternal characteristics					
Age in years, median (range)	24 (15 – 43)	24 (14 – 45)	24 (15 – 41)	24 (15 – 49)	0.78
Literacy, %					0.71
Cannot read at all	33.7	35.5	36.7	34.8	
Can read part of a sentence	18.4	15.3	14.4	14.5	
Can read a complete sentence	47.9	49.2	48.9	50.7	
Parity, %					0.29
1	29.7	27.2	28.0	26.7	
2	20.4	26.9	23.6	23.2	
≥ 3	49.9	45.9	48.4	50.1	
Socioeconomic status, %					0.65
1st quintile (lowest)	22.1	19.9	19.6	17.5	
2nd quintile	21.6	20.0	19.6	18.7	
3rd quintile	17.4	20.9	18.7	21.4	
4th quintile	19.9	19.6	22.0	19.3	
5th quintile (highest)	18.9	19.5	20.1	23.2	
Infant feeding practices					
Continued breastfeeding at 9 months, %	97.5	98.0	98.1	97.4	0.88
Age at complementary feeding initiation, %					0.08
≤ 4 months	6.6	3.9	3.3	3.9	
5 – 6 months	45.2	52.6	52.7	49.7	
≥ 7 months	48.2	43.5	44.0	46.4	

Infant diet over past 24 hours, %					
≥ 4 meals	62.9	73.0	79.1	82.7	<0.01
≥ 4 food groups	6.4	14.4	20.4	24.4	<0.01
Minimally acceptable diet[4]	6.4	14.1	20.4	23.8	<0.01

[1] Assessed at baseline
[2] Assessed at infant age 9 months
[3] Calculated using the 11-item household food security questionnaire; categories are quartiles
[4] ≥ 4 meals *and* ≥ 4 food groups

Table 3.3: Association between household food security and infant feeding practices in 2011-2012 in Kishoreganj, Bangladesh

	Maternal Food Composition Score[1]			
	19.5 – 54.5	55 – 61.5	62 – 76	76.5 – 112
Infant diet over last 24 hours[2]				
≥ 4 meals				
Unadjusted OR (95% CI)	Ref.	1.3 (1.1, 1.8)	1.9 (1.3, 2.2)	1.7 (1.3, 2.2)
Adjusted[3] OR (95% CI)	Ref.	2.2 (1.3, 3.8)	3.0 (1.8, 5.0)	2.7 (1.6, 2.7)
≥ 4 food groups				
Unadjusted OR (95% CI)	Ref.	1.7 (1.2, 2.4)	1.9 (1.3, 2.7)	2.3 (1.7, 3.3)
Adjusted[4] OR (95% CI)	Ref.	1.6 (1.1, 2.3)	2.2 (1.5, 3.2)	3.2 (2.2, 4.6)
Minimally acceptable diet[4]				
Unadjusted OR (95% CI)	Ref.	1.7 (1.2, 2.4)	1.8 (1.3, 2.6)	2.2 (1.6, 3.2)
Adjusted[4] OR (95% CI)	Ref.	1.6 (1.1, 2.3)	2.1 (1.5, 3.1)	3.0 (2.1, 4.3)
	Household food security score[1]			
	23 – 37	38 – 40	41 – 41	42 – 45
Infant diet over last 24 hours[2]				
≥ 4 meals				
Unadjusted OR (95% CI)	Ref.	1.6 (1.2, 2.1)	2.2 (1.6, 3.1)	2.8 (2.1, 3.8)
Adjusted[3] OR (95% CI)	Ref.	1.7 (1.2, 2.3)	2.5 (1.6, 3.9)	3.7 (2.1, 6.5)
≥ 4 food groups				
Unadjusted OR (95% CI)	Ref.	2.5 (1.6, 3.9)	3.8 (2.3, 6.0)	4.7 (3.0, 7.4)
Adjusted[4] OR (95% CI)	Ref.	2.1 (1.3, 3.3)	3.0 (1.8, 4.8)	3.6 (2.3, 5.8)
Minimally acceptable diet[5]				
Unadjusted OR (95% CI)	Ref.	2.4 (1.5, 3.7)	3.8 (2.3, 6.0)	4.6 (2.9, 7.1)
Adjusted[4] OR (95% CI)	Ref.	2.0 (1.3,	2.9 (1.8,	3.5 (2.2,

	3.2)	4.8)	5.6)

[1] Assessed at infant age 3 months
[2] Assessed at infant age 9 months
[3] Adjusted for SES, maternal age, literacy, parity, infant gender, district, time of enrollment and interaction between main exposure and parity
[4] Adjusted for SES, maternal age, literacy, parity, infant gender, district and time of enrollment
[5] ≥ 4 meals *and* ≥ 4 food groups

Table 3.4: Dietary diversity comparison of 2073 mother-child dyads in 2011-2012 in Kishoreganj, Bangladesh (at child age 9 months)

Food groups	**Mother and child ate, %**	**Neither woman nor child ate, %**	**Mother ate, child did not, %**	**Child ate, mother did not, %**	***p***
Grains, roots and tubers	92.9	0.05	6.9	0.1	0.20
Legumes and nuts	11.3	57.8	25.6	5.2	<0.01
Dairy products	11.2	62.7	17.7	8.5	<0.01
Flesh foods	32.2	4.2	63.1	0.5	<0.01
Eggs	5.9	78.7	10.0	5.4	<0.01
Vitamin A rich fruits and vegetables	7.3	75.3	14.1	3.3	<0.01
Other fruits and vegetables	41.1	7.9	49.0	2.0	<0.01

4. Minimum acceptable diet at 9 months but not exclusive breastfeeding at 3 months or timely complementary feeding initiation is predictive of infant growth in rural Bangladesh

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Abstract

The association between suboptimal infant feeding practices and growth faltering is well-established. However, most of this evidence comes from cross-sectional studies. To assess this association prospectively, we interviewed pregnant women at 28 – 31 weeks' pregnancy and at postnatal months 3, 9, 16 and 24 months in rural Bangladesh. Infant feeding practices were assessed using 24-hour dietary recall, and height and weight measurements were used to produce height-for-age (HAZ) and weight-for-height (WHZ) z-scores. Linear regressions were used for HAZ and WHZ as continuous outcomes. Logistic regressions were used for stunting (HAZ < –2.00). All models were adjusted for baseline SES, maternal age, education and parity.

Follow-up was completed by 2189, 2074, 1969 and 1885 mother-child dyads at 3, 9, 16 and 24 months, respectively. Stunting prevalence increased from 25% to 52%, and wasting prevalence from 5% to 13% between infant age 3 and 24 months. Exclusive breastfeeding at 3 months and age at complementary feeding were not associated with infant growth at any follow-up. Receipt of minimally acceptable diet (MAD; as defined by WHO) at 9 months was significantly associated with infant growth at 9, 16 and 24 months of age. Infants receiving MAD had lower odds of being stunted compared to infants who did not receive MAD (adjusted OR = 0.7; 95% CI: 0.6 – 0.9).

Although prevalence of stunting was already high at age 3 months, ensuring infants receive a diverse, high quality diet from 9 months onwards may reduce rates of stunting in the second year of life.

Introduction

Globally, undernutrition is the underlying cause of 3.1 million child deaths each year (3). Children with poor nutrition are also at increased risk of illnesses, such as diarrhea and respiratory infections (14), deficits in cognitive development, as well as diminished work capacity and increased risk of chronic diseases in adulthood (77). According to the most recent global estimates, 165 million children less than 5 years of age are undernourished, with 52 million suffering from severe malnutrition (3); 80% of these children live in one of 20 countries (56). With most of these also being low-or middle-income countries, childhood undernutrition has grave consequences for economic and social development at the national level.

Infant and young child feeding (IYCF) practices are important determinants of nutritional status of children. The World Health Organization (WHO) recommends exclusive breastfeeding (defined as no other food or drink except for medicines and/or nutritional supplements) for the first six months of life, followed by introduction of complementary foods from age 6 months, with continued breastfeeding until the child is two years of age. To facilitate the monitoring of, and improvements in IYCF practices, the WHO established population-based indicators of breastfeeding practices in 1991 (78), and complementary feeding practices in 2008 (17). However, the prevalence of optimal IYCF practices remain low in many parts of the world (13, 22, 45).

Inadequate IYCF practices are increasingly recognized as major contributors to poor infant growth (15, 79, 80). However, most of these studies have used cross-sectional data (22, 62, 63), and are subject to methodological limitations, such as reverse causality. Therefore, well-designed, prospective studies are needed to strengthen the argument for a causal relationship between suboptimal IYCF practices and subsequent childhood growth faltering.

Bangladesh is one of the 20 countries with a disproportionately high burden of childhood undernutrition (56). The prevalence of children less than 5 years of age with height-for-age, weight-for-age, and weight-for-height z-scores less than -2.0 is estimated to be 41%, 36%, and 16%, respectively (57). This high burden of childhood undernutrition occurs concurrently with a high prevalence of inadequate IYCF practices. Only 64% of infants < 6 months are exclusively breastfed, with median duration of exclusive breastfeeding being < 4 months (57). Complementary feeding is delayed for one-third of infants aged 6 – 8 months, and only 18% of infants 6 – 11 months receive a minimally acceptable diet, as defined by WHO (57).

Given the high burden of childhood undernutrition in Bangladesh, there is a need for immediate remedial action, effective and sustainable at the national level. Inviting national governments to be major stakeholders, and including them in the planning and execution of IYCF interventions is essential for ensuring program scale-up, sustainability and success in achieving improvements in childhood growth (81, 82). To contribute to the growing body of longitudinal evidence linking improvements in IYCF practices and subsequent childhood growth, an integrated set of individual-, household- and community-level interventions was implemented in a rural sub-district of Bangladesh, in partnership with the national government. The objective of the present study is to evaluate the relationship between IYCF practices in the first year of life with subsequent childhood growth, in the context of rural Bangladesh.

Methods

Study population and setting

The study setting, population and data collection tools have been described in detail elsewhere (64, 65). Briefly, data for this study were collected in the context of evaluation of Window of Opportunity, a community-based nutrition and infant and young child feeding program implemented by CARE in six countries, including Bangladesh, where it was known as *Akhoni Shomay*. *Akhoni Shomay* was carried out in Karimganj. A rural sub-district of Kishoreganj with a population of ~320,000, Karimganj is approximately 120 km north of Dhaka.

An integrated set of individual-, household- and community-level interventions was implemented. Women living in a second sub-district, Katiadi, served as controls. To evaluate the program, a prospective cohort of ~2400 pregnant women (1200 per sub-district) was recruited between January and September 2011. Pregnant women were recruited in their 7th month of gestation, with follow-up of their offspring scheduled to occur at 3, 9, 16 and 24 months of age.

Variable derivation

Exclusive breastfeeding (EBF) status at 3 months

Breastfeeding status at 3 months was assessed using 24-hour maternal recall of what the child ate/drank. Questions were based on standard Bangladesh Demographic and Health Survey categories (83). EBF status, a binary (0,1) variable, was assigned using the WHO definition of exclusive breastfeeding (44).

Infant age at complementary feeding (CF) initiation

Infant age (in months) at CF initiation was estimated using maternal recall at 9-months' follow-up. CF initiation was considered early if reported age was ≤ 4 months, timely at 5 – 6 months and late if reported age was ≥ 7 months. A 3-level categorical variable was created for infant age at complementary feeding initiation, with timely initiation as referent.

Minimum acceptable diet at 9 months

The indicator for assessing infant diet quality developed by WHO (44) was used to assess whether an infant received a minimum acceptable diet (MAD) at age 9 months. This binary (0,1) indicator is derived from the number of food groups as well as the number of meals consumed by an infant over a 24 hour period. Furthermore, whether an infant received a minimum acceptable diet or not is also determined by his or her age and breastfed status. For example, a 9 months old breastfed infant should receive ≥ 4 food groups and ≥ 4 meals over 24 hours to be considered having received a minimum acceptable diet (MAD = 1); otherwise, the infant would be considered as not having received a minimum acceptable diet (MAD = 0). Using maternal recall at the 9-months' follow-up, everything a child ate over the past 24 hours was categorized into one of seven food groups, as well as the number of meals consumed to determine whether s(he) received MAD.

Infant anthropometric measures

At each follow-up, trained study personnel measured each child's height and weight using methods prescribed by WHO (84). All anthropometric measurements were recorded in duplicate, with the average used in analyses. Age-adjusted height and weight

Z-scores were calculated using the 2006 WHO Child Growth Standards (85). Stunting was defined as height-for-age Z-score (HAZ) < – 2.00. Wasting was defined as weight-for-height Z-score (WHZ) < – 2.00.

Other covariates

Information on socio-demographic variables, including household socioeconomic status, maternal age, literacy and parity were abstracted from the questionnaire administered at recruitment into the study at 28 – 31 weeks' pregnancy. Data on history of infant illness in two previous weeks was collected at each follow-up.

Statistical analysis

Data were imported into Statistical Analysis Software (SAS), version 9.3 for analysis. Median (range) was calculated for continuous variables and frequencies and percentages were calculated for categorical variables. Household socioeconomic status was assessed through residence characteristics and ownership of assets. Principal Component Analysis was used to create an asset based socioeconomic status score using methods described by Filmer and Pritchett (66).

Multivariable linear regression models were used to determine the association between the main outcomes, HAZ and WHZ at age 3, 9, 16 and 24 months, and the main exposures, EBF at 3 months, timing of CF initiation, and receipt of MAD at 9 months (infant feeding practices). Multivariable logistic regression models were used to assess the association between stunting and infant feeding practices. The association between infant feeding practices and wasting, however, was not assessed because prevalence of wasting in the study population was too low to allow for adequately powered analyses.

Separate models were used for each follow-up. Models for 9, 16 and 24 months included all three feeding practices, whereas those for 3 months only included EBF at 3 months. All models were adjusted for baseline SES, maternal age, education, parity, district of residence and wave of enrollment. WHZ models were also adjusted for history of infant illness in the two weeks prior to each follow-up. After collinearity assessment, interactions between each of the three infant feeding practices and all covariates were assessed. Statistical significance was set at $p < 0.05$. All models considered in this analysis are presented in Chapter 4: Appendix.

To account for correlation between outcomes at different follow-up times from same child, we also use generalized estimating equation models. SAS procedure PROC GENMOD was used to generate β estimates and 95% confidence intervals (CI) for HAZ and WHZ, and odds ratios and corresponding 95% CI for stunting, using data from 9, 16 and 24 months of infant age. We assumed an autoregressive(1) (AR(1)) covariance matrix, with robust variance estimates. The AR(1) structure assumes a correlation between measurements from an individual that declines exponentially with time.

To control for random subject-specific effects, we used SAS procedure PROC GLIMMIX with a random intercept, specifying robust variance estimates. The significance of the random intercept was assessed using a Wald test. The logistic model for stunting (HAZ < -2.00) did not converge; the linear models for HAZ and WHZ did. All correlated models were also adjusted for baseline SES, maternal age, education, and parity, district of residence and wave of enrollment. The GENMOD and GLIMMIX models are also presented in Chapter 4: Appendix.

Ethics

This study was approved by the Research Review Committee (RRC) and the Ethical Review Committee (ERC) of the International Center for Diarrheal Disease Research, Bangladesh (icddr,b). At the time of enrollment, informed consent was provided by each woman. Verbal consent was obtained at each follow-up visit.

Results

A total of 2400 women were recruited at baseline, between January and October 2011. Follow-up was completed by 2189, 2074, 1969 and 1885 mother-child dyads at 3, 9, 16 and 24 months of infant age, respectively.

The mean HAZ and WHZ scores at each follow-up are presented in Figure 4.1. At 3 months, the mean HAZ was -1.35 (± 1.20), with 25% of infants categorized as stunted. The corresponding figures for WHZ at 3 months were –0.06 (± 1.20) and 5%. The prevalence of stunting and wasting increased to 52% and 13%, respectively, at 24 months.

Based on maternal report at 3 and 9 months follow-up, 45% of infants were exclusively breastfed at 3 months, timely CF was initiated for 49% of infants, whereas 44% of children in the study were introduced to complementary foods late. Furthermore, only 16% of infants were receiving a minimally acceptable diet at 9 months of age.

Table 4.1 summarizes the characteristics of study households stratified by infant nutritional status at 3 months. Baseline maternal age, education and parity did not differ by stunting or wasting. There were no differences is the proportion of children stunted at 3 months by SES, but prevalence of wasting differed significantly by household wealth quintiles (Table 4.1).

The distribution of stunting and wasting by infant feeding practices is presented in Table 4.2. Prevalence of stunting and wasting did not differ by EBF status at 3 months or by age at which CF was initiated. Wasting prevalence was also similar among infants who did and did not receive MAD at 9 months, but prevalence of stunting was significantly different across the two groups.

The results of multivariable linear regression, multivariable logistic regression and GEE models are summarized in Table 4.3 – 4.6, respectively. After adjusting for baseline SES, maternal age, education, and parity, only receipt of MAD at 9 months was significantly associated with infant linear height. Receiving MAD at 9 months resulted in higher HAZ at 9, 16 and 24 months (adjusted β at 9 months = 0.23, 95% CI: 0.08 – 0.37; adjusted β at 16 months = 0.30, 95% CI: 0.17 – 0.44; adjusted β at 24 months = 0.26, 95% CI: 0.12, 0.39) (Table 4.3). Similarly, the odds of stunting for infant who received MAD at 9 months were lower compared to infants who did not (adjusted OR at 9 months = 0.69, 95% CI: 0.53 – 0.90; adjusted OR at 16 months = 0.67, 95% CI: 0.52 – 0.87; adjusted OR at 24 months = 0.76, 95% CI: 0.59 – 0.98) (Table 4.5).

The results from GENMOD model were comparable. Accounting for the correlation between outcomes, infants who received MAD at 9 months had a higher HAZ (adjusted β = 0.25, 95% CI: 0.13 – 0.38) and correspondingly, had lower odds of being stunted (adjusted OR = 0.72, 95% CI: 0.58 – 0.88) in the second year of life, compared to infants who did not receive MAD at 9 months (Table 4.6). Baseline SES, maternal age, education, and parity were not associated with infant linear height. In addition, the random intercept term included in the GLIMMIX model for HAZ was highly significant with a Z statistic of 19.38 (Wald test $p < 0.001$).

Although EBF at 3 months was not associated with WHZ at 9, 16, and 24 months in multiple linear regression models, at 3 months the relationship between breastfeeding status and WHZ was modified by history of infant illness in the two weeks prior to the follow-up (p-interaction = 0.02; See Figure 4.2/Table 4.4).

Age at CF initiation was not associated with WHZ at any follow-up, but receipt of MAD at 9 months was associated with higher WHZ at 9, 16 and 24 months (adjusted β at 9 months = 0.20, 95% CI: 0.07 – 0.34; adjusted β at 16 months = 0.16, 95% CI: 0.03, 0.29; adjusted β at 24 months = 0.27, 95% CI: 0.15 – 0.40) (Table 4.4). Results from the GENMOD model were similar; infants who received MAD at 9 months had a higher WHZ (adjusted β = 0.22, 95% CI: 0.11 – 0.34) (Table 4.6), compared to those infants who did not. In addition, the random intercept term included in the GLIMMIX model for WHZ was highly significant with a Z statistic of 12.83 (Wald test $p < 0.001$).

Other significant predictors of WHZ included maternal parity for WHZ at 9 months (adjusted β for parity = 2 vs. 1: -0.17, 95% CI: -0.30 – -0.03; adjusted β for parity ≥ 3 vs. 1: -0.16, 95% CI: -0.31 – -0.01) and history of infant illness for WHZ at 9 (adjusted β = -0.18, 95% CI: -0.28 – -0.07), 16 (adjusted β = -0.24, 95% CI: -0.34 – -0.15), and 24 months (adjusted β = -0.17, 95% CI: -0.26 – -0.08), History of infant illness was also significantly associated with WHZ in GEE models (adjusted β = -0.07, 95% CI: -0.11 – -0.02), but maternal parity was not. No other covariate was significant in either the multiple linear regression, or GEE models.

To ascertain differences in growth at age 24 months between infants who received an optimal diet in the first of year of life compared to those who did not, we ran a restricted analysis including only those children who were exposed to all three infant feeding practices considered in this study, and those who were exposed to none of them. There were 86 children in our cohort who were EBF at 3 months, had timely CF initiation, and received MAD at 9 months, and 473 children who did not meet any of these criteria. At 24 months, infants who received the optimal diet had a higher HAZ (adjusted β = 0.31, 95% CI: 0.05, 0.56) and WHZ (adjusted β = 0.29, 95% CI: 0.03, 0.54), compared to infants who did not receive the optimal diet in the first year of life.

Discussion

This study used a prospective cohort to evaluate the association between IYCF practices in the first year of life and subsequent childhood growth. We found that only MAD at age 9 months, and not EBF at 3 months or timely CF initiation, was an independent predictor of childhood growth in the first two years of life.

Median duration of EBF in Bangladesh is < 4 months (57). Therefore, it is not surprising that only 45% of infants in our cohort were being exclusively breastfed at 3 months. We also did not observe an association between EBF at 3 months and HAZ/stunting at any follow-up. This is not unforeseen. Although there is very strong evidence linking EBF with decreased risk of child morbidity and mortality (86, 87), the evidence for the same on child HAZ is less robust (4). We did observe an effect of EBF at 3 months on WHZ at infant age 3 months. Infants who were not EBF and who had a recent illness at 3 months had lower WHZ (Table 4.3a). Furthermore, infants who had a recent history of illness but were EBF had WHZ similar to infants who had not been ill in the two weeks preceding the 3 month follow-up (Figure 4.2). This suggests that EBF protects against WHZ deficits related to illness. Recent morbidity was also a significant predictor of WHZ at 9, 16 and 24 months' follow-ups. Infants with a recent history of illness had lower WHZ at each follow-up. This finding is not surprising as the association between recent morbidity, especially diarrhea, and deficits in growth are well-established (88).

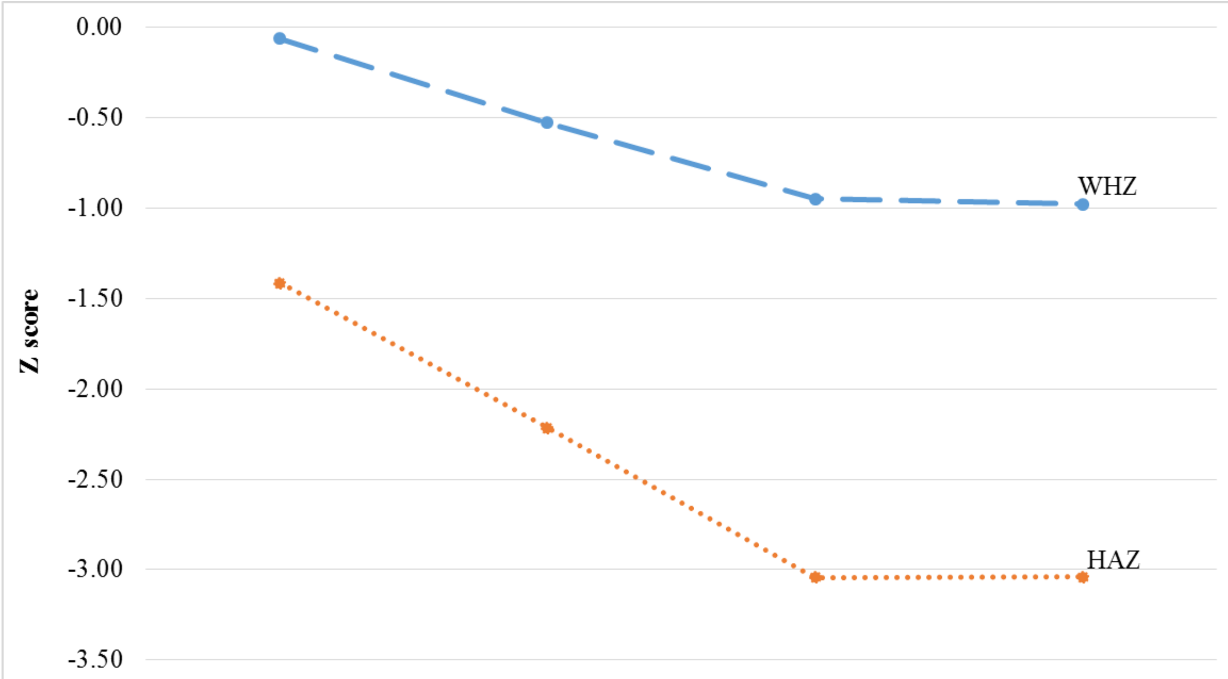
We did not observe an association between age at CF initiation and WHZ, but infants for whom CF was introduced at age 7 months or later had lower HAZ and higher odds of being stunted at 9 months, compared to infants for whom CF initiation was timely (Tables 4.3 and 4.4). We did not observe similar associations for HAZ/stunting at 16 or 24 months. One reason for this may be that by age 9 months, all but 3 infants in our cohort had been introduced to solid/semi-solid/soft foods, even if their diet quality did not meet the WHO recommendations.

Infant diet quality was statistically significantly associated with both short- and long-term infant growth in our cohort. Our findings support the existing and growing literature relating IYCF practices with child growth (4, 89). However, we did not observe an association between child growth and its traditional predictors, such as household SES and maternal education (26, 90). The lack of association between child growth and SES may be explained by the fact that in Bangladesh, prevalence of stunting is high even among the richest households (57).

Although maternal education is an important determinant of IYCF practices (22, 47), we have not observed the same in this setting. Yu et al (65), working with the same population did not find maternal literacy to be a significant predictor of EBF at 3 months. Maternal literacy was also not associated with timely CF initiation in this setting (Owais et al, unpublished data). As maternal education likely impacts child growth through improved CF practices, and this association does not exist in our population, it is not surprising that we did not detect a link between maternal literacy and child growth in our cohort.

A major strength of our study is the large sample size which increases the power of our analysis. Furthermore, our ability to make causal inferences is strengthened as this was a prospective cohort study. However, as with any other observational study, this one also has some limitations. IYCF practices, the main exposures in our study, were determined based on maternal report and not directly observed feeding practices. This is a potential source of exposure misclassification. Furthermore, age at CF initiation is based on maternal recall several months after solid/semi-solid/soft foods were introduced to the infant. This time lag may also be a potential source of misclassification for this exposure, as maternal recall may have been affected. However, for EBF and MAD, 24-hour maternal recall was used to determine infant diet at 3 and 9 months, respectively. For age at CF initiation, we cross-referenced the reported age of complementary feeding initiation at the 9-month follow-up with infant diet (based on 24-hour maternal recall) reported at the 3-month follow-up. A discrepancy was present for only 3% of infants included in this study and adjustments to the age at complementary feeding initiation were made accordingly.

In conclusion, this study adds to the growing body of longitudinal evidence linking IYCF practices and subsequent childhood growth. Ensuring infants receive a diverse, high quality diet from 9 months onwards may improve growth in the second year of life. Nutrition programs aimed at improving child growth should include interventions, such as targeted educational messages, that can improve the quality of infant diet between 6 – 12 months of age.



	3 months	9 months	16 months	24 months
N	2189	2074	1969	1885
Mean WHZ (± SD)	-0.06 (± 1.20)	-0.53 (± 1.11)	-0.95 (± 1.02)	-0.98 (± 1.01)
Mean HAZ (± SD)	-1.35 (± 1.20)	-1.69 (± 1.17)	-2.10 (± 1.12)	-2.06 (± 1.05)

Figure 4.1: Mean HAZ and WHZ by infant age in Kishoreganj, Bangladesh

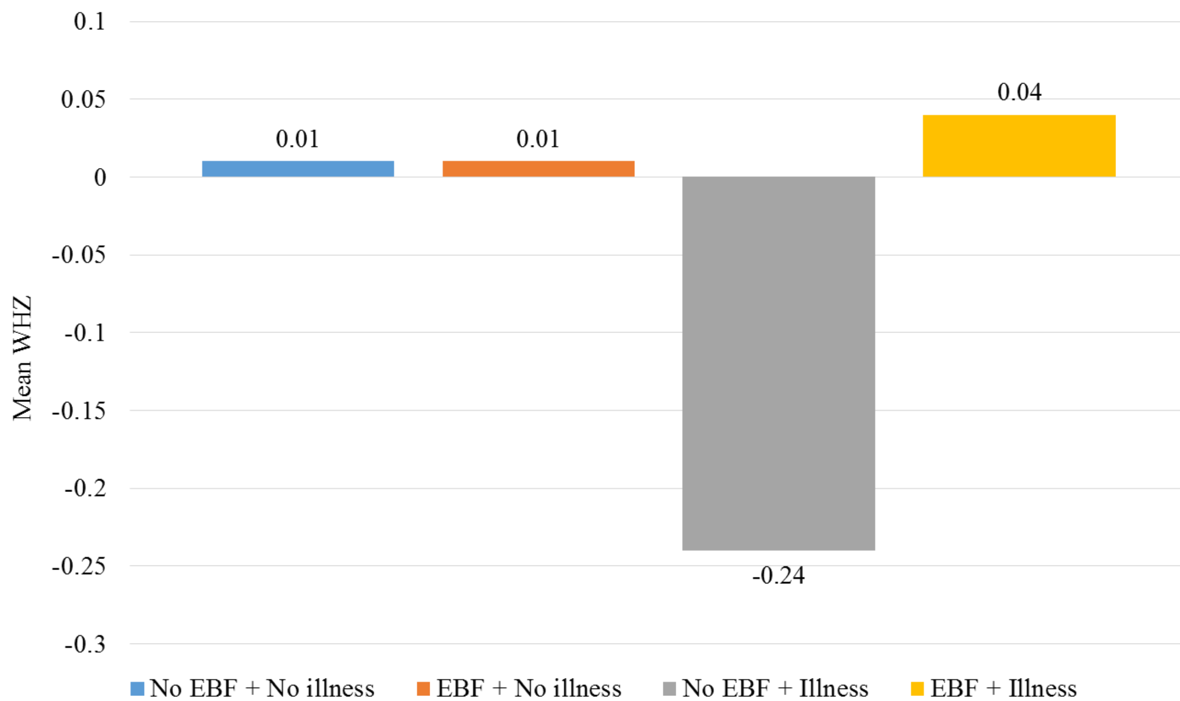


Figure 4.2: Interaction between exclusive breastfeeding (EBF) and history of illness at infant age 3 months in Kishoreganj, Bangladesh (p = 0.02)

Table 4.1: Characteristics of 2189 mother-child dyads in Kishoreganj, Bangladesh, by infant nutritional status at 3 months

	HAZ			WHZ		
	≥ -2.00	< -2.00	*p*	≥ -2.00	< -2.00	*p*
n	1637	552		2085	101	
Maternal characteristics						
Age, %			0.39			0.11
≤ 24 years	52.0	55.2		53.0	48.9	
25 – 34 years	41.8	38.4		40.5	48.9	
≥ 35 years	6.3	6.5		6.5	2.2	
Literacy, %			0.11			0.99
Cannot read at all	36.2	31.5		35.0	34.7	
Can read part of a sentence	15.5	15.4		15.4	15.8	
Can read a complete sentence	48.4	53.1		49.5	49.5	
Parity, %			0.50			0.81
1	27.1	29.7		27.9	25.0	
2	24.4	23.3		24.1	26.1	
≥ 3	48.5	47.0		48.0	48.9	
Socioeconomic status, %			0.62			<0.01
1st quintile (lowest)	20.8	18.1		19.3	36.6	
2nd quintile	19.7	20.5		20.5	8.9	
3rd quintile	19.7	21.4		20.1	18.8	
4th quintile	20.0	19.2		19.9	18.8	
5th quintile (highest)	19.7	20.8		20.1	16.8	
Infant characteristics						
Exclusive breastfeeding at 3 months	46.1	41.8	0.08	45.1	43.6	0.76
History of illness in past 2 weeks	57.8	57.8	0.94	57.5	64.4	0.17

Table 4.2: Infant feeding practices and prevalence of stunting and wasting in Kishoreganj, Bangladesh

Stunting	3 months			9 months			16 months			24 months		
	n	% Stunted	*p*	*n*	% Stunted	*p*	*n*	% Stunted	*p*	*n*	% Stunted	*p*
Exclusive breastfeeding at 3 months			0.08			0.98			0.29			0.26
No	1203	26.7		1117	36.1		1052	54.5		996	53.3	
Yes	983	23.4		952	36.1		906	52.1		872	50.7	
Age at complementary feeding initiation						0.05			0.55			0.36
Early (≤ 4 months)	-	-		141	36.2		132	56.1		127	55.9	
Timely (5 – 6 months)	-	-		1011	33.5		957	52.1		909	50.5	
Late (≥ 7 months)	-	-		922	38.9		871	54.2		816	53.2	
Minimally acceptable diet at 9 months						<0.01			<0.01			0.02
No	-	-		1740	37.5		1639	54.9		1548	53.3	
Yes	-	-		334	29.0		321	45.5		304	45.7	

Wasting	3 months			9 months			16 months			24 months		
	n	% Wasted	*p*	*n*	% Wasted	*p*	*n*	% Wasted	*p*	*n*	% Wasted	*p*
Exclusive breastfeeding at 3 months			0.77			0.59			0.14			0.92
No	1203	4.7		1117	7.3		1052	14.1		996	13.5	

Yes	983	4.5	952	7.9		906	11.8		872	13.6	
Age at complementary feeding initiation					0.30			0.41			0.65
Early (≤ 4 months)	-	-	141	9.2		132	15.1		127	11.0	
Timely (5 – 6 months)	-	-	1011	6.7		957	12.0		909	14.0	
Late (≥ 7 months)	-	-	922	8.4		871	13.8		816	13.5	
Minimally acceptable diet at 9 months					0.09			0.22			0.06
No	-	-	1740	8.1		1639	13.4		1548	14.2	
Yes	-	-	334	5.4		321	10.9		304	10.2	

Table 4.3: Association between infant feeding practices and infant nutritional status[1] in Kishoreganj, Bangladesh – results from multivariable linear regression

	HAZ[2]			
	3 months	9 months	16 months	24 months
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Exclusive breastfeeding at 3 months				
No	Ref.	Ref.	Ref.	Ref.
Yes	0.05 (-0.06, 0.15)	0.06 (-0.05, 0.16)	0.04 (-0.06, 0.14)	0.08 (-0.02, 0.18)
Age at complementary feeding initiation[4]				
Early (≤ 4 months)	-	-0.01 (-0.20, 0.22)	0.02 (-0.19, 0.22)	0.01(-0.19, 0.20)
Timely (5 – 6 months)	-	Ref.	Ref.	Ref.
Late (≥ 7 months)	-	-0.13 (-0.23, -0.02)	-0.03 (-0.13, 0.07)	0.01 (-0.10, 0.11)
Minimally acceptable diet at 9 months				
No	-	Ref.	Ref.	Ref.
Yes	-	0.23 (0.08, 0.37)	0.30 (0.17, 0.44)	0.26 (0.12, 0.39)
	WHZ[2,3]			
	3 months	9 months	16 months	24 months
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Exclusive breastfeeding at 3 months				

No	Ref.	Ref.	Ref.	Ref.
Yes	See Figure 4.2/Table 4.4	0.09 (-0.01, 0.19)	0.08 (-0.02, 0.17)	0.04 (-0.05, 0.14)
Age at complementary feeding initiation				
Early (≤ 4 months)	-	-0.11 (-0.31, 0.09)	0.06 (-0.13, 0.25)	0.15 (-0.04, 0.34)
Timely (5 – 6 months)	-	Ref.	Ref.	Ref.
Late (≥ 7 months)	-	-0.02 (-0.13, 0.08)	0.01 (-0.08, 0.11)	-0.04 (-0.14, 0.05)
Minimally acceptable diet at 9 months				
No	-	Ref.	Ref.	Ref.
Yes	-	0.20 (0.07, 0.34)	0.16 (0.03, 0.29)	0.27 (0.15, 0.40)

[1]HAZ: height-for-age z-score; WHZ: weight-for-height z-score
[2]All models adjusted for SES, maternal age, literacy, parity, district and time of enrollment
[3]All models adjusted for history of infant illness in past 2 weeks

Table 4.4: Modification of the effect of exclusive breastfeeding at 3 months on weight-for-height z-scores by history of infant illness at 3 months in Kishoreganj, Bangladesh

		History of illness in past 2 weeks (at infant age 3 months)			
		No		Yes	
		n	β (95% CI)	*n*	β (95% CI)
Exclusive breastfeeding at 3 months	No	489	Ref.	718	-0.20 (-0.35, -0.06)
	Yes	437	-0.01 (-0.17, 0.15)	549	0.03 (-0.13, 0.18)

Table 4.5: Association between infant feeding practices and stunting in Kishoreganj, Bangladesh – results from multivariable logistic regression

	Stunting[1]			
	3 months	9 months	16 months	24 months
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Exclusive breastfeeding at 3 months				
No	Ref.	Ref.	Ref.	Ref.
Yes	0.84 (0.68, 1.03)	0.99 (0.81, 1.19)	0.90 (0.74, 1.08)	0.92 (0.76, 1.12)
Age at complementary feeding initiation				
Early (≤ 4 months)	-	1.07 (0.74, 1.57)	1.09 (0.75, 1.59)	1.13 (0.76, 1.67)
Timely (5 – 6 months)	-	Ref.	Ref.	Ref.
Late (≥ 7 months)	-	1.30 (1.08, 1.58)	1.09 (0.90, 1.32)	1.09 (0.89, 1.32)
Minimally acceptable diet at 9 months				
No	-	Ref.	Ref.	Ref.
Yes	-	0.69 (0.53, 0.90)	0.67 (0.52, 0.87)	0.76 (0.59, 0.98)

[1]All models adjusted for SES, maternal age, literacy, parity, district and time of enrollment

Table 4.6: Association between infant feeding practices and infant nutritional status[1] in Kishoreganj, Bangladesh – results from GEE models[2]

	HAZ[3] β (95% CI)	WHZ[3,4] β (95% CI)	Stunting[3] OR (95% CI)
Exclusive breastfeeding at 3 months			
No	Ref.	Ref.	Ref.
Yes	0.07 (-0.02, 0.16)	0.07 (-0.002, 0.15)	0.94 (0.80, 1.10)
Age at complementary feeding initiation			
Early (≤ 4 months)	0.003 (-0.15, 0.16)	-0.001 (-0.16, 0.15)	1.09 (0.82, 1.46)
Timely (5 – 6 months)	Ref.	Ref.	Ref.
Late (≥ 7 months)	-0.07 (-0.17, 0.02)	-0.02 (-0.11, 0.06)	1.17 (1.00, 1.37)
Minimum acceptable diet at 9 months			
No	Ref.	Ref.	Ref.
Yes	0.25 (0.13, 0.38)	0.22 (0.11, 0.34)	0.72 (0.58, 0.88)

[1]HAZ: height-for-age z-score; WHZ: weight-for-height z-score
[2] Include observations from 9, 16 and 24 months
[3]Adjusted for SES, maternal age, literacy, parity, district and time of enrollment
[4] Adjusted for history of infant illness in past 2 weeks

5. A prospective cohort-based evaluation of a nutrition education program for improving infant feeding practices and growth in rural Bangladesh

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Abstract

Childhood undernutrition is a major public health problem in Bangladesh. To evaluate a nutrition education intervention program aimed at improving infant and young child feeding (IYCF) practices and growth, we enrolled a prospective cohort of 2400 women (1200 from Karimganj, the intervention district, 1200 from Katiadi, the control district) at 28–31 weeks' pregnancy over 3 waves between January and October 2011. Follow-up occurred at 3, 9, 16 and 24 months of offspring age. The main outcomes were IYCF practices and child growth. IYCF practices were assessed using 24-hour dietary recall and defined as exclusive breastfeeding (EBF) at 3 months, timing of complementary feeding (CF) initiation and minimally acceptable diet (MAD) at 9 months. Child growth was assessed via height-for-age (HAZ) and weight-for-height (WHZ) z-scores. The main exposures were district of residence and wave of enrollment. For infant feeding practices as outcomes, logistic regressions were used. For child growth, linear regressions were used at each follow-up.

Follow-up was completed by 2189, 2074, 1969 and 1885 mother-child dyads at 3, 9, 16 and 24 months, respectively. The intervention was not associated with improved rates of EBF at 3 months. Infants whose mothers were recruited from Karimganj in the third wave were more likely to receive MAD at 9 months compared to those whose mothers were recruited in Katiadi in the same wave (OR for Karimganj = 6.6, 95% CI: 4.2, 10.4 vs. OR for Katiadi = 0.9, 95% CI: 0.5, 1.6). The intervention was also not associated with significant improvements in infant growth.

This program was successful in improving the quality of infant diet at 9 months. These findings support the case for implementing nutrition messages in all programs aimed at improving infant diet, especially in settings where supplementing household diet may not be feasible.

Introduction

Undernutrition is the single largest underlying cause of mortality among children under 5 years of age, leading to more than 3.1 million (45%) child deaths each year (3). Suboptimal infant and young child feeding (IYCF) practices are a key determinant of childhood undernutrition especially between the ages of 3 and 24 months (5). The World Health Organization (WHO) recommends exclusive breastfeeding for all children up to 6 months of age, followed by introduction of nutritionally adequate and safe complementary foods, while continuing breastfeeding until the child is two years old (12). In addition to increased risk of mortality, inappropriate infant feeding practices in the first two years of life have lifelong consequences in the form of deficits in linear growth and cognitive ability (3, 4).

Bangladesh is one of the 20 countries where 80% of the world's undernourished children live (56). The prevalence of children less than 5 years of age with height-for-age, weight-for-age, and weight-for-height z-scores less than -2.0 in the country is estimated to be 41%, 36%, and 16%, respectively (57). Suboptimal infant feeding practices are also widespread. Median duration of exclusive breastfeeding is < 4 months (57). Complementary feeding is delayed for one-third of infants aged 6 – 8 months, and only 18% of infants 6 – 11 months receive a minimally acceptable diet, as defined by WHO (57).

Interventions using behavior change communication (BCC) strategies have been successful in improving a host of child health outcomes, including reduced incidence of diarrhea (48), improved childhood immunization rates (49), and decreased prevalence of underweight and morbidity (50). Based on the findings of several recently conducted systematic reviews, BCC strategies are also effective in not only improving IYCF practices, but also childhood nutritional status and growth (35, 51, 80, 91, 92). However, most of the studies included in these reviews had relatively small sample sizes, short duration of intervention and/or follow-up, and frequent and regular interactions between study staff and participants, which may lead respondents to change their behavior for the duration of the study only. In many cases, the intervention programs were undertaken by research intuitions and/or non-governmental organizations (NGOs), with little collaboration and/or input from national governments. Given the finite resources of most countries with a high burden of childhood undernutrition, inviting national governments to be major stakeholders, and including them in the planning and execution of these interventions is essential for ensuring program scale-up and sustainability.

Given the high burden of childhood undernutrition in Bangladesh, an integrated set of individual-, household- and community-level BCC strategies was implemented in a rural sub-district in 2011. These interventions were developed in partnership with the Government of Bangladesh and local non-governmental organizations already active in the sub-district. The objective of the present study is to assess the effectiveness of this nutrition education program implemented within the existing framework of public health services in improving IYCF practices and infant growth in rural Bangladesh.

Methods

Description of the intervention

This intervention program is embedded in CARE's Window of Opportunity, a community-based nutrition and infant and young child feeding (IYCF) program implemented in six countries, including Bangladesh, where it was known as *Akhoni Shomay*. *Akhoni Shomay* was carried out in Karimganj, a rural sub-district of Kishoreganj with a population of ~320,000, approximately 120 km north of Dhaka.

The program, which was rolled out in January 2011, focused on changing maternal and other key influencers' behavior around IYCF practices. The intervention, which included messages regarding maternal nutrition, breastfeeding initiation, exclusivity and maintenance, and appropriate complementary feeding practices were delivered through individual and group counseling sessions. A list of key IYCF behaviors promoted in *Akhoni Shomay* is presented in Table 5.1.

A government-supported cadre of community health and nutrition workers, trained by CARE to deliver *Akhoni Shomay* messages, carried out the counseling sessions. Individual counseling sessions were held for mothers of children < 2 years of age, with 5 visits scheduled for the first 6 months of infant's life, and 7 visits between 6 – 23 months of age. These mothers also participated in mother-to-mother support groups within their community once every 45 days. Group counseling sessions were carried out for other key influencers of IYCF practices in rural Bangladesh. A monthly session was held for elderly women, including mothers-in-law, aunts and grandmothers, residing in the study households. A group counseling session for fathers was held once every three months.

Data collection and enrollment

As mentioned above, *Akhoni Shomay* was implemented in Karimganj. For program evaluation purposes, a second sub-district, Katiadi, with a population of ~265,000 served as control. A prospective cohort of 2400 pregnant women (1200 per sub-district) was recruited in three waves between January and September 2011. The first wave of participants was enrolled in January and February 2011, the second in May and June 2011, and the third and final wave of participants were enrolled in September and October 2011. Pregnant women were recruited in their 7th month of gestation, with follow-up of their offspring scheduled to occur at 3, 9, 16 and 24 months of age. Development of data collection instruments and methodology are described elsewhere (64, 65).

Variable derivation

<u>Exclusive breastfeeding (EBF) status at 3 months</u>

Breastfeeding status at 3 months was assessed using 24-hour maternal recall of what the child ate/drank. Questions were based on standard Bangladesh Demographic and Health Survey categories (83). EBF status was assigned using WHO definitions (44).

<u>Infant age at complementary feeding (CF) initiation</u>

Infant age (in months) at CF initiation was estimated using maternal recall at 9-months' follow-up. CF initiation was considered early if reported age was ≤ 4 months, timely at 5 – 6 months and late if reported age was ≥ 7 months. A 3-level categorical variable was created for infant age at complementary feeding initiation, with timely initiation as referent.

Minimally acceptable diet at 9 months

The indicator for assessing infant diet quality developed by WHO (44) was used to assess whether an infant received a minimally acceptable diet (MAD) at age 9 months. This binary indicator is derived from the number of food groups as well as the number of meals consumed by an infant over a 24 hour period. Furthermore, whether an infant received MAD or not is also determined by his or her age and breastfed status. For example, a 9 month old breastfed infant should receive $\geq$ 4 food groups and $\geq$ 4 meals over 24 hours to be considered having received MAD. Using maternal recall at the 9-months' follow-up, everything a child ate over the past 24 hours was categorized into one of seven food groups, as well as the number of meals consumed to determine whether s(he) received MAD.

Infant anthropometric measures

At each follow-up, trained study personnel measured each child's height and weight using an electronic scale and wooden height board, as prescribed by WHO (84). All anthropometric measurements were recorded in duplicate, with the average used in analyses. Age-adjusted height and weight Z-scores were calculated using the 2006 WHO Child Growth Standards (85). Stunting was defined as height-for-age Z-score (HAZ) < -2.00. Wasting was defined as weight-for-height Z-score (WHZ) < -2.00.

Other covariates

Information on socio-demographic variables, including household socioeconomic status, maternal age, literacy, and parity were abstracted from the questionnaire administered at recruitment into the study at 28 – 31 weeks' pregnancy.

Statistical analysis

Data were imported into Statistical Analysis Software (SAS), version 9.3 for analysis. Median (range) was calculated for continuous variables and frequencies and percentages were calculated for categorical variables. Household socioeconomic status was assessed through residence characteristics and ownership of assets. Principal Component Analysis was used to create an asset based socioeconomic status score using methods described by Filmer and Pritchett (66). Household food security was assessed using a scale developed specifically for rural Bangladesh by Frongillo et al (70). This questionnaire grades food insecurity based on frequency of food purchases, cooking and meals consumed, as well as management strategies.

The main exposures were district of residence (intervention arm; a binary variable) and the timing of enrollment (a 3-level categorical variable). Timing of enrollment was considered an exposure as the intervention was being rolled out concurrently with the first wave of recruitment. Therefore, the three waves of participants from the intervention district experienced the program for varying lengths of time.

The main outcomes were infant feeding practices of EBF at 3 months, timing of CF initiation, and receipt of MAD at 9 months, and infant growth measured via HAZ/stunting and WHZ, at 3, 9, 16 and 24 months. The association between the main exposures and wasting was not assessed, however, because prevalence of wasting in the study population was too low to allow for adequately powered analyses.

The associations between the main exposures and outcomes were assessed using multivariable regression models. Logistic regression models were used for EBF at 3 months, receipt of MAD at 9 months and stunting as separate outcomes. The association between the main exposures and early or late vs. timely complementary feeding initiation as outcome, was assessed via polytomous logistic regression. Multivariable linear regression models were used to determine the association between the main exposures and HAZ and WHZ as separate outcomes. Because we were interested in differences within, as well as across sub-districts, we also included the interaction between district of residence and timing of enrollment in all models. For infant growth indicators of HAZ/stunting and WHZ, separate models were used at 3, 9, 16 and 24 months of infant age. All models considered in this analysis are presented in Chapter 5: Appendix.

To account for correlation between HAZ/stunting and WHZ at different follow-up times from same child, we also used generalized estimating equation models. SAS procedure PROC GENMOD was used to generate β estimates and 95% confidence intervals (CI) for HAZ and WHZ, and odds ratios and corresponding 95% CI for stunting, using data from 3, 9, 16 and 24 months of infant age. We assumed an autoregressive(1) (AR(1)) covariance matrix, with robust variance estimates. The AR(1) structure assumes a correlation between measurements from an individual that declines exponentially with time.

To control for random subject-specific effects, we also used SAS procedure PROC GLIMMIX with a random intercept, specifying robust variance estimates. The significance of the random intercept was assessed using a Wald test. The logistic model for stunting (HAZ < -2.00) did not converge; the linear models for HAZ and WHZ did. All correlated models also included the interaction between district of residence and timing of enrollment. The GENMOD and GLIMMIX models are also presented in Chapter 5: Appendix.

Ethics

This study was approved by the Research Review Committee (RRC) and the Ethical Review Committee (ERC) of the International Center for Diarrheal Disease Research, Bangladesh (icddr,b). At the time of enrollment, informed consent was provided by each woman. Verbal consent was obtained at each follow-up visit.

Results

Of the 2400 women recruited into the study at baseline, follow-up was completed by 2189, 2074, 1969 and 1885 mother-child dyads at 3, 9, 16 and 24 months of infant age, respectively. Selected characteristics of women recruited into the study, stratified by treatment arm are presented in Table 5.2. Maternal age, parity and household SES were similar across the two groups. However, a higher proportion of mothers in the intervention district reported receiving nutrition counseling during pregnancy and a lower proportion of household in Karimganj were in the most food insecure tertile ($p < 0.01$).

The associations between the intervention and infant feeding practices, stratified by timing of enrollment into the intervention program are summarized in Table 5.3. Overall, a higher proportion of infants in Karimganj were exclusively breastfed at 3 months (57.6% vs. 32.5% in Katiadi). As there was no evidence of collinearity, interaction between the intervention and timing of enrollment was assessed, which was not significant at $p < 0.05$, indicating that rates of EBF at 3 months did not differ significantly within the three waves enrolled in Karimganj.

Generally, CF was initiated on time for a higher proportion of infants in the control district of Katiadi (53.0%) compared to Karimganj (44.6%). However, in Katiadi, the proportions of infants receiving timely CF across the three cohorts were 45%, 64% and 50%, respectively. The corresponding proportions in Karimganj, were, 27%, 50% and 55%, respectively. This represents a significant trend toward starting complementary feeding at the right time for infants in the intervention district.

The overall prevalence of infants receiving MAD in Kishoreganj was low at 16.1%. However, there were significant differences in this prevalence by intervention group and timing of enrollment as Table 5.3 illustrates (interaction $p < 0.01$). In the first cohort, the proportion of infants receiving MAD proportion in both sub-districts was similar at 8%. However, while this proportion did not change in Katiadi across the three waves, it increased significantly in Karimganj to 29% and 35%, by the second and third wave, respectively. Infants living in Karimganj and whose mothers were enrolled in the third wave of study recruitment were significantly more likely to receive MAD compared to infants who lived in Katiadi and whose mothers were also enrolled in the third wave (OR for Karimganj = 6.6, 95% CI: 4.2, 10.4 vs. OR for Katiadi = 0.9, 95% CI: 0.5, 1.6)

The associations between the intervention and indicators of infant growth, stratified by timing of enrollments are presented in Tables 5.4 – 5.6. The prevalence of stunting in Karimganj increased from 25.1% at infant age 3 months to 51.9% at infant age 24 months. The corresponding figures for the control district of Katiadi were 25.4% and 52.2%, respectively. The prevalence of wasting increased from 4.1% to 11. 6% in Karimganj, and from 5.1% to 15.5% in Katiadi, at infant age 3 and 24 months, respectively.

In independent models, the interaction between the intervention and timing of enrollment was significant at $p < 0.05$ only for infant growth indicators at 3 months (Tables 5.4 and 5.5). Infants living in Karimganj and whose mothers were enrolled in the second and third waves of study recruitment had a lower HAZ at 3 months compared to infants living in Katiadi and whose mothers were enrolled in the first wave (adjusted β for Wave 2 = -0.38, 95% CI: -0.55, -0.20; adjusted β for Wave 3 = -0.21, 95% CI: -0.38, -

0.04). The interaction between the intervention and timing of enrollment was not significant at $p < 0.05$ for infant growth indicators at 9, 16 and 24 months.

In GENMOD models, no differences in HAZ/stunting or WHZ were observed across or within the sub-districts (Table 5.6). However, the random intercept term included in the GLIMMIX model for HAZ was highly significant with a Z statistic of 5.89 (Wald test $p < 0.001$). The random intercept term included in the GLIMMIX model for WHZ, on the other hand, was not significant at $p < 0.05$.

We also assessed the relationship between program participation and IYCF practices and child growth in our setting. At the 9-month follow-up, 67% of mothers in the intervention district reported having met a counselor from CARE at least once since the birth of their child (Table 5.7). Mothers who participated in the program in Karimganj were more likely to employ improved infant feeding practices (Table 5.8). Their infants were also significantly taller at 24 months compared to those in Katiadi (Table 5.9).

Discussion

This prospective cohort-based evaluation of a nutrition intervention program assesses the success of behavior change communication strategies in improving infant feeding practices and growth indicators in the first two years of life in rural Bangladesh. Providing nutrition counseling and education to mothers has shown to improve duration and rates of exclusive breastfeeding, complementary feeding practices as well as infant growth indicators in other settings (35, 51, 80, 91, 92). However, not all our findings aligned with those from previous studies. Although we did observe that rates of CF initiation and infant diet quality at age 9 months across the three waves of enrollment were significantly improved in the intervention district of Karimganj, we did not see similar improvements in prevalence of EBF at 3 months. We also did not observe a significant improvement in infant growth indicators in Karimganj.

Even though mothers in Karimganj were much more likely to exclusively breastfeed their infants at 3 months compared to those in the control district of Katiadi, we believe this is due baseline differences between the two districts and not due to *Akhoni Shomay*. This conclusion is supported by the fact that we did not observe an effect of the intervention on EBF rates at 3 months as measured by the interaction term between the intervention and the timing of maternal enrollment into the study (interaction $p > 0.05$). In the questionnaire administered at recruitment, a higher proportion of mothers in Karimganj reported receiving nutrition counseling during the antenatal period, through which they presumably received education on breastfeeding initiation, maintenance and exclusivity. This is reflected in the higher proportion of mothers who reported their intention to breastfeed exclusively for 6 months at baseline. Furthermore, Yu et al, working with the same population found that prenatal EBF intention was significantly associated with EBF at 3 months (65).

Mothers from Karimganj, who were enrolled in the first and second wave of study recruitment, were significantly more likely to initiate late complementary feeding compared to mothers from Katiadi, who were enrolled in the first wave (Table 5.3). However, this relationship did not hold for those mothers who were enrolled in the third wave from Karimganj. We believe this finding is indicative of the success of BCC messages regarding timely complementary feeding initiation that were imparted to mothers enrolled in *Akhoni Shomay*. The intervention program was rolled out at the same time the first wave of study recruitment was taking place. Therefore, the three cohorts from Karimganj were exposed to different intensities of the intervention. With the third cohort being enrolled once *Akhoni Shomay* was fully operational, we believe these mother-child dyads benefited most from the intervention, leading to a decrease in late CF initiation in this cohort. This conclusion is supported by the fact that when we analyzed the timing of CF initiation based on maternal report of participation in the program, mothers who reported meeting a CARE counselor at least once since the birth of their child, were significantly more likely to initiate timely CF (Table 5.8)

Akhoni Shomay was most successful in improving quality of infant diet at age 9 months. The proportion of infants receiving MAD at age 9 months is 18% in Bangladesh (57). The prevalence of the same was much lower at 8% in our study setting, both in the control district of Katiadi across all 3 cohorts of participants, as well as the first cohort recruited in Karimganj. By the third cohort in intervention district, the prevalence of infants receiving MAD at 9 months of age had increased to 35%. Improved infant feeding practices, including receipt of MAD and iron-rich foods, between 6 – 12 of age, are also associated with improved infant growth indicators in the second year of life (Owais et al unpublished data, (89)). Therefore, future nutrition programs aimed at improving infant growth must include interventions aimed at improving the quality of infant diet from age 6 months onwards.

We were surprised to find that *Akhoni Shomay* did not result in larger improvements in infant growth indicators in Karimganj, especially as quality of infant diet at 9 months was greatly improved in the district. There are several possible explanations for this. First, children in our setting are likely suffering from environmental enteropathy, which leads to malabsorption of important nutrients and causes growth deficits among young children (43). Second, this null finding may be due to sample size issues. Even though the proportion of infants receiving MAD in Karimganj at age 9 months did increase significantly, it was still only 25.6% across the three cohorts in the intervention district and 16.1% across all six cohorts. Therefore, the corresponding sample size of 334 was likely not adequate to capture differences in HAZ and WHZ across six strata.

A major strength of our study is the ability to make causal inferences, as this was a prospective cohort-based evaluation. However, as with any other observational study, this one also has some limitations. Outcome classification for infant feeding practices is based on maternal recall and not via directly observed feeding practices. Furthermore, for complementary feeding initiation, age was assessed several months after solid/semi-solid/soft foods were introduced to the infant. This time lag may also be a potential source of outcome misclassification as maternal recall may have been affected. However, we did cross-reference the reported age of complementary feeding initiation at the 9-month follow-up with infant diet (based on 24-hour maternal recall) reported at the 3-month follow-up. A discrepancy was present for only 3% of infants included in this study and adjustments to the age at complementary feeding initiation were made accordingly.

In conclusion, this evaluation of a nutrition education program shows that nutrition messages delivered to mothers at regular intervals are effective in improving timely CF initiation and quality of infant diet at 9 months. These findings are important in light of the fact that most childhood undernutrition occurs in populations with low economic and food security, and where supplementing household diet to improve infant feeding practices, especially at scale, is not feasible.

Table 5.1: List of key behaviors promoted during *Akhoni Shomay* in Karimganj, Bangladesh

Initiation of breastfeeding immediately (within 1 hour of birth) after birth[1]
No pre- or post-lacteal foods are given to child 0-5 months
Exclusive breastfeeding for children 0-6 months of age[1]
Continue breastfeeding up to 24 months of age[1]
Age appropriate complementary feeding (quantity, quality, and diversity) for children 7-24 months[1]
Responsive complementary feeding for children 7 – 24 months
Hand washing thoroughly with soap before food preparation and feeding the child of 6-24 months
Pregnant and lactating women will consume additional and diversified food each day
Pregnant women will take 2 hours rest during day time
Women will go for ANC, TT during pregnancy and PNC after delivery

[1] WHO infant and young child feeding indicators

Table 5.2: Selected characteristics of women recruited at pregnancy month 7 in Kishoreganj, Bangladesh by intervention district

	Karimganj (Intervention)	Katiadi (Control)	
N	1200	1200	*p*
Maternal			
Age			0.05
≤ 24 years	50.4	55.3	
25 – 34 years	42.8	39.2	
≥ 35 years	6.8	5.6	
Literacy			0.01
Cannot read at all	37.9	32.4	
Can read part of a sentence	13.9	16.8	
Can read a complete sentence	48.2	50.7	
Parity			0.46
1	27.1	28.7	
2	24.8	22.8	
≥ 3	48.1	48.5	
Received nutrition counseling during pregnancy	49.6	39.6	<0.01
Breastfeeding intentions			
Intend to exclusively breastfeed	90.6	83.3	<0.01
Intend to exclusively breastfeed for 6 months	69.8	54.4	<0.01
Household			
Socioeconomic status			0.59
1st quintile (lowest)	19.5	20.5	
2nd quintile	19.8	20.3	
3rd quintile	21.0	19.0	
4th quintile	20.6	19.4	
5th quintile (highest)	19.2	20.8	

Food security score			<0.01
1st tertile (most insecure)	26.3	37.7	
2nd tertile	44.5	37.6	
3rd tertile (least insecure)	29.2	24.7	

Data in columns are percentages

Table 5.3: Association between district of residence and infant feeding practices in Kishoreganj, Bangladesh, by timing of enrollment – results from multivariable logistic regression

	N[1]	Exclusively breastfed at 3 months		*N*[2]	Complementary feeding initiation				Minimally acceptable diet[3] at 9 months	
					< 4 months		> 6 months			
		%	OR (95% CI)[4]		%	OR (95% CI)[5,6]	%	OR (95% CI)[5,6]	%	OR (95% CI)[6]
Katiadi (Control)										
Wave 1 (Jan – Feb 2011)	365	27.7	Ref.	340	12.1	Ref.	42.9	Ref.	8.2	Ref.
Wave 2 (May – Jun 2011)	372	30.9	1.17 (0.85, 1.61)	355	9.9	0.58 (0.35, 0.95)	26.5	0.44 (0.31, 0.61)	6.8	0.81 (0.46, 1.42)
Wave 3 (Sep – Oct 2011)	365	38.9	1.66 (1.22, 2.72)	341	2.3	0.18 (0.08, 0.39)	47.8	1.00 (0.74, 1.37)	7.6	0.92 (0.53, 1.60)
Karimganj (Intervention)										
Wave 1 (Jan – Feb 2011)	364	55.8	3.30 (2.42, 4.49)	332	7.8	1.08 (0.62, 1.88)	65.1	2.52 (1.80, 3.51)	8.4	1.03 (0.59, 1.77)
Wave 2 (May – Jun 2011)	369	59.6	3.30 (2.44, 4.47)	359	5.3	0.67 (0.37, 1.21)	43.7	2.06 (1.50, 2.85)	29.0	5.62 (3.50, 9.02)
Wave 3 (Sep – Oct 2011)	358	57.3	2.10 (1.56, 2.83)	351	3.7	1.44 (0.58, 3.56)	41.6	0.79 (0.59, 1.08)	35.3	6.62 (4.20, 10.44)

OR: odds ratio; CI: confidence interval
[1] At child age 3 months
[2] At child age 9 months
[3] At least 4 food groups and at least 4 meals daily
[4] Interaction between district and wave was not significant at $p < 0.05$
[5] Results from polytomous logistic regression with timely complementary feeding initiation as referent
[6] Interaction between district and wave was significant at $p < 0.01$

Table 5.4: Association between district of residence and infant growth in Kishoreganj, Bangladesh, stratified by timing of enrollment – results from multivariable linear regression

	Height-for-age Z score											
	3 months[1]			9 months[2]			16 months[2]			24 months[2]		
	n	% < -2.00	β (95% CI)	*n*	% < -2.00	β (95% CI)	*n*	% < -2.00	β (95% CI)	*n*	% < -2.00	β (95% CI)
Katiadi (Control)												
Wave 1 (Jan – Feb 2011)	365	20.0	Ref.	337	36.2	Ref.	312	54.5	Ref.	296	57.1	Ref.
Wave 2 (May – Jun 2011)	371	22.6	-0.16 (-0.33, 0.01)	355	37.2	0.10 (-0.07, 0.27)	335	51.6	0.07 (-0.10, 0.24)	312	47.8	0.25 (0.08, 0.41)
Wave 3 (Sep – Oct 2011)	363	33.6	-0.42 (-0.59, -0.24)	340	35.9	0.10 (-0.07, 0.28)	316	53.2	0.07 (-0.10, 0.25)	297	51.9	0.22 (0.05, 0.39)
Karimganj (Intervention)												
Wave 1 (Jan – Feb 2011)	364	19.2	-0.08 (-0.25, 0.09)	332	39.5	-0.02 (-0.20, 0.16)	324	54.6	0.02 (-0.16, 0.19)	326	55.8	0.04 (-0.13, 0.20)
Wave 2 (May – Jun 2011)	369	29.0	-0.38 (-0.55, -0.20)	359	39.3	-0.01 (-0.19, 0.16)	340	55.9	0.00 (-0.17, 0.17)	337	53.1	0.20 (0.04, 0.36)
Wave 3 (Sep – Oct 2011)	357	26.9	-0.21 (-0.38, -0.04)	351	28.8	0.28 (0.10, 0.45)	342	49.7	0.21 (0.04, 0.38)	317	46.7	0.24 (0.07, 0.40)

	Weight-for-height Z score											
	3 months[1]			9 months[2]			16 months[2]			24 months[2]		
	n	% < -2.00	β (95% CI)	*n*	% < -2.00	β (95% CI)	*n*	% < -2.00	β (95% CI)	*n*	% < -2.00	β (95% CI)
Katiadi (Control)												
Wave 1 (Jan – Feb 2011)	365	6.3	Ref.	337	8.0	Ref.	312	16.3	Ref.	296	11.8	Ref.
Wave 2 (May – Jun 2011)	369	5.4	-0.03 (-0.21, 0.14)	354	7.6	-0.19 (-0.36, -0.03)	334	15.0	0.04 (-0.12, 0.20)	311	16.4	-0.30 (-0.46, -0.14)

Wave 3 (Sep – Oct 2011)	363	3.6	0.16 (-0.01, 0.34)	340	10.3	-0.26 (-0.43, -0.09)	316	11.1	0.21 (0.05, 0.37)	297	18.2	-0.11 (-0.27, 0.05)
Karimganj (Intervention)												
Wave 1 (Jan – Feb 2011)	364	6.3	0.02 (-0.16, 0.20)	331	7.9	-0.05 (-0.22, 0.11)	324	14.5	0.02 (-0.14, 0.18)	326	9.2	0.12 (-0.03, 0.28)
Wave 2 (May – Jun 2011)	368	4.3	0.23 (0.06, 0.41)	357	5.3	-0.01 (-0.18, 0.15)	340	12.1	0.08 (-0.07, 0.24)	336	12.2	-0.20 (-0.35, -0.04)
Wave 3 (Sep – Oct 2011)	357	1.7	0.14 (-0.03, 0.32)	351	6.8	-0.18 (-0.34, -0.01)	342	10.2	0.22 (0.07, 0.38)	317	13.6	-0.11 (-0.27, 0.04)

CI: confidence interval
[1] Interaction between district and wave was significant at $p < 0.01$
[2] Interaction between district and wave was not significant at $p < 0.05$

Table 5.5: Association between district of residence and childhood stunting[1] in Kishoreganj, Bangladesh, stratified by timing of enrollment – results from multivariable logistic regression

	3 months[2]	9 months[3]	16 months[3]	24 months[3]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Katiadi (Control)				
Wave 1 (Jan – Feb 2011)	Ref.	Ref.	Ref.	Ref.
Wave 2 (May – Jun 2011)	1.17 (0.82, 1.67)	1.04 (0.77, 1.42)	0.89 (0.66, 1.22)	0.68 (0.50, 0.95)
Wave 3 (Sep – Oct 2011)	2.03 (1.45, 2.84)	0.99 (0.72, 1.35)	0.95 (0.69, 1.30)	0.81 (0.59, 1.12)
Karimganj (Intervention)				
Wave 1 (Jan – Feb 2011)	0.95 (0.66, 1.37)	1.15 (0.84, 1.57)	1.01 (0.74, 1.37)	0.95 (0.69, 1.31)
Wave 2 (May – Jun 2011)	1.40 (1.00, 1.94)	1.09 (0.81, 1.48)	1.19 (0.88, 1.61)	1.24 (0.91, 1.69)
Wave 3 (Sep – Oct 2011)	0.73 (0.53, 1.00)	0.72 (0.52, 0.99)	0.87 (0.64, 1.18)	0.81 (0.59, 1.12)

OR: odds ratio; CI: confidence interval
[1] Height-for-age z score < -2.00
[2] Interaction between district and wave was significant at $p < 0.05$
[3] Interaction between district and wave was not significant at $p < 0.05$

Table 5.6: Association between district of residence and infant growth in Kishoreganj, Bangladesh, stratified by timing of enrollment – results from GEE models

	Height-for-age Z score	**Weight-for-height Z score**	**Stunting**[1]
	β (95% CI)[2]	β (95% CI)[3]	OR (95% CI)[2]
Katiadi (Control)			
Wave 1 (Jan – Feb 2011)	Ref.	Ref.	Ref.
Wave 2 (May – June 2011)	0.01 (-0.13, 0.16)	-0.13 (-0.26, 0.00)	1.06 (0.85, 1.33)
Wave 3 (Sept – Oct 2011)	-0.11 (-0.25, 0.04)	0.02 (-0.11, 0.15)	0.85 (0.68, 1.07)
Karimganj (Intervention)			
Wave 1 (Jan – Feb 2011)	-0.04 (-0.17, 0.09)	0.03 (-0.10, 0.17)	0.99 (0.79, 1.23)
Wave 2 (May – June 2011)	-0.11 (-0.26, 0.03)	0.02 (-0.11, 0.15)	0.87 (0.70, 1.09)
Wave 3 (Sept – Oct 2011)	0.05 (-0.09, 0.19)	0.01 (-0.12, 0.14)	1.10 (0.87, 1.38)

OR: odds ratio; CI: confidence interval
[1] Height-for-age z score < -2.00
[2] Interaction between district and wave was significant at $p < 0.05$
[3] Interaction between district and wave was not significant at $p < 0.05$

Table 5.7: Participation in *Akhoni Shomay* at infant age 9 months, in Kishoreganj, Bangladesh

	Intervention (Karimganj)				Control (Katiadi)			
	Wave 1	Wave 2	Wave 3	Total	Wave 1	Wave 2	Wave 3	Total
Met with counsellor from CARE, %	0.0	97.8	99.4	67.2	0.0	27.3	9.4	12.5

Table 5.8: Participation in *Akhoni Shomay* and infant feeding practices in Kishoreganj, Bangladesh

	Intervention (Karimganj)			Control (Katiadi)		
	Timing of CF initiation		MAD at 9 months	Timing of CF initiation		MAD at 9 months
	Early vs. timely	Late vs. timely		Early vs. timely	Late vs. timely	
	OR (95% CI)			OR (95% CI)		
Met with counsellor from CARE						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	0.35 (0.26, 0.46)	0.30 (0.17, 0.52)	4.05 (2.76, 5.94)	0.81 (0.41, 1.59)	0.46 (0.30, 0.71)	1.04 (0.52, 2.07)

CF: complementary feeding; MAD: minimally acceptable diet; OR: odds ratio; CI: confidence interval

Table 5.9: Participation in *Akhoni Shomay* and infant growth in Kishoreganj, Bangladesh

	Intervention (Karimganj)			Control (Katiadi)		
	Height-or-age Z score (β, 95% CI)					
	9 month	16 months	24 months	9 month	16 months	24 months
Met with counsellor from CARE						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	0.14 (-0.02, 0.30)	0.06 (-0.08, 0.21)	0.16 (0.01, 0.30)	0.05 (-0.16, 0.26)	-0.07 (-0.29, 0.15)	0.17 (-0.03, 0.37)
	Weight-for-height Z score (β, 95% CI)					
Met with counsellor from CARE						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	-0.05 (-0.20, 0.09)	0.14 (0.01, 0.26)	-0.27 (-0.40, -0.14)	0.04 (-0.17, 0.24)	0.04 (-0.16, 0.25)	-0.18 (-0.39, 0.02)
	Stunting (OR 95% CI)					
Met with counsellor from CARE						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	0.81 (0.62, 1.05)	0.97 (0.74, 1.26)	0.82 (0.62, 1.07)	1.16 (0.80, 1.70)	0.90 (0.62, 1.32)	0.76 (0.51, 1.12)

Stunting: HAZ < -2.00; OR: odds ratio; CI: confidence interval

6. Dissertation in context – contributions, limitations and implications

Childhood undernutrition remains a major global public health problem, with implications for morbidity and mortality not only in the early years of life, but in adulthood as well. Furthermore, deficits in growth and development in early years are linked to deficits in educational attainment, economic productivity and income earned in later life. As a result, countries and regions with a high burden of undernutrition suffer substantial loss of economic growth and productivity at a national level. That is why understanding the predictors of infant growth and development, and finding ways of modifying factors detrimental to optimal infant growth and development remains a global public health imperative. This dissertation contributes to that goal.

Study 1

In Study 1, we assessed the relationship between maternal knowledge and attitudes regarding complementary feeding and the age at which infants were introduced to solid/semi-solid or soft foods. We observed that in our setting of Kishoreganj, in rural Bangladesh, improved maternal knowledge regarding complementary feeding practices was not associated with timely introduction of complementary foods to their infants. However, when comparing infants for whom initiation of complementary feeding was too late (≥ 7 months of age) to those for whom it was timely (5 – 6 months of age), mothers with more favorable attitudes towards complimentary feeding were more likely to introduce complimentary foods too late.

These results are contrary to what we expected, especially the null finding of improved maternal knowledge not being associated with timely complementary feeding initiation. However, ours is not the first study to observe this. In Zambia, knowledge about WHO IYCF recommendations also did not result in good practice (93). It seems likely that cultural beliefs and norms in our setting may be trumping knowledge. Therefore, understanding the contextual factors that serve as barriers to knowledge leading to good practice is important to ensure programmatic success and improve IYCF practices. This also provides an important avenue for future research.

This study also has a few limitations that should be kept in mind when interpreting the results. That maternal knowledge and attitudes were assessed before the outcome supports the argument for causality. However, the design of the program meant that mothers were to receive at least one more counseling session between the time of knowledge and attitudes assessment at infant age three months, and infant age 5 – 6 months, when complementary feeds should have been initiated. Therefore, it is possible that maternal knowledge and attitudes at 3 months differed from those at 5 – 6 months. Secondly, the questions used to assess maternal knowledge and attitudes covered a range of recommended complementary feeding practices, of which timing of initiation is one component. As mentioned above, there are likely other contextual factors that more strongly determine when solids/semi-solids/soft foods are introduced to a child in our setting.

The finding of this study has programmatic and policy implications. Knowing what does not work is as important as knowing what does, especially in resource-constrained settings such as ours. Future programs need to focus on identifying contextual factors contributing to delayed complementary feeding initiation in Bangladesh and determine which of these are modifiable.

Study 2

In study 2 we assessed how household food security predicted infant diet at age 9 months. We observed that infants from more food secure household were more likely to receive a minimally acceptable diet, as defined by WHO, at age 9 months. However, infant diet quality was very poor across Kishoreganj. Only about 1 in 6 children received a minimally acceptable diet in the 24 hours prior to the 9-month follow-up. Furthermore, infant diet quality was poor even when food was available to the household as evidenced by the comparison with maternal dietary consumption.

This study does have several limitations. Therefore, these findings should be interpreted in light of these. First, classification of infant feeding practices is based on 24-hour dietary recall. Therefore, it is possible that infants who were classified as not receiving minimally acceptable diet, may simply have not received an adequate diet in the 24 hours prior to the 9-month follow-up, but may have received it on other days. Therefore, these infants may have been misclassified as unexposed.

Second, we were unable to assess the adequacy of caloric intake for these children. Meal frequency only captures the number of times a meal was eaten by an infant, not the quantity of food consumed at each feeding. Therefore, even if children are consuming the minimum number of meals recommended by WHO, they may not be receiving the energy required for optimal growth.

The findings of this study also have programmatic and policy implications. Interventions aimed at improving household food security should include an educational component to ensure that the foods available to the household are also given to infants, ensuring adequate dietary diversity and quantity for children ≥ 6 months of age.

Study 3

In this study, we assessed the impact of infant feeding practices in the first year of life, on child growth up to 2 years of age. We observed that neither exclusive breastfeeding at 3 months, nor timely introduction to complementary feeds affected growth in the second year of life. Only receiving a minimally acceptable diet at 9 months was predictive of growth until 24 months of age. However, the effect size was relatively small at 0.26 SD for HAZ at 24 months. With the mean HAZ at that age being -2.06, intervention programs focusing on improving infant diet only will likely not have a meaningful impact on reducing the prevalence of stunting at the population level. Therefore, a more holistic approach towards improving child undernutrition will be necessary.

An important avenue of future research on IYCF practices and their effect on growth is to investigate other components of diet and feeding behaviors, such as consumption of flesh foods, or responsive feeding behaviors, and their association with child growth outcomes. As mentioned earlier, only 16% of infants across the study received minimally acceptable diet at 9 months, but at 24 months, more than 50% were stunted. Furthermore, household level factors, such as SES and maternal education, were not associated with child growth outcomes in our settings. Therefore, there must be other factors that are protective against growth deficits for children who did not receive MAD at 9 months, but were also not stunted at 24 months.

As for the previous two studies, the findings of this one should also be interpreted in light of its limitations. Breastfeeding status and minimally acceptable diet were classified using 24-hour dietary recall. As mentioned earlier, it is possible that infants who were classified as not exclusively breastfed at 3 months or not receiving minimally acceptable diet at 9 months had simply not received these diets in the 24 hours prior to the follow-up visits, but may have done so on other days. Therefore, these children may have been misclassified.

Minimally acceptable diet is also not a good indicator for adequate energy intake. Even if a child is receiving the minimum number of meals required to meet this criterion, it is possible that these feedings do not have adequate energy density to meet the demands for optimal growth.

This study underscores the importance of infant diet at 9 months of age, and its association with child growth until age 2 years. Interventions aimed at reducing rates of stunting in the first few years of life need to include components focusing on improving diet diversity and quantity for infants 6 – 12 months of age. Research should also be conducted to create an indicator of quantity consumed at each feeding by an infant. This will assist in measuring infants' caloric intake and its association with growth.

Study 4

In the fourth and final study, we assessed the success of the nutrition intervention program that is the data source for this dissertation. We observed that the program was successful in improving rates of timely introduction of solid/semi-solid/soft foods and infant diet quality at age 9 months. The proportion of infants receiving timely CF initiation more than doubled and those receiving MAD at 9 months more than quadrupled between the first cohort enrolled in Karimganj (and when the intervention was being rolled out) and the third cohort.

The program however, was not as successful in improving child growth in Karimganj. The mean HAZ at each of the 4 follow-up visits was very similar between the intervention and control sub-districts, as were the rates of stunting. When we analyzed the impact of program participation on child linear height, stratified by sub-district, we did observe a statistically significant improvement in linear height among children from Karimganj at age 24 months. However, as the mean HAZ at 24 months was -2.06 in the region, the increase of 0.11 SD is not likely to be clinically significant.

The lack of improvement in child growth in Karimganj warrants further research. The link between improved complementary feeding practices and child growth is well-established, and as stated above, the program was successful in improving IYCF practices. One reason for this null finding may be the presence of environmental enteropathy among the children in our cohort. Environmental enteropathy leads to malabsorption of nutrients consumed through diet. Therefore, even though children were receiving an improved diet, they did not absorb the nutrients required for optimal growth.

Program penetration was high, at least for the second and third cohorts enrolled in Karimganj. At the 9-month follow-up, almost all mothers enrolled in the second and third wave in Karimganj reported receiving a visit from a CARE counselor at least once since their child had been born.

This study has some limitations and its findings should be interpreted in light of them. Breastfeeding status and minimally acceptable diet were classified using 24-hour dietary recall. As mentioned earlier, it is possible that infants who were classified as not exclusively breastfed at 3 months or not receiving minimally acceptable diet at 9 months had simply not received these diets in the 24 hours prior to the follow-up visits, but may have done so on other days. Therefore, these children may have been misclassified.

Minimally acceptable diet is also not a good indicator for adequate energy intake. Even if a child is receiving the minimum number of meals required to meet this criterion, it is possible that these feedings do not have adequate energy density to meet the demands for optimal growth. This may also be a reason for not finding an impact of the nutrition program on child growth. Even if diet quality was improved, the quantity at each feeding may not have yielded the calories required for optimal growth.

Contributions

Taken together, the studies from this dissertation contribute to the growing literature using longitudinal data to study the predictors of an important determinant of childhood undernutrition, infant feeding practices, and investigate the consequences of infant feeding practices on subsequent growth. There are many notable findings from this dissertation, which can inform nutrition intervention programs to be more effective in achieving improvements in infant diet and growth, especially in populations with high level of poverty and low levels of food security.

First, delayed complementary feeding initiation remains widely prevalent in rural Bangladesh. Therefore, intervention programs aimed at improving infant feeding practices and nutritional status in the country need to focus on emphasizing timely complementary feeding initiation. Second, household food security and maternal diet are predictive of infant feeding practices, specifically infant dietary diversity. However, infant diet is often poor even in more food secure household. This may be due to cultural beliefs that dictate what a child should or should not eat. This interpretation is supported by the differences between what mothers and infants eat – clearly there would be enough food in the house to give a little to the infant if the mother (and presumably the father, other men, etc.) are eating a food. This potential barrier to optimal feeding practices should be studied in more detail, perhaps using qualitative research methods. If this association holds true, cultural beliefs that negatively impact infant feeding practice will need to be effectively addressed by intervention programs.

Third, quality of infant diet at age 9 months is predictive of growth through the second year of life, much more so than exclusive breastfeeding and timing of complementary feeding initiation. Therefore, ensuring diet quantity, quality and diversity for infants old enough to eat solid/semi-solid/soft foods should be a priority for intervention programs.

The improvements in infant diet and growth observed in this dissertation were a result of nutrition educational messages delivered to mothers at strategic intervals, throughout the first two years of their off-spring’s life. These findings are important in light of the fact that most childhood undernutrition occurs in low-income, populous countries, where more expensive nutrition interventions, such as supplementing household diet, are not feasible, especially at scale.

The nutrition intervention program, *Akhoni Shomay*, which is the data source for this dissertation, was carried out in Bangladesh, a country with a very high burden of childhood undernutrition. The findings from this dissertation will help inform the discussion and design of a cohesive national framework for addressing childhood undernutrition in Bangladesh.

Another contribution of this dissertation is the unique design of both the intervention program, and the prospective cohort used to evaluate it. The interventions delivered through the program focused on one milestone of IYCF practices at a time. Mothers were recruited in the last trimester of their pregnancy. The interventions during this time emphasized maternal nutrition and antenatal care, as well as focused on breastfeeding initiation and exclusivity. Once the child was born, the interventions emphasized breastfeeding exclusivity and maintenance, as well as maternal nutrition and postnatal care. Closer to infant age 6 months, the interventions focused on age-appropriate complementary feeding practices, including quantity, quality, and diversity, as well as responsive feeding and encouraging home-based fortification of complementary foods using micronutrient powders.

Conventional program evaluations use a baseline/endline approach to assess the impact of interventions. This does not take into account the fact that study participants are exposed to the program at different intensities. Later enrollees are likely to gain more benefit from the program, as interventions are delivered by more experienced program staff. Furthermore, as the program becomes better known and established within the community, participants enrolled later are more receptive to the interventions being delivered and are therefore, likely to adhere more closely to any new recommendations. The conventional baseline/endline approach does not take this increasing program penetration into account. Furthermore, as these surveys are in effect cross-sectional, they are at risk of biases inherent to cross-sectional studies, such as reverse causality. The prospective cohort approach, with three waves of enrollment used to evaluate *Akhoni Shomay* addresses all of the above-mentioned limitations. Indeed, as summarized in Study 4, infant feeding practices were much more improved for infants whose mothers were enrolled in the second and third waves in Karimganj, compared to those enrolled in the first wave.

Limitations

As this dissertation uses data from an observational study, the findings are subject to some limitations, and should be interpreted in light of them. Infant feeding practices were determined based on maternal report and not directly observed feeding practices. This is a potential source of outcome misclassification for studies 1, 2, and 4, and exposure misclassification for study 3. Second, loss to follow-up was 21% between recruitment during pregnancy and the last follow-up at infant age 24 months. Furthermore, data on infant nutritional status at birth was not available. As being born small-for-gestational age is a risk factor for stunting at 24 months, potential confounding due to fetal growth restriction is a possibility.

There are also some challenges and limitations unique to using data from a country halfway around the world from where the analysis is being carried out. Resource constraints meant that the author of this dissertation could only visit Bangladesh once throughout this process. She is also not fluent in Bangla, the language most commonly spoken in the study region. Therefore, even though she did observe a number of follow-up interviews during her visit to Bangladesh, it was impossible to independently assess the quality of the data collection process, having to rely on interpreters to communicate with study participants and staff. Second, as the visit was planned well in advance, all the study staff in Bangladesh were aware of the visit. Therefore, it was impossible to do a surprise data quality check.

The baseline and follow-up interviews were carried out in Bangla using questionnaires translated from English. The responses to the questions were also recorded in Bangla. These responses were then translated into English and entered into a statistical software package for analysis. Therefore, the back translation of the responses is also a possible source of limitation for this study.

Policy implications for Bangladesh

Despite the persistently high burden of childhood undernutrition and prevalence of suboptimal IYCF practices, nutrition policy in Bangladesh has not included a sufficiently robust component for improving IYCF practices in the country (94). Awareness of the importance of IYCF practices seems to be lacking (95). The Government of Bangladesh has largely focused on alleviating food insecurity and improving primary healthcare services (96). In order to improve childhood nutrition, improving IYCF practices needs to be front and center in the child nutrition agenda for the country. As the program, which was the data source for this dissertation, was conceived and implemented with the help the national government, the findings from this dissertation will be disseminated to policymakers in Bangladesh. Specific recommendations for a cohesive national IYCF policy for Bangladesh include:

- Nutrition education should be incorporated into primary healthcare services provided by the government, with a focus on ensuring timely complementary feeding initiation and infant dietary diversity
- Programs for improving household food security should include a nutrition education element highlighting the food ‘use’ component of food security, especially as it pertains to diet of infants ≥ 6 months of age
- Promotion of home-based fortification of complementary foods should be incorporated to ameliorate micronutrient deficiencies resulting from lack of infant dietary diversity

Future research directions

Understanding the determinants of infant feeding practices and growth remains a global public health imperative. These findings are directly applicable to Bangladesh, specifically to the rural areas of the country. However, the determinants of infant feeding practices and child growth can, and do vary from one country or region to another; as does the success of interventions that seek to improve these outcomes. Therefore, similar studies are needed in different settings to identify population-specific modifiable determinants of infant feeding practices and growth. Further research is also needed to better understand the predictors of maternal/primary care-giver’s behaviors around infant feeding so programs can most effectively address them to achieve optimal IYCF practices.

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8. Appendix

Chapter 3: Appendix

Full model:

$$\text{logit } P(D) = \alpha_0 + \beta\text{ (FCS or HHFSI)} + \gamma_1\text{(SES)} + \gamma_2\text{(age)} + \gamma_3\text{(education)} + \gamma_4\text{(parity)} + \gamma_5\text{(child's gender)} + \gamma_6\text{(district)} + \gamma_7\text{(wave)} + \delta_1\text{(FCS or HHFSI quartiles * SES)} + \delta_2\text{(FCS or HHFSI quartiles * age)} + \delta_3\text{(FCS or HHFSI quartiles * education)} + \delta_4\text{(FCS or HHFSI quartiles * parity)} + \delta_5\text{(FCS or HHFSI quartiles * child's gender)},$$

where D = minimum number of meals, minimum number of food groups, or minimally acceptable diet

For each of the three indicators of infant feeding practices, collinearity assessment was conducted between both measures of household food security and each of the covariates, as specified in the full model above. Interactions for minimum number of food groups and minimally acceptable diet as outcomes could not be assessed due to unresolvable collinearity issues.

For minimum number of meals as outcome, CI for the full model was > 30. As child's gender had the highest VDP at 0.6788, collinearity was reassessed after removing the interaction term between child's gender and household food security. For the reduced model, CI was < 30. Therefore, interactions between household food security and each of the covariates, except child's gender were assessed using the model specified below.

Reduced model:

$$\text{logit } P(D) = \alpha_0 + \beta\text{ (FCS or HHFSI)} + \gamma_1\text{(SES)} + \gamma_2\text{(age)} + \gamma_3\text{(education)} + \gamma_4\text{(parity)} + \gamma_5\text{(child's gender)} + \gamma_6\text{(district)} + \gamma_7\text{(wave)} + \delta_1\text{(FCS or HHFSI quartiles * SES)} +$$

δ_2(FCS or HHFSI quartiles * age) + δ_3(FCS or HHFSI quartiles * education) + δ_4(FCS or HHFSI quartiles * parity),

where D = minimum number of meals

Chapter 4: Appendix

Linear models for growth at 3 months:

Full (interaction) models

$$HAZ = \alpha_0 + (\text{EBF at 3 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}) + \delta_1(\text{EBF at 3 months * SES}) + \delta_2(\text{EBF at 3 months * age}) + \delta_3(\text{EBF at 3 months * education}) + \delta_4(\text{EBF at 3 months * parity}) + \varepsilon$$

$$WHZ = \alpha_0 + (\text{EBF at 3 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{child illness}) + \gamma_6(\text{district}) + \gamma_7(\text{wave}) + \delta_1(\text{EBF at 3 months * SES}) + \delta_2(\text{EBF at 3 months * age}) + \delta_3(\text{EBF at 3 months * education}) + \delta_4(\text{EBF at 3 months * parity}) + \delta_5(\text{EBF at 3 months * child illness}) + \varepsilon$$

Reduced models

$$HAZ = \alpha_0 + (\text{EBF at 3 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}) + \varepsilon$$

$$WHZ = \alpha_0 + (\text{EBF at 3 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{child illness}) + \gamma_6(\text{district}) + \gamma_7(\text{wave}) + \delta_1(\text{EBF at 3 months * child illness}) + \varepsilon$$

Logistic model for stunting at 3 months:

Full (interaction) model

$$\text{logit } P(D) = \alpha_0 + \beta(\text{EBF at 3 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}) + \delta_1(\text{EBF at 3 months * SES}) + \delta_2(\text{EBF at 3 months * age}) + \delta_3(\text{EBF at 3 months * education}) + \delta_4(\text{EBF at 3 months * parity})$$

Reduced model

$$\text{logit } P(D) = \alpha_0 + \beta(\text{EBF at 3 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave})$$

<u>Linear models for growth at 9, 16 and 24 months:</u>

Full (interaction) model

$$\text{HAZ} = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}) + \delta_1(\text{EBF at 3 months * SES}) + \delta_2(\text{EBF at 3 months * age}) + \delta_3(\text{EBF at 3 months * education}) + \delta_4(\text{EBF at 3 months * parity}) + \delta_5(\text{timing of CF initiation * SES}) + \delta_6(\text{timing of CF initiation * age}) + \delta_7(\text{timing of CF initiation * education}) + \delta_8(\text{timing of CF initiation * parity}) + \delta_9(\text{MAD at 9 months * SES}) + \delta_{10}(\text{MAD at 9 months * age}) + \delta_{11}(\text{MAD at 9 months * education}) + \delta_{12}(\text{MAD at 9 months * parity}) + \varepsilon$$

$$\text{WHZ} = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{child illness}) + \gamma_6(\text{district}) + \gamma_7(\text{wave}) + \delta_1(\text{EBF at 3 months * SES}) + \delta_2(\text{EBF at 3 months * age}) + \delta_3(\text{EBF at 3 months * education}) + \delta_4(\text{EBF at 3 months * parity}) + \delta_5(\text{EBF at 3 months * child illness}) + \delta_6(\text{timing of CF initiation * SES}) + \delta_7(\text{timing of CF initiation * age}) + \delta_8(\text{timing of CF initiation * education}) + \delta_9(\text{timing of CF initiation * parity}) + \delta_{10}(\text{timing of CF initiation * child illness}) + \delta_{11}(\text{MAD at 9 months * SES}) + \delta_{12}(\text{MAD at 9 months * age}) + \delta_{13}(\text{MAD at 9 months * education}) + \delta_{14}(\text{MAD at 9 months * parity}) + \delta_{15}(\text{MAD at 9 months * child illness}) + \varepsilon$$

Reduced models

$$HAZ = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}) + \varepsilon$$

$$WHZ = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{child illness}) + \gamma_6(\text{district}) + \gamma_7(\text{wave}) + \varepsilon$$

<u>Logistic models for stunting at 9, 16 and 24 months:</u>

Full (interaction) model

$$\text{logit } P(D) = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}) + \delta_1(\text{EBF at 3 months * SES}) + \delta_2(\text{EBF at 3 months * age}) + \delta_3(\text{EBF at 3 months * education}) + \delta_4(\text{EBF at 3 months * parity}) + \delta_5(\text{timing of CF initiation * SES}) + \delta_6(\text{timing of CF initiation * age}) + \delta_7(\text{timing of CF initiation * education}) + \delta_8(\text{timing of CF initiation * parity}) + \delta_9(\text{MAD at 9 months * SES}) + \delta_{10}(\text{MAD at 9 months * age}) + \delta_{11}(\text{MAD at 9 months * education}) + \delta_{12}(\text{MAD at 9 months * parity})$$

Reduced model

$$\text{logit } P(D) = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave})$$

<u>GENMOD model for HAZ, WHZ and stunting:</u>

$$E(Y_{ij}) = \alpha_0 + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months} + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}),$$

where j = 9, 16 and 24 months

<u>GLIMMIX model with random intercept, for HAZ, WHZ and stunting:</u>

$$E(Y_{ij}) = \alpha_0 + a_{i0} + \beta_1(\text{EBF at 3 months}) + \beta_2(\text{timing of CF initiation}) + \beta_3(\text{MAD at 9 months}) + \gamma_1(\text{SES}) + \gamma_2(\text{age}) + \gamma_3(\text{education}) + \gamma_4(\text{parity}) + \gamma_5(\text{district}) + \gamma_6(\text{wave}),$$

where j = 9, 16 and 24 months

Chapter 5: Appendix

In the all the models specified below, 'district' is a binary (0, 1) variable and 'wave' is a 3-level categorical (0, 1, 2) variable.

<u>EBF at 3 months:</u>

$$\text{logit P(EBF at 3 months)} = \alpha_0 + \beta_1(\text{district}) + \beta_2(\text{wave}) + \delta_1(\text{district*wave})$$

<u>Age at CF initiation:</u>

$$\ln[\text{P(D='Early')/P(D='Timely')}] = \alpha_1 + \beta_{11}(\text{district}) + \beta_{12}(\text{wave}) + \delta_{11}(\text{district*wave})$$

$$\ln[\text{P(D='Late')/P(D='Timely')}] = \alpha_2 + \beta_{21}(\text{district}) + \beta_{22}(\text{wave}) + \delta_{21}(\text{district*wave})$$

<u>MAD at 9 months:</u>

$$\text{logit P(MAD at 9 months)} = \alpha_0 + \beta_1(\text{district}) + \beta_2(\text{wave}) + \delta_1(\text{district*wave})$$

<u>Linear models for growth at 3, 9, 16 and 24 months:</u>

$$\text{HAZ/HAZ} = \alpha_0 + \beta_1(\text{district}) + \beta_2(\text{wave}) + \delta_1(\text{district*wave}) + \varepsilon$$

<u>Logistic models for stunting at 3, 9, 16 and 24 months:</u>

$$\text{logit P(D)} = \alpha_0 + \beta_1(\text{district}) + \beta_2(\text{wave}) + \delta_1(\text{district*wave})$$

<u>GENMOD model for HAZ, WHZ and stunting:</u>

$$E(Y_{ij}) = \alpha_0 + \beta_1(\text{district}) + \beta_2(\text{wave}) + \delta_1(\text{district*wave}),$$

where j = 3, 9 16 and 24 months

<u>GLIMMIX model with random intercept, for HAZ, WHZ and stunting:</u>

$$E(Y_{ij}) = \alpha_0 + a_{i0} + \beta_1(\text{district}) + \beta_2(\text{wave}) + \delta_1(\text{district*wave}),$$

where j = 3, 9 16 and 24 months