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# MATERNAL PERCEIVED STRESS, HIV STATUS, AND FEEDING STYLES ARE PREDICTORS OF INFANT DIETARY INTAKE IN GHANA

**Adhikari P[1], Marquis GS[1]* and A Lartey[2]**

**Prerana Adhikari**

*Corresponding author email: grace.marquis@mcgill.ca

[1]School of Human Nutrition, Macdonald Campus, McGill University, 21, 111 Lakeshore Rd., Ste. Anne-de-Bellevue, Quebec, Canada H9X 3V9.

[2]Department of Nutrition, University of Ghana, Legon, Ghana

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## ABSTRACT

Indicators of poor maternal mental health have been associated with non-responsive feeding styles that affect dietary intake in infants. This study examined the association between maternal mental health indicators and infant dietary intake and infant feeding behaviors within a 2003 to 2008 longitudinal observational cohort study in Ghana (the Research to Improve Infant Nutrition and Growth [RIING] project). A random sample of one third of the RIING cohort (19 HIV positive [HIV-P], 29 HIV negative [HIV-N], and 24 HIV unknown [HIV-U]) and their infants was selected for an in-home 24-hr weighed dietary study at 9 months postpartum. Maternal depressive symptoms and perceived stress scores had been measured at 6 months using the Edinburgh Postnatal Depression Scale (EPDS) and Perceived Stress Scale (PSS), respectively. All foods and liquids were weighed to determine energy and nutrient intake values. Human milk intake was weighed. Each feeding session was observed, and the feeding style was recorded. Multiple linear regression showed that maternal perceived stress was negatively associated with total food (-12.4 g, 95% CI: -21.0 to -3.8), energy (-19.5 kcal, 95% CI: -33.8 to -5.2), and fat (-0.7 g, 95% CI: -1.4 to -0.1) intake from complementary foods and liquids in infants. An HIV-P status was associated with a lower intake of fat (-6.3 g, 95% CI: -11.1 to -1.5) and vitamin A (-293.9 µg, 95% CI: -529.9 to -57.8) compared to HIV-N. Maternal mental health indicators were not associated with feeding style. However, a positive feeding style was associated with a higher intake of fat (4.8 g, 95% CI: 0.3 to 9.2) and vitamin A (245.3 µg, 95% CI: 28.2 to 462.5) compared to a passive feeding style. This study highlights the importance of focusing on how the infants are fed during the complementary feeding period. Interventions to improve infant dietary intake should prioritize maternal mental health and promote positive feeding styles among high-risk caregivers.

Key words: maternal depression, perceived stress, HIV, infant, feeding style, diet, Ghana

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## INTRODUCTION

Common maternal mental health disorders (CMD) have been associated with child stunting and underweight [1]. One possible pathway through which maternal mental health is associated with child undernutrition can be through its effect on care giving and feeding practices of mothers which impact the dietary intake of children. Depressive symptoms have been associated with inappropriate complementary feeding practices (not meeting minimum dietary diversity (MDD), minimum meal frequency (MMF), and minimum acceptable diet (MAD) [2] and maternal stress during complementary feeding period has been linked to mothers not preparing the food or not being able to find sufficient food [3]. One study in China showed that maternal depressive symptoms were associated with lower energy, protein, and fat intake in infants [4]. Another recent study from Nepal reported that maternal depressive symptoms were associated with lower dietary diversity in children, with 11% lower likelihood of a child (23-66 mo) consuming an additional food group and 13% lower likelihood of the child consuming an additional animal source food [5].

Maternal depression has been shown to affect mother-child interaction leading to less responsiveness towards the child which in turn could have negative influence on the feeding practices adopted by mothers [3]. The interaction between the caregiver and infant while feeding—referred to as feeding style, is an important determinant of dietary intake [6]. Feeding styles have been classified as responsive and non-responsive. Responsive feeding style refers to the caregiver's ability to recognize and respond to the hunger and satiety cues of her child which is reflected as positive feeding (with encouragement) whereas non-responsive feeding styles involve passive feeding (no encouragement), forced, and restrictive (controlled) feeding. In children below 2 years of age, maternal mental health indicators have been associated with non-responsive feeding styles, with depressive symptoms being associated with forceful, uninvolved, and indulgent feeding, stress being associated with forceful and uninvolved feeding and psychological distress being associated with monitoring and restrictive feeding [7, 8].

Maternal depression is the most commonly assessed mental health indicator whereas maternal anxiety and stress are less frequently observed. A systematic review that included 35 studies from eight African countries reported that the prevalence of postnatal depressive symptoms (PND) in the first 18 months postpartum ranged from 3 % to 48% with mean weighted prevalence of 18% [9]. A previously published analysis from the Research to Improve Infant Nutrition and

Growth (RIING) project reported the prevalence of depressive symptoms at 6 months postpartum to be 17% in HIV positive (HIV-P) mothers compared to 3% in HIV negative (HIV-N) and 10% in HIV unknown (HIV-U) mothers, indicating that maternal HIV status may act as an added stressor on maternal mental health [10]. There are a limited number of studies that have investigated quantitatively the association of maternal mental health indicators and feeding styles with dietary intake in infants. Therefore, the objectives of this analysis were to examine whether maternal mental health indicators and feeding styles were associated with infant dietary intake at 9 months and whether the association between maternal mental health indicators and infant dietary intake was modified by maternal HIV status.

## MATERIALS AND METHODS

### Study site

This paper is based on the secondary analysis of data from the RIING project (2003 - 2008) which was a cohort study conducted in two semi-urban districts in the Eastern region of Ghana. In 2003, the Eastern region had the highest HIV prevalence of 3.7% in Ghana, affecting more women (4.4%) than men (2.9%) [11]. The high HIV infection rate is still relevant today. In 2019, the estimated prevalence of HIV among adults aged 15 to 49 years in the Eastern region was 2.1% [12]. The two study districts still have the highest prevalence of HIV within the Eastern region (Lower Manya Krobo: 5.7% and Yilo Krobo: 3.7%) and are in the top 20 districts with the highest HIV prevalence in Ghana.

### Participant recruitment and sample

The RIING study enrolled pregnant women who were followed up for 12 months postpartum. The methods are explained in detail in the previous publications [10, 13, 14]. The participants were recruited from the prenatal clinics of three public hospitals in the districts that were providing voluntary counseling and testing (VCT) for HIV which was part of the regular Ghana Health Service (GHS) antenatal clinic procedures.

To be eligible for the study women had to be 1) pregnant at the time of enrollment, 2) at least 18 years of age, 3) go through pre- and post-VCT and if tested agree to release her HIV test results to the project coordinator, 4) available for the entire study period (12 months), and 5) free from any clinical or physical conditions that would limit mother's ability to care for her infant. The study enrolled 552 women: 190 HIV positive (tested positive for HIV; HIV-P), 185 HIV negative (tested negative for HIV; HIV-N) and 177 HIV unknown (refused to be tested for HIV; HIV-

U). The HIV tests were done using the Rapid Test Abbott Determine HIV-1/2 (Abbott Laboratories, Abbott Park, IL, USA). The antiretroviral therapy available at the time of the study was Nevirapine—which was given to the mothers during labor and to the infant at birth to prevent mother-to-child transmission of HIV. The present analysis used data from a randomly chosen subsample of 72 mothers and their infants who were available for a home study at 9 months (19 HIV-P mothers, 29 HIV-N mothers, and 24 HIV-U mothers).

**Data collection**

Data were collected at different time points throughout the duration of the study. Only the variables used in the analyses are described here. The demographic and housing characteristics (household possessions) data were collected at enrollment. An amenities score for each household was created from the household's possession of durable goods using Principal Component Analysis with varimax rotation [15] which was used as a proxy for socioeconomic status. Household food security score at 9 months postpartum was determined with a 7-item scale derived from the 18-item USDA Household Food Security Survey Module (HFSSM) [13]. Maternal depressive symptoms were measured using the Edinburgh Postnatal Depression Scale (EPDS) [16] and the perceived maternal stress was measured using the 4- item Perceived Stress Scale (PSS) at 6 months postpartum [17].

The food and liquid consumed by 9 months old infants over 24 hours were weighed in order to determine nutrient intake. When possible, all ingredients used for food preparation were weighed to the nearest 0.1 g using a food scale (Ohaus LS2000 Portable Standard Scale, Pine Brook, NJ). The portion served and left uneaten was weighed to determine the portion consumed by the infant. The nutrient content of the food was determined using ESHA Food Processor Plus, FPRO (Version 6.20. Esha Research, Salem, OR). Human milk intake was determined by weighing the infants before and after each feed to estimate the total 24-hour intake. The feeding session was observed to record the feeding behavior practiced by the caregiver. Information on who fed the child and the feeding style used was recorded. The feeder was categorized as mothers only or others (another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver). The types of feeding styles observed included passive feeding style (little or no encouragement to eat), positive (active) feeding style, and forced (verbal/physical) feeding style. Infants who were fed using two or more types of feeding styles were categorized as being fed by using 'mixed feeding style'. Duplicate measurements of infant weight to the nearest 0.1 kg were made on the day of dietary data collection using the Tanita digital weighing scale (Tanita

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Corporation of America Inc., Arlington Heights, IL, USA). The incidence of infant fever on the day of dietary data collection was also recorded.

**Data Analysis**

Out of the 72 cases analyzed, two outliers were identified with unusually high intake of natural peanut butter (118 g, 94.1 standard deviation (SD) away from the mean) and red palm oil (66.3 g, 13.0 SD away from the mean), respectively. Both outliers were replaced by the mean intake of the respective food—5.1 g for the peanut butter and 6.4 g for the red palm oil. The total grams of food, energy, macronutrient, and micronutrient intakes were then calculated based on these replaced values.

Data were analyzed using SPSS for Windows version 27. For descriptive data, mean and standard deviation or median and interquartile range were calculated for continuous variables and frequency and percentages were reported for categorical variables. Bivariate analysis was done using ANOVA (with Bonferroni post-hoc tests) for normally distributed continuous variables and Mann-Whitney U Test or Kruskal-Wallis (with pairwise comparison) for non-normally distributed continuous variables. For categorical variables Chi-square test or Fisher's exact test was used.

Multiple linear regression was used to determine the predictors of dietary intake from complementary foods (total grams of food, energy, protein, fat, vitamin A, iron, zinc, and calcium). Human milk intake, reported in g, was included as a covariate. The variables that were statistically significant in bivariate analysis or identified a priori in the literature were added into the models. For maternal mental health indicators, the continuous scores were used for the regression models—EPDS scores and perceived stress scores. Maternal HIV, EPDS scores, perceived stress score, human milk intake, and meal frequency were retained in all the models. Other predictors added in the models were maternal age, education, occupation, the interaction terms HIV status*EPDS score and HIV status*perceived stress scores, infant weight, the feeder, feeding style used, infant fever, and household food security. The final models were developed using backwards elimination method where other predictors with a $p<0.1$ were retained in the model.

**Ethical Approval**

Ethical approval for this study was obtained from the Institutional Review Boards of McGill University, Iowa State University, University of Ghana, and University of Connecticut. All women provided written informed consent for themselves and their infants.

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## RESULTS AND DISCUSSION

### Baseline characteristics

Maternal age ranged from 18 to 42 years with a mean age of 28.9 ± 5.8 years. The majority of women were married or co-habiting (83.3%, n= 60). Approximately half of the mothers were traders (54.2%, n= 39), 38.9% (n=28) of mothers were involved in other occupation (seamstress, secretary, hairdresser, teacher, baker, or a farmer) and 6.9% (n=5) were unemployed. More than half of the mothers (68.1%, n=49) were of the Ga/Adangbe ethnic group—the local ethnic group of the study area. One third of the mothers (34.7%, n= 25) had none or primary education, almost half of the mothers (47.2%, n=34) had junior secondary education, and 18.1% (n=13) of mothers had achieved some senior secondary or above education. The median EPDS score was 1.5 (0.0, 7.8) and the median stress score was 7.0 (5.0, 8.0). When the cut-off value of 13 was used for EPDS score, seven out of 72 mothers reported symptoms of depression at 6 months postpartum. Four mothers did not have data on stress (1 HIV-P mother and 3 HIV-N mothers). When stress level was categorized as low and high perceived stress using the median score of 7 as a cut-off, low perceived stressed were reported by 43 mothers (63.2%) and high perceived stress was reported by 25 mothers (36.8%). About 60% (n=43) of mothers were food secure and 25% (n=18) of mothers were food insecure. Overall, 38 out of 72 infants were fed by mothers only and 34 infants were fed by others (another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver). Almost half of the infants were fed using positive feeding style (48.6%).

The only HIV group differences were in the amenities score and infant weight (Table 1). The HIV-P mothers had lower socio-economic status as indicated by the lower amenities score than HIV-N and HIV-U mothers. Infants born to HIV-P mothers had 1.1 kg lower weight at 9 months of age compared to infants born to HIV-U mothers.

### Maternal indicators, feeding practices, and intake from complementary foods

Maternal factors including age, HIV status, education, and occupation were not associated with infant's dietary intake from complementary foods in the bivariate analysis. The EPDS score and perceived stress score were not significantly correlated with dietary intake in infants. When maternal mental health indicators were used as a dichotomous variable—depressive symptoms and no depressive symptoms and low perceived stress and high perceived stress, no significant differences were observed in terms of dietary intake between the groups (Tables

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2a & 2b). Meal frequency was positively associated with EPDS score. There were no significant differences in the EPDS scores and perceived stress scores across the categories of breastfeeding status, the feeder, and the feeding style.

**Other factors associated with intake of complementary foods**

Only child fever, the feeder, and the feeding style were associated with complementary food intakes in the bivariate analysis (Tables 2a & 2b). Compared to infants who did not have fever, infants with fever consumed less (-105 g of complementary food, -134 kcal energy, and -0.5 mg zinc). Fever tended to be negatively associated with intakes of protein, iron, and calcium. Vitamin A and iron intakes were lower when the feeder was the mother only compared to others. Similar tendencies were seen with energy, zinc, and calcium. Infants who were fed using positive feeding style had higher energy, protein, vitamin A, and zinc intake compared to infants who were fed using passive feeding style. Fat, iron, and calcium intake showed similar tendencies.

**Predictors of intake of complementary foods**

Maternal perceived stress was associated with lower total food, energy, and fat intake from complementary foods in infants (Table 3a). No study looking at the association of maternal perceived stress with energy and nutrient intake was identified in the literature. However, the findings of this study are in line with stress being linked to impaired ability of mothers to prepare or find sufficient food during the complementary feeding period [3]. This study showed that maternal depressive symptoms only tended to be negatively associated with infant iron and calcium intake from complementary foods. In contrast, Wang et al. [4], in a hospital-based cohort study in China, reported infants of mothers with depressive symptoms (measured using EPDS with cut-off score of 9) had 84.9 kcal lower energy, 3.2 g lower protein, and 4.2 g lower fat intake compared to infants of mothers without depressive symptoms. However, the depressive symptoms were measured three days after delivery and the dietary intake data were recorded at 8 months using 24-hr dietary recall. The depressive symptoms measured immediately after the delivery might not be representative of depressive symptoms at the later postpartum period. In this study, depressive symptoms were measured at 6 months postpartum which is closer to the date of dietary data collection. However, very few mothers reported in the higher range of EPDS score (7 out of 72 mothers showed depressive symptoms using cut-off score of 13), which might have affected the ability to detect significant association with the infant dietary intake.

In Ghana, extended families play an important role in providing support to the nursing mothers in terms of household chores and childcare [18, 19]. A

community-based cross-sectional study including mother-child pairs (6-23 months of age), showed that there was no significant association between maternal depressive symptoms and complementary feeding indicators—MDD, MMF, and MAD [19]. This was attributed to the contribution of other adults in the households to childcare which is commonly seen in Ghanaian families. This support was also reflected in this study where almost half of the infants (47%) were fed by others (another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver), which might have played a protective role against mother's depressive symptoms from affecting feeding practices and infant dietary intake.

Studies have shown that meal frequency [20], maternal education [21, 22], occupation [18], maternal age [19, 23], and socio-economic status [21] to be associated with infant dietary intake. In this study, higher meal frequency was associated with higher intake of total food, energy, protein, fat, and iron intake. This finding is in line with Harding et al. [20], that showed eating more times a day was associated with greater diversity, higher daily intake of energy, calcium, iron, and zinc in children aged two and five years of age. A study done in northern Ghana showed that higher maternal education was associated higher MDD (aOR: 2.1, 95% CI: 1.3 to 3.4), MMF (aOR: 1.7, 95% CI: 1.1 to 2.7), and MAD (aOR: 2.1, 95% CI: 1.3 to 3.4) in children aged 6 to 23 months old [22]. In this study, maternal education showed significant association only with zinc intake—with higher level of education being linked to lower zinc intake. Maternal age was shown to be a significant predictor of zinc intake—0.1 mg lower zinc intake with each year increase in maternal age. This finding contrasts with a study done in India that showed higher maternal age being linked to increased likelihood of meeting MDD (aOR: 2.25, 95% CI: 1.41 to 3.58) and MAD (aOR: 2.24, 95% CI: 1.07 to 4.66) in infants given that older mothers would be expected to have more experience in terms of appropriate infant and young child feeding practices [23]. Studies have shown better MDD and MAD in infants of mothers with higher education level and older age suggesting better nutrient intakes. However, the results of this study showed significant associations of higher education level and age with lower zinc intake. The major sources of zinc for the infants were porridges made from processed cereal product in few cases and starchy staples (rice, corn, millet, and cassava). These preparations were consumed more among infants with younger and less educated mothers.

Moreover, in this study, maternal occupation was not a significant predictor of infant dietary intake which might be due to the support of other family members for feeding the infant. In Ghana, household poverty was a significant determinant associated with not meeting MDD in children (6-23 mo) [21]. The amenities score

which was used as a proxy indicator for socioeconomic status in this study was positively associated with food security. Interestingly, neither the amenities scores nor the food security was associated with infant dietary intake. A study by Agbadi et al. [24] showed that although children living in food insecure households were less likely to meet MAD (OR: 0.53, 95% CI: 0.35 to 0.82), 80% of the children from food secure household did not meet the MAD recommendation either, indicating that household food security is a poor indicator of adequate dietary intake in children. This further emphasizes the need to focus on the 'how' the food is being utilized and fed to the child in addition to 'what' is available.

The results of this study showed that there were no significant differences in EPDS scores and perceived stress scores across the different types of feeding style used. In contrast to these findings, studies examining the association of maternal mental health indicators with feeding style in children below two years of age have shown that maternal mental health indicators are associated with non-responsive feeding styles [7, 8]. Nonetheless, this study showed that feeding style was a significant predictor of infant complementary food intake. Positive feeding style was shown to be associated with higher intake of fat and vitamin A compared to passive feeding style and similar tendencies were seen with protein and calcium intake. Moreover, forced feeding style which is a non-responsive feeding style was associated with higher intake of vitamin A and similar tendencies were seen with fat and calcium. However, forced feeding style was being compared to passive feeding style and not positive (responsive feeding style). Compared to the previous studies that have reported on the association of feeding styles and mouthfuls of food accepted by infants [25, 26], the findings of this study showed that feeding styles are further associated with the types of food being eaten.

A recent meta-analysis showed that being HIV positive was associated with higher risk of antenatal and postnatal depressive symptoms (OR 1.42, 95% CI (1.12, 1.80) and OR 1.58, 95% CI (1.08, 2.32), respectively) [27]. However, the studies used different screening tools and different cut-off values. In this study, the continuous scores for maternal depressive symptoms and perceived stress were used and there were no significant differences in EPDS scores and perceived stress scores between the HIV groups. The findings are in line with a study from Zambia that reported HIV status not being associated with postnatal depressive symptoms (aOR: 1.22, 95% CI 0.50 to 2.96) [28]. However, this study was done in a tertiary hospital where the participants were receiving postnatal care and like this study, the participants had undergone voluntary counseling. Given that the participants received pre- and post-test counseling, these findings might not be representative of mothers not receiving VCT or mothers living in rural areas.

Moreover, a study from Malawi showed that it was the HIV status of the infant and not of the mother that was associated with postnatal depression (prevalence ratio PR: 2.0, 95% CI: 1.1 to 3.6) [29]. At the time of this study, the Ghana Health Service did not routinely test children for HIV in the first year, hence, the association could not be examined. Although previously published study by Okronipa et al. [10] had also shown that maternal HIV status acted as an added stressor on maternal mental health, the interaction term HIV status*EPDS score, and HIV status*stress scores did not show significant association with infant dietary intake indicating there was no synergistic effect of maternal HIV status and mental health indicators on infant dietary intake.

One of the major strengths of the study was the use of 24-hr weighed dietary intake data which is considered to be the most precise method for estimating food and nutrient intakes [30]. Therefore, the findings of the study add to the limited number of studies that have investigated the association of maternal mental health indicators and feeding styles with dietary intake quantitatively. Both the tools used to measure the depressive symptoms and perceived stress—the EPDS and the PSS-4 item scale have been adequately validated [16, 17]. This study also had some limitations. Firstly, the mental health indicators were measured 6 months postpartum and the dietary intake data were recorded at 9 months, therefore, the immediate effect of depressive symptoms or stress could not be assessed. Secondly, very few mothers reporting in the higher range of the EPDS score might have affected the ability to detect significant association.

## CONCLUSION

The results of this study highlighted the importance of maternal mental health on infant dietary intake. Interventions to improve infant intake of complementary foods should prioritize maternal mental health and promote positive feeding styles among caregivers. Given the significant contribution of other adult caregivers to infant feeding, interventions on infant and young child feeding practices should also target other household members.

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**Table 1: Characteristics of mothers and their infants by maternal HIV status in the Eastern Region, Ghana**

| Characteristics | HIV-P (N= 19) | HIV-N (N= 29) | HIV-U (N= 24) | p value |
|---|---|---|---|---|
| **Maternal** | | | | |
| Age (y) | 26.9 (5.6) | 29.1 (5.6) | 30.3 (6.0) | 0.159 |
| Marital status | | | | 0.497 |
| Living with partner/husband | 15 (78.9) | 26 (89.7) | 19 (79.2) | |
| Other[1] | 4 (21.1) | 3 (10.3) | 5 (20.8) | |
| Occupation | | | | 0.260 |
| Trader | 8 (42.1) | 15 (51.7) | 16 (66.7) | |
| Other[2] | 11 (57.9) | 14 (48.3) | 8 (33.3) | |
| Education | | | | 0.118 |
| None or Primary | 8 (42.1) | 6 (20.7) | 11 (45.8) | |
| Junior Secondary | 9 (47.4) | 14 (48.3) | 11 (45.8) | |
| Some Senior Secondary or above | 2 (10.5) | 9 (31.0) | 2 (8.3) | |
| Ethnicity[3] | | | | 0.657 |
| Local | 14 (73.7) | 18 (62.1) | 17 (70.8) | |
| Non-local | 5 (26.3) | 11 (37.9) | 7 (29.2) | |

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| | | | | |
|---|---|---|---|---|
| EPDS score at 6 mo postpartum[4] | 1.0 (0.0, 4.0) | 1.0 (0.0, 5.5) | 4.0 (0.0, 11.8) | 0.145 |
| Perceived stress score at 6 mo postpartum[5] | 7.0 (5.8, 8.0) | 6.0 (4.0, 8.0) | 7.0 (6.0, 9.8) | 0.114 |
| Depressive symptoms at 6 mo postpartum[6] | | | | 0.268 |
| Yes | 2 (10.5) | 1 (3.4) | 4 (16.7) | |
| No | 17 (89.5) | 28 (96.6) | 20 (83.3) | |
| Perceived stress at 6 mo postpartum[7] | | | | 0.374 |
| Low stress | 11 (57.9) | 19 (65.5) | 13 (54.2) | |
| High stress | 7 (36.8) | 7 (24.1) | 11 (45.8) | |
| **Household** | | | | |
| Amenities score[8] | 4.1 (2.4)[a] | 8.1 (3.8)[b] | 8.8 (5.5)[b] | 0.001 |
| Food security[9] | | | | 0.398 |
| Food secure | 9 (47.4) | 20 (69.0) | 14 (58.3) | |
| Food insecure | 5 (26.3) | 5 (17.2) | 8 (33.3) | |
| **Infant** | | | | |
| Sex | | | | 0.094 |
| Male | 13 (68.4) | 11 (37.9) | 14 (58.3) | |
| Female | 6 (31.6) | 18 (62.1) | 10 (41.7) | |

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| | | | | |
|---|---|---|---|---|
| Weight at 9 mo (kg) | 7.7[a] (7.2, 8.4) | 8.2[a,b] (7.6, 9.0) | 8.8[b] (7.5, 9.5) | 0.033 |
| Feeder | | | | 0.866 |
| Mother only | 11 (57.9) | 15 (51.7) | 12 (50.0) | |
| Others[10] | 8 (42.1) | 14 (48.3) | 12 (50.0) | |
| Feeding style[11] | | | | 0.140 |
| Passive | 2 (10.5) | 9 (31.0) | 3 (12.5) | |
| Positive | 11 (57.9) | 11 (37.9) | 13 (54.2) | |
| Force | 3 (15.8) | 1 (3.4) | 5 (20.8) | |
| Mixed | 3 (15.8) | 8 (27.6) | 3 (12.5) | |
| Human milk intake at 9 mo (g) | 648.0 (462.3, 785.0) | 495.5 (272.5, 669.8) | 484.5 (333.0, 763.5) | 0.300 |
| Meal frequency | 2.0 (1.0, 5.0) | 3.0 (2.0, 3.0) | 2.5 (1.3, 3.0) | 0.782 |
| Fever at 9 mo | | | | 0.366 |
| Yes | 1 (5.3) | 2 (6.9) | 4 (16.7) | |
| No | 18 (94.7) | 27 (93.1) | 20 (83.3) | |

Results presented as mean (standard deviation), median (25$^{th}$, 75$^{th}$ percentile), or n (%)

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Tested using ANOVA (with Bonferroni post-hoc test), Kruskal-Wallis Test, or Chi-square test. Mean/median values within a row with unlike superscript letters were significantly different ($p < 0.05$).

HIV-P: HIV positive; HIV-N: HIV negative; HIV-U: HIV unknown status

[1] Marital status: other= single, separated or divorced

[2] Occupation: other= seamstress, secretary, hairdresser, teacher, baker, or farmer or unemployed

[3] Ethnicity: local= Ga/Adangbe, non-local= Ewe, Akan, northerner, others

[4] EPDS score= Edinburgh Postnatal Depression Scale (EPDS) score was determined using a 10-item EPDS questionnaire with each item scored on a 4-point rating scale—scores ranging from 0 to 30 [16]

[5] Perceived stress score was determined using Cohen *et al.* 4 item Perceived Stress Scale (PSS) [17]. The frequency of the perceptions was determined; the responses and corresponding scores involved—never (1), only once or twice (2), at least once a week (3), more than once a week (4), and almost daily (5) in the last month. The total summative score was determined

[6] Participants with EPDS scores <13 were classified as not showing symptoms of maternal depression and participants with EPDS scores ≥13 were classified as showing symptoms of maternal depression

[7] Participants with perceived stress scores higher than the median >7 were categorized as having high stress and participants with scores at or below ≤ 7 were categorized as having low stress

[8] Amenities score was created from households' possession of 19 durable goods (VCR, CD player, DVD player, TV, radio, electric stove, blender, fridge, fan, air conditioner, pressing iron, generator, telephone/ mobile phone, dresser, car batteries, Pyrex bowls/glass utensils, aluminum utensils, car, coal pot) using Principal Component Analysis (PCA) with varimax rotation

[9] Food security score was determined using a 7-item scale derived from the 18-item USDA Household Food Security Survey Model (HFSSM). Each item was scored as present (0) and not present (1). Households having score of 0 were categorized as being food secure and households having score ≥1 were categorized as being food insecure

[10] Feeder: others= another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver

[11] Feeding style: passive = fed with little or no encouragement, positive = active/responsive feeding, forced= fed using verbal/physical force, mixed= fed using two or more feeding style stated

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**Table 2a: Bivariate associations between maternal and infant factors with total food, energy, and macronutrient intake from complementary foods and liquids in 9 months old infants in the Eastern Region, Ghana**

| Factors | Total food intake (g) | | Energy (kcal) | | Protein (g) | | Fat (g) | |
|---|---|---|---|---|---|---|---|---|
| | Median | p | Median | p | Median | p | Median | p |
| **Maternal** | | | | | | | | |
| HIV status | | 0.805 | | 0.778 | | 0.621 | | 0.334 |
| HIV-N | 147.0 (66.4, 201.2) | | 210.1 (89.4, 356.3) | | 2.8 (1.9, 7.4) | | 5.8 (1.6, 15.3) | |
| HIV-U | 143.3 (67.8, 298.1) | | 145.8 (71.0, 350.3) | | 3.6 (1.3, 7.7) | | 4.2 (0.9, 6.4) | |
| HIV-P | 132.0 (48.0, 225.8) | | 181.8 (78.1, 421.3) | | 6.1 (1.2, 17.4) | | 3.6 (0.3, 12.2) | |
| Depressive symptoms at 6 mo postpartum[1] | | 0.141 | | 0.180 | | 0.186 | | 0.711 |
| Yes | 332.0 (65.5, 754.1) | | 358.1 (98.9, 721.2) | | 6.9 (2.9, 25.7) | | 5.9 (1.8, 12.2) | |
| No | 133.5 (56.5, 214.4) | | 170.9 (79.0, 350.8) | | 3.5 (1.5, 7.7) | | 4.6 (1.1, 9.4) | |
| Perceived stress at 6 mo postpartum[2] | | 0.377 | | 0.537 | | 0.707 | | 0.377 |
| Low stress | 147.0 (81.0, 230.5) | | 210.1 (78.1, 347.0) | | 3.7 (2.0, 7.5) | | 5.0 (1.2, 9.5) | |
| High stress | 108.6 (47.4, 248.7) | | 98.9 (76.9, 366.9) | | 1.9 (1.3, 11.0) | | 3.4 (0.8, 7.9) | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Education | | 0.739 | | 0.439 | | 0.591 | | 0.418 |
| None or Primary | 128.8 (53.6, 216.8) | | 158.1 (69.3, 359.6) | | 3.7 (1.2, 8.5) | | 3.4 (0.7, 7.8) | |
| Junior Secondary | 133.4 (76.6, 253.9) | | 157.3 (77.6, 354.5) | | 3.1 (1.5, 7.5) | | 4.7 (1.0, 12.2) | |
| Some Senior Secondary or above | 154.5 (79.7, 267.7) | | 262.6 (109.5, 437.0) | | 3.7 (1.9, 11.8) | | 5.8 (2.8, 9.7) | |
| **Infant** | | | | | | | | |
| Feeder | | 0.125 | | 0.052 | | 0.169 | | 0.122 |
| Mother only | 113.9 (49.1, 208.7) | | 136.8 (73.2, 269.2) | | 2.8 (1.5, 7.3) | | 3.2 (0.7, 8.6) | |
| Others[3] | 153.3 (76.9, 318.6) | | 279.4 (89.9, 433.8) | | 4.5 (1.6, 10.7) | | 6.0 (2.4, 12.2) | |
| Feeding style[4] | | 0.179 | | 0.017 | | 0.012 | | 0.044 |
| Passive | 112.8 (44.0, 178.7) | | 75.7 (44.1, 248.6)[a] | 0.045 | 1.7 (0.9, 3.3)[a] | 0.017 | 0.9 (0.3, 5.5) | |
| Positive | 183.2 (74.6, 308.9) | | 259.3 (133.0, 381.6)[b] | | 5.0 (2.7, 9.8)[b] | | 5.9 (2.9, 10.0) | |
| Forced | 65.5 (28.4, 166.1) | | 79.8 (36.9, 282.6)[ab] | | 1.8 (0.5, 8.0)[ab] | | 3.9 (0.4, 6.3) | |
| Mixed | 132.8 (81.6, 187.9) | | 197.2 (89.9, 328.2)[ab] | | 3.8 (1.9, 7.3)[ab] | | 6.1 (2.2, 12.5) | |
| Fever at 9 mo | | **0.019** | | **0.019** | | 0.082 | | 0.337 |
| Yes | 29.7 (23.7, 147.0) | | 74.0 (55.8, 97.5) | | 1.4 (1.1, 3.7) | | 2.1 (0.7, 6.5) | |

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| | | | | |
|---|---|---|---|---|
| No | 134.7 (77.8, 257.8) | 208.0 (85.9, 363.2) | 3.7 (1.8, 8.5) | 4.9 (1.3, 9.7) |

Data are presented as median (25th, 75th percentiles)

p-value from Mann-Whitney U Test or Kruskal Wallis test

HIV-N = HIV negative; HIV-P= HIV positive; HIV-U= HIV unknown

[1] Maternal depressive symptoms measured using Edinburgh Postnatal Depression Scale (EPDS) [16]. Participants with EPDS scores <13 were classified as not showing symptoms of maternal depression and participants with EPDS scores ≥13 were classified as showing symptoms of maternal depression.

[2] Maternal perceived stress measured with Cohen *et al.* 4-item Perceived Stress Scale (PSS) [17]. Participants with scores higher than the median >7 were categorized as having high stress and participants with scores at or below ≤ 7 were categorized as having low stress.

[3] Feeder: others= another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver

[4] Feeding style: passive= fed with little or no encouragement, positive= active/responsive feeding, forced= fed using verbal/physical force, mixed= fed using two or more feeding style stated

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**Table 2b: Bivariate associations between maternal and infant factors with micronutrient intake from complementary foods and liquids in 9 months old infants in the Eastern Region, Ghana**

| Factors | Vitamin A (µg) | | Iron (mg) | | Zinc (mg) | | Calcium (mg) | |
|---|---|---|---|---|---|---|---|---|
| | Median | p | Median | p | Median | p | Median | p |
| **Maternal** | | | | | | | | |
| HIV status | | 0.822 | | 0.842 | | 0.530 | | 0.299 |
| HIV-N | 29.4 (7.6, 353.3) | | 1.9 (0.8, 3.2) | | 0.5 (0.3, 1.1) | | 35.3 (21.0, 138.4) | |
| HIV-U | 51.6 (11.1, 242.0) | | 1.7 (0.7, 4.2) | | 0.5 (0.2, 1.3) | | 30.8 (10.5, 51.1) | |
| HIV-P | 92.3 (3.3, 330.5) | | 1.9 (1.0, 6.2) | | 1.3 (0.2, 3.1) | | 46.4 (13.6, 174.0) | |
| Depressive symptoms at 6 mo postpartum[1] | | 0.938 | | 0.242 | | 0.537 | | 0.512 |
| Yes | 58.0 (1.6, 319.1) | | 4.2 (0.8, 14.3) | | 1.2 (0.3, 3.0) | | 43.0 (14.7, 214.5) | |
| No | 65.8 (7.2, 323.1) | | 1.9 (0.8, 3.4) | | 0.6 (0.3, 1.5) | | 35.3 (14.2, 98.2) | |
| Perceived stress at 6 mo postpartum[2] | | 0.382 | | 0.736 | | 0.780 | | 0.717 |
| Low stress | 80.7 (10.2, 320.1) | | 1.9 (1.0, 3.3) | | 0.7 (0.3, 1.3) | | 40.3 (13.9, 89.5) | |
| High stress | 36.1 (1.9, 285.7) | | 1.2 (0.7, 5.2) | | 0.4 (0.2, 2.8) | | 20.2 (14.1, 172.4) | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Education | | 0.932 | | 0.357 | | 0.422 | | 0.245 |
| None or Primary | | | | | | | | |
| Junior Secondary | 65.8 (5.4, 352.7) | | 1.7 (0.7, 3.1) | | 0.5 (0.3, 1.4) | | 29.4 (15.0, 64.8) | |
| Some Senior Secondary or above | 88.1 (13.8, 322.7) | | 2.0 (1.4, 9.0) | | 0.7 (0.5, 2.6) | | 67.2 (29.8, 214.7) | |
| **Infant** | | | | | | | | |
| Feeder | | **0.030** | | **0.030** | | 0.099 | | 0.078 |
| Mother only | 22.0 (2.7, 250.0) | | 1.4 (0.7, 3.0) | | 0.5 (0.3, 1.1) | | 26.8 (12.0, 64.6) | |
| Others[3] | 152.0 (26.4, 366.8) | | 2.5 (0.9, 5.0) | | 1.0 (0.4, 1.7) | | 60.6 (14.7, 129.3) | |
| Feeding style[4] | | 0.008 | | 0.044 | | 0.016 | | 0.087 |
| Passive | 3.9 (0.0, 21.1)[a] | 0.005 | 1.2 (0.5, 2.3) | | 0.3 (0.1, 0.8)[a] | 0.025 | 20.9 (10.4, 43.8) | |
| Positive | 150.3 (40.0, 434.9)[b] | | 2.8 (1.3, 4.6) | | 1.1 (0.4, 1.7)[b] | | 50.1 (20.1, 153.9) | |
| Forced | 159.3 (13.7, 341.6)[ab] | | 1.0 (0.4, 4.0) | | 0.3 (0.1, 3.0)[ab] | | 15.3 (7.5, 130.7) | |
| Mixed | 23.9 (6.8, 312.2)[ab] | | 1.9 (0.8, 4.9) | | 0.8 (0.4, 1.2)[ab] | | 54.5 (24.7, 115.8) | |
| Fever at 9 mo | | 0.577 | | 0.061 | | 0.049 | | 0.085 |
| Yes | 46.8 (0.0, 385.9) | | 1.0 (0.5, 1.8) | | 0.3 (0.2, 0.5) | | 14.5 (5.4, 56.6) | |

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| | | | | |
|---|---|---|---|---|
| No | 65.8 (7.5, 319.1) | 2.0 (0.8, 4.3) | 0.8 (0.3, 1.5) | 40.3 (14.9, 114.0) |

Data are presented as median (25th, 75th percentiles)

p-value from Mann-Whitney U Test or Kruskal Wallis test

HIV-N = HIV negative; HIV-P= HIV positive; HIV-U= HIV unknown

[1] Maternal depressive symptoms measured using Edinburgh Postnatal Depression Scale (EPDS) [16]. Participants with EPDS scores <13 were classified as not showing symptoms of maternal depression and participants with EPDS scores ≥13 were classified as showing symptoms of maternal depression

[2] Maternal perceived stress measured with Cohen *et al.* 4-item Perceived Stress Scale (PSS) [17]. Participants with scores higher than the median >7 were categorized as having high stress and participants with scores at or below ≤ 7 were categorized as having low stress

[3] Feeder: others= another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver

[4] Feeding style: passive= fed with little or no encouragement, positive= active/responsive feeding, forced= fed using verbal/physical force, mixed= fed using two or more feeding style stated

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**Table 3a: Predictors of total food, energy, and macronutrient intakes from complementary foods and liquids in 9 months old infants in the Eastern Region, Ghana**

| Factors | Total food (g) | | Energy (kcal) | | Protein (g) | | Fat (g) | |
|---|---|---|---|---|---|---|---|---|
| | b (95% CI) | p | b (95% CI) | p | b (95% CI) | p | b (95% CI) | p |
| **Maternal** | | | | | | | | |
| HIV status | | | | | | | | |
| HIV-N (ref) | | | | | | | | |
| HIV-U | 19.4 (-29.1, 68.0) | 0.425 | -6.1 (-85.8, 73.6) | 0.879 | -0.3 (-2.9, 2.4) | 0.829 | -3.7 (-7.7, 0.3) | 0.066 |
| HIV-P | -47.2 (-103.8, 9.3) | 0.1 | -93.9 (-191.1, 3.3) | 0.058 | -0.7 (-3.9, 2.5) | 0.66 | -6.3 (-11.1, -1.5) | 0.011 |
| EPDS score at 6 mo postpartum[1] | -3.5 (-8.5, 1.4) | 0.16 | -2.7 (-10.7, 5.3) | 0.497 | -0.1 (-0.4, 0.2) | 0.474 | -0.2 (-0.6, 0.2) | 0.257 |
| Perceived stress score at 6 mo postpartum[2] | -12.4 (-21.0, -3.8) | 0.006 | -19.5 (-33.8, -5.2) | 0.009 | -0.2 (-0.6, 0.3) | 0.397 | -0.7 (-1.4, -0.1) | 0.036 |
| **Infant** | | | | | | | | |
| Feeding style[3] | | | | | | | | |
| Passive (ref) | | | | | | | | |
| Positive | | | | | 2.7 (-0.2, 5.7) | 0.068 | 4.8 (0.3, 9.2) | 0.035 |
| Forced | | | | | 1.5 (-2.6, 5.6) | 0.457 | 5.8 (-0.3, 11.9) | 0.062 |
| Mixed | | | | | 0.2 (-3.2, 3.6) | 0.909 | 2.5 (-2.6, 7.7) | 0.326 |
| Human milk intake at 9 mo (g) | 0.1 (0.1, 0.2) | 0 | 0.1 (-0.03, 0.2) | 0.139 | 0.001 (-0.003, 0.004) | 0.718 | 0.003 (-0.003, 0.01) | 0.344 |
| Meal frequency at 9 mo (#) | 44.7 (25.6, 63.8) | 0 | 44.4 (11.2, 77.6) | 0.01 | 1.3 (0.3, 2.3) | 0.015 | 1.7 (0.1, 3.2) | 0.036 |
| Constant | 55.7 (-24.9, 136.4) | 0.171 | 392.0 (87.4, 696.7) | 0.013 | 1.2 (-3.2, 5.6) | 0.584 | 5.8 (-0.9, 12.4) | 0.087 |
| | Adjusted $r^2$= 0.411 p= 0.000 | | Adjusted $r^2$= 0.328 p= 0.002 | | Adjusted $r^2$= 0.087 p= 0.149 | | Adjusted $r^2$= 0.206 p= 0.017 | |

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Multiple linear regression was used to determine the models. n=56 for all the models. In addition to the listed covariates, HIV*stress interaction, maternal age, education, occupation, the feeder, food security, infant weight, and fever at 9 months were tested in all the models but removed ($p \geq 0.1$)

EPDS= Edinburgh Postnatal Depression Scale; HIV-N = HIV negative; HIV-P= HIV positive; HIV-U= HIV unknown

[1] EPDS score used the 10-item EPDS questionnaire with each item scored on a 4-point rating scale (0 to 3). The total score ranged from 0 to 30 [16]

[2] Perceived stress score was determined using the 4-item Perceived Stress Scale with each item scored as: never (1), only once or twice (2), at least once a week (3), more than once a week (4), and almost daily (5) in the last month. The total summative score ranged from 4 to 20. [17]

[3] Feeding styles: passive= fed with little or no encouragement, positive= active/responsive feeding, forced= fed using verbal/physical force, mixed= fed using two or more feeding styles

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**Table 3b: Predictors of micronutrient intakes from complementary foods and liquids in 9 months old infants in the Eastern Region, Ghana**

| Factors | Vitamin A (µg) *b* (95% CI) | p | Iron (mg) *b* (95% CI) | p | Zinc (mg) *b* (95% CI) | p | Calcium (mg) *b* (95% CI) | p |
|---|---|---|---|---|---|---|---|---|
| **Maternal** | | | | | | | | |
| HIV status | | | | | | | | |
| HIV-N (ref) | | | | | | | | |
| HIV-U | -192.1 (-384.3, 0.01) | 0.05 | 0.4 (-0.6, 1.5) | 0.394 | 0.2 (-0.3, 0.8) | 0.415 | -23.8 (-75.2, 27.6) | 0.356 |
| HIV-P | -293.9 (-529.9, -57.8) | **0.016** | -0.1 (-1.3, 1.1) | 0.814 | -0.2 (-0.9, 0.5) | 0.639 | -47.6 (-109.6, 14.4) | 0.129 |
| EPDS score at 6 mo postpartum[1] | -10.1 (-29.0, 8.8) | 0.288 | -0.1 (-0.2, 0.02) | 0.099 | -0.02 (-0.1, 0.05) | 0.622 | -4.3 (-9.3, 0.7) | 0.09 |
| Perceived stress score at 6 mo postpartum[2] | -19.7 (-52.5, 13.1) | 0.232 | -0.1 (-0.2, 0.1) | 0.516 | -0.04 (-0.1, 0.1) | 0.51 | -1.7 (-10.4, 7.0) | 0.699 |
| Age (y) | | | | | -0.1 (-0.1, -0.02) | **0.009** | | |
| Education[3] | | | | | | | | |
| None or Primary (ref) | | | | | | | | |
| Junior Secondary | | | | | -0.7 (-1.3, -0.1) | **0.016** | | |
| Some Senior Secondary or above | | | | | -0.9 (-1.8, -0.1) | **0.032** | | |
| **Infant** | | | | | | | | |
| Feeder | | | | | | | | |
| Mother only | | | | | -0.7 (-1.4, -0.05) | **0.037** | | |
| Others[4] (ref) | | | | | | | | |
| Feeding style[5] | | | | | | | | |
| Passive (ref) | | | | | | | | |
| Positive | 245.3 (28.2, 462.5) | **0.028** | | | | | 51.6 (-5.9, 109.2) | 0.077 |
| Forced | 322.2 (16.2, 628.1) | **0.04** | | | | | 69.0 (-10.1, 148.2) | 0.086 |
| Mixed | -19.6 (-270.1, 230.9) | 0.876 | | | | | -0.2 (-67.1, 66.7) | 0.995 |
| Human milk intake at 9 mo (g) | 0.2 (-0.1, 0.5) | 0.208 | 0.001 (-0.001, 0.002) | 0.252 | 0.0 (-0.001, 0.001) | 0.501 | 0.03 (-0.04, 0.1) | 0.383 |
| Meal frequency at 9 mo (#) | 39.6 (-37.2, 116.3) | 0.305 | 0.7 (0.3, 1.1) | **0.001** | 0.1 (-0.1, 0.4) | 0.236 | 18.4 (-1.7, 38.4) | 0.072 |
| Fever at 9 mo | | | | | -0.7 (-1.5, 0.1) | 0.069 | | |
| Constant | 150.5 (-171.7, 472.7) | 0.352 | 0.5 (-1.2, 2.2) | 0.547 | 3.7 (1.2, 6.2) | 0.004 | 10.7 (-75.0, 96.3) | 0.803 |
| | Adjusted $r^2$= 0.130 p= 0.081 | | Adjusted $r^2$= 0.144 p= 0.032 | | Adjusted $r^2$= 0.136 p= 0.093 | | Adjusted $r^2$= 0.059 p= 0.223 | |

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Multiple linear regression was used to determine the models. n ranged from 54 to 56. In addition to the listed covariates, HIV*stress interaction, maternal occupation, food security, and infant weight were tested in all the models but removed (p≥0.1)

EPDS= Edinburgh Postnatal Depression Scale; HIV-N = HIV negative; HIV-P= HIV positive; HIV-U= HIV unknown

[1] EPDS score used the 10-item EPDS questionnaire with each item scored on a 4-point rating scale (0 to 3). The total score ranged from 0 to 30. [16]

[2] Perceived stress score was determined using the 4-item Perceived Stress Scale with each item scored as: never (1), only once or twice (2), at least once a week (3), more than once a week (4), and almost daily (5) in the last month. The total summative score ranged from 4 to 20. [17]

[3] Education: none or primary= none to class 6, Junior secondary= class 7 to 9, and Some senior or above= class 10 or above

[4] Feeder: others= another adult caregiver, a child, the child with the caregiver and/or mother, or mother and caregiver

[5] Feeding styles: passive= fed with little or no encouragement, positive= active/responsive feeding, forced= fed using verbal/physical force, mixed= fed using two or more feeding styles

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