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Authors
Kumwenda, Chiza
Hemsworth, Jaimie
Phuka, John
et al.

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Original Article

Factors associated with breast milk intake among 9–10-month-old Malawian infants

Chiza Kumwenda*, Jaimie Hemsworth†, John Phuka‡, Mary Arimond§, Ulla Ashorn*, Kenneth Maleta‡, Per Ashorn*, Marjorie J. Haskell§ and Kathryn G. Dewey§

*Department for International Health, University of Tampere School of Medicine, University of Tampere, Tampere, Finland, †Department of Population Health, Nutrition Group, London School of Hygiene and Tropical Medicine, London, UK, ‡Department of Community Health, College of Medicine, University of Malawi, Blantyre, Malawi, and §Program in International and Community Nutrition, Department of Nutrition, University of California, Davis, California, USA

Abstract

Exclusive breastfeeding is recommended during the first 6 months of life; thereafter, continued breastfeeding along with nutritious complementary foods is recommended. Continued breastfeeding contributes a substantial proportion of nutrient needs and promotes healthy growth and development, but the quantity of breast milk consumed may be highly variable and little is known about the factors associated with breast milk intake after 6 months of age. The present study was conducted to assess factors associated with breast milk intake of Malawian infants at 9–10 months of age. Breast milk intake was measured using the dose-to-mother deuterium oxide dilution method in a subsample of 358 Malawian infants who were participating in a randomized controlled trial of lipid-based nutrient supplements. Regression analysis was used to assess associations between breast milk intake and several maternal and infant variables. Mean (standard deviation) breast milk intake was 752 (244) g day^{-1}. In multiple regression, breast milk intake was positively associated with infant weight (+62 g per kg body weight, $P < 0.01$) and maternal height ($P < 0.01$) and negatively associated with maternal education and age ($P < 0.01$). There was a non-significant ($P = 0.063$) inverse association between energy from non-breast milk sources and breast milk intake. In this rural Malawian population, infant weight is the main predictor of breast milk intake, even after the first 6 months of life.

Keywords: infant, breast milk intake, lipid-based nutrient supplements, Malawi, deuterium oxide, dietary intake assessment.

Correspondence: Dr Kathryn G. Dewey, Program in International and Community Nutrition, Department of Nutrition, University of California, One Shields Avenue, Davis, CA 95616, USA. E-mail: kgdewey@ucdavis.edu.

Introduction

The medical literature is replete with evidence demonstrating the beneficial effects of breastfeeding on the growth, development and health of infants (Eidelman 2012). It is also well known that breast milk provides the energy and nutrients that infants need for the first 6 months of life (Butte *et al*. 2003). Despite the prevailing body of evidence demonstrating that breast milk is critical for the health and survival of infants, suboptimal breastfeeding practices are still highly prevalent across the globe (Roberts *et al*. 2013) including in Malawi (NSO 2011). Unsurprisingly, suboptimal breastfeeding continues to be a significant contributing factor to disease burden among infants (Lamberti *et al*. 2011). Recent estimates indicate that suboptimal breastfeeding results in more than 800 000 child deaths annually (Black *et al*. 2013).

The benefits of breast milk to infant and child survival and health extend beyond the recommended exclusive breastfeeding period of the first 6 months. Breast milk continues to provide up to half or more of nutritional needs during the second half of infancy (Hill *et al*. 2004). In developing countries breastfeeding for up to 2 years reduces the risk of child mortality (WHO Collaborative study team on the role of breastfeeding on the prevention of infant mortality 2000), partly due to the immunological properties of breast milk (Morrow & Rangel 2004).

Previous studies demonstrate that breast milk intake can be influenced by infant-specific, maternal and environmental factors operating differently across different settings. Infant-specific factors include sex, age and weight (Imong *et al*. 1989; Dewey *et al*. 1991; Galpin *et al*. 2007). Additionally, provision of complementary foods to breastfed infants before 6 months of age generally displaces breast milk (Cohen *et al*. 1994; Wells *et al*. 2012) consistent with infants' ability to self-regulate their total energy intake (Dewey & Lonnerdal 1986) and with the observation that lactation performance is mainly determined by infant demand (Dewey *et al*. 1991). The magnitude of displacement of breast milk by complementary foods varies with the age of infant (WHO 1998). For instance, among 1–6-month-old and 9–12-month-old Thai infants, one additional kcal from non-breast milk sources was associated with a reduction in breast milk intake equivalent to 0.6–0.7 and 0.3 kcal, respectively (Drewett *et al*. 1989). Therefore, in contexts where available complementary foods are often nutrient poor (Gibson *et al*. 1998), it is particularly important to assess whether higher intake of complementary food is associated with lower intake of breast milk.

Some of the maternal factors associated with breast milk intake include age (Haisma *et al*. 2003), parity (Ingram *et al*. 1999) and ethnicity (De Amici *et al*. 2001). Although Prentice *et al*. (1994) demonstrated no association between maternal body mass index (BMI) and breast milk intake in several populations, some subsequent studies suggest that maternal body fatness is inversely associated with breast milk intake (Perez-Escamilla *et al*. 1995; Ettyang *et al*. 2005; Galpin *et al*. 2007; Nazlee *et al*. 2011). The most likely explanation for the latter findings is that greater body fatness is associated with a higher concentration of fat in breast milk (and thus higher energy density) (Brown *et al*. 1986), and consequently infants of mothers with more body fat can satisfy their energy needs with a lower volume of breast milk.

We recently completed a study to assess the effect of consumption of lipid-based nutrient supplements on breast milk intake in 9–10-month-old Malawian infants who participated in the iLiNS-DOSE trial (Kumwenda *et al*. 2014). Understanding the factors that influence breast milk intake may contribute towards designing locally appropriate public health strategies for improving breastfeeding practices. Thus, using the data from that study, our objective in this paper is to assess factors associated with breast milk intake in that cohort of infants.

Materials and methods

Study site and participants

The iLiNS-DOSE trial was carried out in southern Malawi in areas surrounding Mangochi District Hospital and Namwera Health Centre. The main iLiNS-DOSE trial ($N = 1932$) was registered at ClinicalTrials.gov as ID: NCT00945698. From the main iLiNS-DOSE trial, a total of 595 mother–infant dyads were approached to participate in the breast

Key messages

- There is a paucity of quantitative data on breast milk intake and its determinants, particularly after 6 months of age.
- In southern Malawi, breast milk intake at 9–10 months of age was higher among infants of mothers who were taller, younger or had less education. Infant weight was positively associated with breast milk intake.
- Breast milk meets energy and nutrient needs for infants up to 6 months of age and it continues to supply up to half or more of nutritional needs during the second half of infancy.

milk intake substudy. Infants in the present study were 9–10 months old when they took part in the breast milk intake assessment substudy (Kumwenda *et al*. 2014). Informed consent was obtained from the mother, for herself and her infant to enrol into both the main iLiNS-DOSE trial and the breast milk intake substudy. Study protocols were approved by the Institutional Review Boards of the College of Medicine, University of Malawi and the Pirkanmaa Hospital District, Finland.

Anthropometric measurements

Anthropometric measurements were taken following the standardized protocol for the main trial. In brief, measurements were taken by trained fieldworkers, who were supervised and re-trained every 3 months; all measurements were performed in triplicate. Mothers were weighed in light clothing to the nearest 0.01 kg using an electronic scale (SECA 846; Chasmors Ltd, London, UK), and height was measured to the nearest 0.1 cm using a stadiometer (Harpenden; Holtain Ltd, Crosswell, UK). Infants were weighed nude to the nearest 0.01 kg using an electronic scale (SECA 735; Chasmors Ltd), and length was assessed using a high-quality length board and recorded to the nearest 1 mm.

Estimation of breast milk intake

Breast milk intakes were measured using the dose-to-mother deuterium oxide dilution technique developed by Coward *et al*. (1982). The method is suitable for estimating average daily breast milk intake in community settings. The details of the assessment of breast milk intake have been described elsewhere (Kumwenda *et al*. 2014). Briefly, prior to consumption of deuterium oxide, baseline saliva samples were collected from mother–baby dyads followed by an oral intake of a 30 g dose of deuterium oxide by mothers. Further saliva samples from mothers and babies were collected at six time points after administration of deuterium oxide during a period of 14 days. Deuterium enrichment in saliva was measured by Fourier transform infrared spectroscopy (FTIR 8400 Series; Shimadzu Corporation) (IAEA 2010), and using the solver function in Excel a two-compartment steady-state model (Coward *et al*. 1982) was run to estimate mean breast milk intake. In the two-compartment steady-state model, the mother's total body water forms the first compartment and the baby's total water pool the second (IAEA 2010). The two compartments are connected by breast milk transferred from the mother to her baby. Based on the transfer of deuterium oxide from the mother to the infant the amount of breast milk can be estimated. Furthermore, a steady state implies that the compartments do not change over the study period (the total water input is equal to the total water output) which is true for mothers but not infants, whose total body water increases due to growth (IAEA 2010). Calculation of breast milk intake is carried out by fitting the deuterium enrichment data to a model for water turnover in the mother and the baby, at which stage the solver function in Excel is used using the spreadsheet developed by the International Atomic Energy Agency.

Socio-demographic and other independent variables

The independent variables to be examined in these analyses were chosen based on evidence from the literature on their potential associations with breastfeeding and breast milk intake among younger infants. Maternal educational level (years spent in school) and age were obtained at enrolment through personal interviews using structured questionnaires. Place of residence was categorized into a dichotomous variable for semi-urban vs. rural locations. Information on breastfeeding frequency was collected using a food frequency questionnaire from the main iLiNS-DOSE trial at approximately the same (9.0–10.0 months) time point as the breast milk intake assessment; pre-coded responses (0 = not at all; 1 = only at night; 2 = very little, only one or two times during the day; 3 = moderately, about three to five times during the day; 4 = very often, at least six times during the day) were read to mothers, who were asked to identify the response that most closely matched the frequency of breastfeeding the infant in the previous day. Responses 0–3 were combined into a single category representing low breastfeeding frequency whereas response 4 was categorized as high breastfeeding frequency.

Daily energy intake from non-breast milk sources and meal frequency were derived from dietary intake assessments performed within the same 14-day study period as the breast milk intake assessment. Dietary intake (J.C. Hemsworth, unpublished PhD thesis) was assessed using two four-pass interactive 24-h recalls (Ferguson *et al*. 1995). Non-breast milk energy and nutrients consumed by infants were calculated as averages from the two recall days using a food composition table specifically developed from regional (Korkalo *et al*. 2011; FAO 2012) as well as international sources (USDA 2007; USDA 2011). A 'meal' was defined as any feeding episode where the infant consumed a starchy staple in the form of a porridge (phala) or thick porridge (nsima) or boiled rice, and the number of such meals was summed for each day. Meal frequency was defined as the average of this sum across the 2 days.

Statistical analysis and sample size

The present analysis is based on a total sample of 358 infants. The sample size was calculated based on the assumptions stated elsewhere (Kumwenda *et al*. 2014). Data analysis was carried out using STATA (version 13; STATA Corp, College Station, TX, USA). Continuous variables were assessed for normality before analysis, and non-parametric techniques were used when required. Baseline characteristics for participants who were not enrolled into the substudy and those in the present substudy were compared using *t*-test and chi-square tests.

The independent variables included in the analysis were infant weight, energy from non-breast milk sources, breastfeeding frequency, meal frequency, residence and the following maternal factors: educational level, height, BMI and age. Volume of non-breast milk fluids was excluded from the model because the variable is mathematically related to breast milk intake when using the dose-to-mother deuterium oxide dilution technique (the two-compartment steady-state model estimates both breast milk intake and non-breast milk oral fluid intake by way of subtraction). Bivariate associations between continuous independent variables and breast milk intake as the outcome were assessed using Pearson correlation. The differences in mean breast milk intake between semi-urban and rural residence categories, and between infants with high (six or more episodes per day) and low (five or less episodes per day) breastfeeding frequency, were compared using two sample *t*-tests.

Variables associated with breast milk intake in the bivariate analysis were included in the multiple regression analysis. Some independent variables (energy from non-breast milk sources, maternal education and age) were included in the multiple regression models even if not significant in bivariate analyses, based on the known biologically plausible relationship with breast milk intake. Path analysis, a statistical technique used to examine hypothesized causal relationships between two or more variables (Lleras 2005), was conducted to further understand the pathways through which the above variables were related to each other and ultimately to breast milk intake. Three sets of regression analyses were run for the path analysis: the first set included energy from non-breast milk sources and the other two models were run without energy from non-breast milk sources. The rationale for running three sets of regression analyses was to explore whether or not energy from non-breast milk sources mediated the association of some of the independent variables with breast milk intake. For the latter two models, one was run without meal frequency to maximize the sample size (because the number of participants with meal frequency data was less than the total sample for the present study). The *P*-value of ≤ 0.05 was considered statistically significant for all tests.

Results

From the main iLiNS-DOSE trial, 595 mother–infant pairs were eligible for enrolment into the substudy. A total of 358 mother–baby dyads completed the substudy on breast milk intake and were included in the present analyses (Fig. 1). There were no statistically significant differences in baseline characteristics between those who completed the substudy protocol and those who were not included in the final sample.

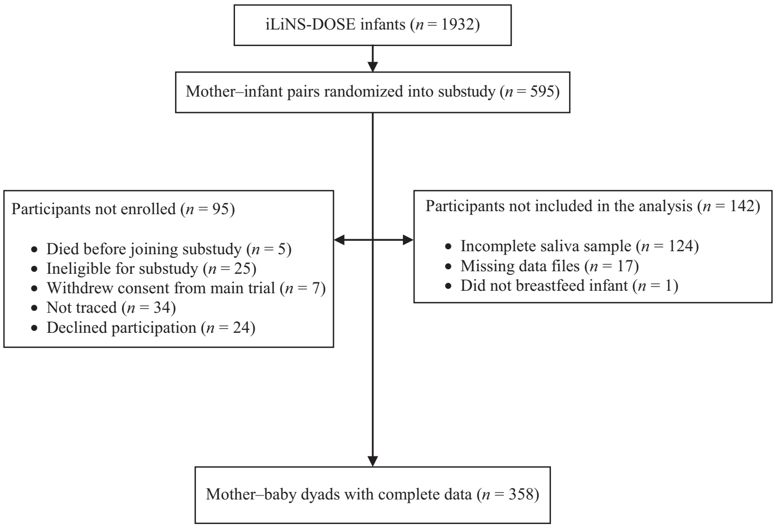


Fig. 1. Participant flow.

Table 1. Baseline characteristics*

Study group	Breast milk intake substudy ($n = 358$)	Participants not included in the substudy ($n = 1337$)	P-value
Infant characteristics			
Proportion of males	47%	51%	0.74
Length for age z-score at 5.5–6 months of age	–1.43 (1.03)	–1.39 (1.06)	0.07
Weight for length z-score at 5.5–6 months of age	0.27 (1.10)	0.25 (1.12)	0.81
Maternal characteristics			
Height† (cm)	155.1 (5.4)	155.0 (5.7)	0.27
Weight (kg)	52.7 (8.1)	53.4 (8.1)	0.96
Age (years)‡	26 (17–43)	25 (21–30)	0.77
Education (years)‡	4 (0–12)	5 (2–7)	0.32
Body mass index (kg m^{-2})	21.9 (3.0)	21.9 (2.9)	0.94
Parity‡	3 (1–9)	3 (2–4)	0.80

*Continuous values are means (standard deviations) and were compared by t-test; proportions were compared by chi-square test. †Height was measured at enrolment into the main trial. ‡Maternal age, parity and education are medians (interquartile range).

Also, participants in the main study who were not randomized into the substudy did not differ significantly from those included in the present analyses (Table 1).

Descriptive statistics for breast milk intake and the independent variables are shown in Table 2. The overall mean breast milk intake was 752 g day^{-1}, 90% of infants breastfed more than six times per day and the mean intake of energy from non-breast milk sources was 403 kcal day^{-1}. The distribution of breast milk intake is shown in Fig. 2. Table 3 shows the bivariate analysis between breast milk intake and the independent variables. Only infant body weight (Fig. 3) and maternal height were significantly correlated with breast milk intake ($r = 0.21$, $P < 0.000$ and $r = 0.14$, $P < 0.007$, respectively). The mean (standard deviation) breast milk intake of infants with high (more than six episodes per day) vs. low (less than five episodes per day) breastfeeding frequency was 748 (217) vs. 678 (257), respectively ($P = 0.053$). The correlation of breast milk intake with energy from non-breast milk sources was negative but not statistically significant ($r = -0.10$, $P = 0.238$).

Table 2. Descriptive statistics for breast milk intake and independent variables

Variable	*n*	Mean (SD) or %	Min	Max
Breast milk intake (g day^{-1})	358	752 (244)	125	1895
Energy from non-breast milk sources (kcal day^{-1})	284	403 (171)	32	1019
Meal frequency	284	6 (2)	1	13
Breastfeeding frequency			–	–
0 = Not at all	1	0.3%		
1 = Only at night	1	0.3%	–	–
2 = Very little, only one or two times during the day	2	0.7%	–	–
3 = Moderately, about three to five times during the day	25	8.4%	–	–
4 = Very frequent, more than five times during the day	269	90.0%	–	–
Residence (% semi-urban)	358	63%	–	–
Maternal height (cm)	358	155.1 (5.0)	137.4	171.7
Maternal BMI (kg m^{-2})	358	21.9 (3)	15.1	36.0
Maternal education (years)	351	4 (0–12)*	0	12
Infant weight (kg)	358	8.1 (1.0)	5.5	12.7
Maternal age (years)	350	26 (17–43)*	16	45

BMI, body mass index; SD, standard deviation. *Values are medians and interquartile range.

Fig. 2. Histogram of breast milk intake (g day^{-1}).

Table 4 shows variables related to breast milk intake using multiple regression. Infant weight was the independent variable most significantly associated with breast milk intake. An increase in infant weight by a kilogram was associated with an increase in breast milk intake of 68 g day^{-1}. When controlling for the other variables, breast milk intake was positively related to maternal height and negatively related to maternal education and age (Table 4). Energy from non-breast milk sources was also inversely associated with breast milk intake, but the association did not reach statistical significance ($P = 0.063$).

The results of the path analysis model (Fig. 4) are presented with energy intake from non-breast milk sources included, as exclusion of this variable did not result in marked differences in the coefficients (data not shown). Standardized coefficients superimposed on each arrow in Fig. 4 show the direction of the relationship between breast milk intake and the independent variables. The direct, indirect and total 'effects' of variables on breast milk intake calculated from the path analysis are presented in Table 5. As in the multiple regression model, infant weight had the strongest relationship with breast milk intake ($\beta = 0.28$) followed by maternal height ($\beta = 0.21$). Meal frequency and residence in semi-urban areas were both independently related to energy from non-breast milk sources, with meal frequency having a stronger relationship ($\beta = 0.47$) than semi-urban residence ($\beta = 0.16$). Maternal BMI and height were both positively related to infant weight, but the relationship of maternal height to breast milk intake was only partially explained by its association with infant weight.

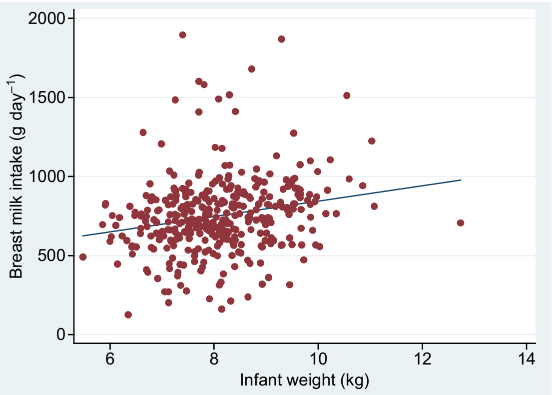
Discussion

In this cohort of 9–10-month-old Malawian infants, mean breast milk intake was 752 g day^{-1}, but there was a wide range from 125 to 1895 g day^{-1}. In multiple

Table 3. Relationship of breast milk intake with independent variables by Pearson's correlation coefficient (*r*) and regression*

Independent variable	*n*	Correlation coefficient	*P*-value
Energy from non-breast milk sources	284	−0.10	0.238
Maternal height	358	0.14	0.007
Maternal education	351	−0.10	0.245
Maternal BMI	358	0.04	0.438
Maternal age	350	−0.05	0.367
Infant weight	358	0.21	0.000
Meal frequency	284	−0.07	0.273
Breastfeeding frequency (more than six times per day)*	298	70†	0.107
Semi-urban (vs. rural) residence*	358	36†	0.176

BMI, body mass index. *From simple regression analysis. †Refers to regression coefficient for breast milk intake (g day^{-1}).



$r = 0.21$, P-value < 0.01

Fig. 3. Scatter plot of breast milk intake (g day^{-1}) against infant weight (kg).

regression, breast milk intake was significantly associated with infant weight as well as maternal height, age and education level. After controlling for infant weight and maternal factors, energy from non-breast milk sources was not significantly associated with breast milk intake. To our knowledge the present study is one of the first to examine maternal and infant characteristics associated with quantitative breast milk intake in a developing country. Previous studies have examined the relationship of maternal and infant characteristics to breastfeeding practices (Kamudoni *et al.* 2007, 2010; Kerr *et al.* 2007), but not to quantity of breast milk consumed.

Infant weight at 9–10 months was the strongest positive predictor of breast milk intake, which is expected given that energy needs (and thus infant appetite) are largely driven by body size. Previous studies have shown that breast milk intake is positively associated with infant weight, both at birth (Dewey *et al.* 1991; Perez-Escamilla *et al.* 1995; Humphreys *et al.* 1998) and beyond (Dewey *et al.* 1991). In a cross-sectional analysis such as this study, it is not possible to determine which comes first: greater infant weight driving higher breast milk intake, or higher breast milk intake causing greater infant weight. Maternal perception that heavier infants need to be given more breast milk may play a role. In a US study, Lee & Gould (2009) showed that mothers who perceived that their infants were heavier were likely to have a higher breastfeeding frequency than mothers with very low weight infants, but this has not been documented to date in Malawi, and the influence of perception of infant weight on breastfeeding practices could vary across cultures. We would expect breastfeeding frequency to be related to breast milk intake (Dewey *et al.* 1991). However, in the present study, the difference in breast milk intake between those with higher vs. lower breastfeeding frequency was only marginally significant. The lack of association between breast milk intake and breastfeeding frequency may be due at least in part to the low variability in breastfeeding frequency in our sample.

Maternal age and education were inversely associated with breast milk intake, which is in agreement with evidence from studies of correlates or determinants of breastfeeding practices including duration, initiation and frequency (Salami 2006; Chaves *et al.* 2007; Kimani-Murage *et al.* 2011; El Shafei & Labib

Table 4. Multiple regression model for the association between breast milk intake (g day^{-1}) and independent variables

Independent variables	Coefficient	95% CI	*P*-value
Infant weight (kg)	67.6	39.2 to 96.0	0.000
Maternal age (years)	−6.5	−10.8 to −2.2	0.003
Maternal education (years)	−10.9	−19 to −2.9	0.008
Maternal height (cm)	6.8	1.7 to 12.0	0.009
Energy from non-breast milk sources (kcal day^{-1})	−0.2	−0.3 to 0	0.063

CI, confidence interval.

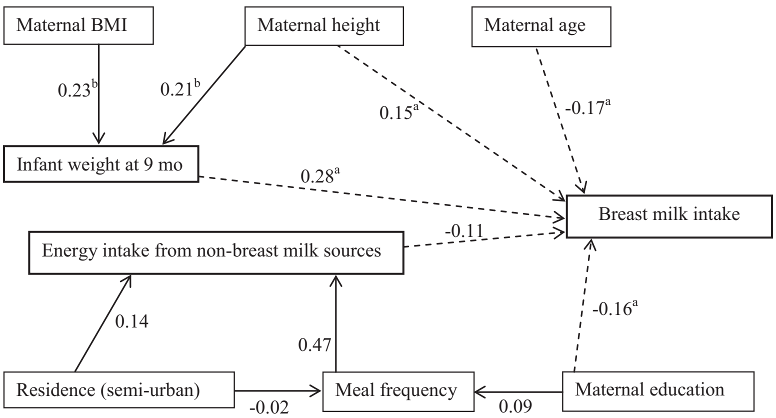


Fig. 4. Path analysis for breast milk intake and independent variables. [a]Variables significantly related to breast milk intake ($P < 0.01$). [b]Variables significantly related to infant weight ($P = 0.01$). All coefficients shown are standardized regression coefficients. Dashed lines are used to show relationships between the outcome (breast milk intake) and covariates, whereas solid lines show relationships between covariates.

Table 5. Standardized effects of the variables on breast milk intake from the path analysis

Variable	Effects		
	Direct	Indirect	Total
Maternal height (cm)	0.15*	0.06	0.21
Maternal BMI (kg m^{-2})	–	0.06	0.06
Maternal age (years)	−0.17*	–	−0.17
Maternal education (years)	−0.16*	0.005	0.16
Infant weight (kg)	0.28*	–	0.28
Meal frequency	–	−0.05	−0.05
Residence (semi-urban)	–	−0.02	−0.02
Energy from non-breast milk intake (kcal day^{-1})	−0.11	–	−0.11

BMI, body mass index. *Variables significantly related to breast milk intake ($P < 0.01$).

2014). Maternal education may reflect maternal employment outside the home, which may leave mothers with less time to spend nursing their infants as suggested by Thulier & Mercer (2009). However, in our sample, maternal education was not a strong predictor of employment outside the home (data not shown), perhaps because there were few women with enough education to increase the likelihood of outside employment.

At the global level, the direction of the relationship between maternal education and breastfeeding practices appears to differ between high- and low-income countries. Studies from high-income countries have shown a positive association between education levels and breastfeeding duration (Scott *et al*. 1999; Bertini *et al*. 2003; Kohlhuber *et al*. 2008). In low-income countries, the association of education level to various breastfeeding practices is mixed. Abada *et al*. (2001) report a negative association between education and breastfeeding duration, while among Mauritian mothers, duration was not associated with maternal education (Motee *et al*. 2013). Aidam *et al*. (2005) report a positive association between breastfeeding and maternal education in urban Ghana. The observed inconsistencies may be a reflection of differences in socio-economic factors between low- and high-income countries.

Maternal height was positively associated with breast milk intake in our study. In the path analysis model, maternal height was directly associated with breast milk intake but the relationship was also partly mediated through infant weight. Others have also reported a positive association between maternal height and infant breast milk intake (Michaelsen *et al*. 1994). Maternal height is positively associated with infant birth length and weight (Fawzi *et al*. 1997; Walker *et al*. 2003), which may be linked to greater breastfeeding success early in infancy, with a sustained effect on breast milk intake at later ages.

We found a non-significant, inverse association between energy from non-breast milk sources, a proxy for complementary foods, and breast milk intake. Several studies have demonstrated an inverse association between breast milk intake and complementary food intake among infants (Haisma *et al*. 2003; Islam *et al*. 2006; Galpin *et al*. 2007). Because complementary foods contribute to the total energy needs of infants, the net result is usually some displacement of breast milk intake. Breast milk continues to be an important source of some nutrients during complementary feeding (Hill *et al*. 2004), which is critical for infants receiving complementary foods with low nutrient and energy density, as is the case in rural Malawi (Gibson *et al*. 1998). The observed weak association between breast milk intake and energy intake from non-breast milk sources was surprising, and may be due to several reasons. Dietary assessment is prone to measurement error, which together with day-to-day variability has the potential to attenuate any association (Livingstone & Black 2003). Further, breast milk intake was assessed as an average across a 14-day period whereas dietary intake was assessed on two of the 14 days; this temporal difference may also have attenuated an association. The other possibility is that variation in energy expenditure, including physical activity (Wells & Davis 1998), may obscure the usual inverse association between breast milk intake and energy from non-breast milk sources.

Our study had a number of strengths. Breast milk and dietary intake were measured concurrently using state-of-the-art methods (J.C. Hemsworth, unpublished PhD thesis; Kumwenda *et al.* 2014). The sample size was larger than any previously published study of breast milk intake. However, interpretation of our findings should take into account the following limitations: maternal age was self-reported and was not objectively verified, and infant dietary intake was based on maternal recall rather than observed intakes. Recall bias may have resulted in either under- or over-estimation of infant energy intake. However, the dietary assessment method used was validated in the study area (Ferguson *et al*. 1995). Also because we examined a number of associations, some of the significant associations observed may be due to chance.

Our results suggest that in rural Malawi, infant weight is the main predictor of breast milk intake, even after the first 6 months of life. Thus, breastfeeding on demand should continue to be promoted among older infants while nutritious complementary foods are being provided to meet their energy and nutrient requirements.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

The authors' responsibilities were as follows: KGD, MJH, PA and KM designed the breast milk intake substudy, supervised the research and contributed to the manuscript. MA designed data collection on breastfeeding practices and contributed to the manuscript. JP and UA coordinated and supervised anthropometry and socio-demographic data collection, respectively; they also contributed to the manuscript. CK conducted the research, analysed the data and wrote the draft manuscript. JH designed and supervised the dietary intake assessment and contributed to the manuscript. All authors read and approved the final manuscript.

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