# Child development in rural Ghana: Associations between cognitive/language milestones and indicators of nutrition and stimulation of children under two years of age

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## ABSTRACT

**OBJECTIVES:** Two studies aimed to assess the provision of nutrition and psychosocial stimulation in the home and to examine associations between mental development and nutrition and stimulation using a validated measure of development milestones.

**METHODS:** The first study consisted of secondary analyses on health and nutrition data from 1081 mother–child pairs (the children aged 0–12 months) and their households in Ghana's Eastern Region. For the second study, the Ghana Milestones Measure, consisting of items assessing cognitive and language development, was used to assess child development in a subsample ($N = 330$) of Study 1 participants one year later (children 10–24 months of age). This measure was mother-reported and had been validated in a separate community in Ghana. Correlation and linear regression analyses were used to analyze the data.

**RESULTS:** Family assets and maternal education were identified as key factors of the family context. Both variables were positively associated with preventive health practices ($r = 0.08$ to 0.13, $p < 0.0001$ to 0.01), and dietary diversity ($r = 0.15$, $p = 0.0001$ to 0.0006), and negatively associated with maternal depressive symptoms ($r = -0.19$ to $-0.12$, $p < 0.0001$). Taller children had higher receptive (standardized beta = 0.16; $p = 0.04$) and expressive (0.21; 0.003) language, but not cognitive (0.15; 0.07) milestone scores, and psychosocial stimulation was positively associated with all three milestones (receptive = 0.13, $p = 0.01$; expressive = 0.21, $p < 0.0001$; and cognitive = 0.24, $p < 0.0001$).

**CONCLUSION:** Our study provides the first validated measure of children's language and cognitive development in Ghana, finding associations with nutrition and stimulation. The Ghana Milestones Measure can be used to assess and help promote children's mental development.

**KEY WORDS:** Child development; cognitive/language milestones; home environment; Ghana

La traduction du résumé se trouve à la fin de l'article.

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Mental development refers to the cognitive, language, socio-emotional and fine motor maturity of children as they age. It is now acknowledged that 39% of children under 5 years of age do not reach their developmental potential.[1] The determinants of delayed development are largely related to poverty, which is associated with inadequate psychosocial stimulation and nutrition.[2]

Many cross-sectional studies have found significant associations between nutrition and child health and development outcomes.[1] Lower length-for-age (LAZ) and weight-for-age *z*-scores (WAZ) were associated with lower language and cognitive development scores in different sub-Saharan African samples.[3–6] These studies highlight the associations between nutrition and mental development in the region, however, there remain gaps in the knowledge about the individual determinants of poor nutrition and mental development in Ghana.

Studies investigating the influences of nutrition on child outcomes in Ghana primarily focus on growth and health but not on development. Findings from the 2014 Demographic Health Survey revealed that 19% of Ghanaian children under 5 years were stunted and 11% were underweight.[7] Micronutrient malnutrition was highly prevalent and more than half of children aged 6 months to 5 years were anemic.[7] Small-scale studies on child health and nutrition in Ghana showed similar or higher levels of stunting and anemia, as well as a high percentage of food insecurity at the household level.[8,9]

There have been few efforts to study or measure mental development in Ghana.[10] Psychosocial stimulation was assessed using parental provision of learning support and number of learning materials in the 2011 Ghana Multiple Indicator Cluster Survey (MICS). Less than half (39.8%) of children aged 3–5 years

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lived in households where adult members engaged in 4–6 activities (e.g., reading books, telling stories, singing songs) with them over the last three days; the remainder engaged in three or fewer activities. Only 7.1% of households had 3 or more books for children under 5 years.[10] Findings from the MICS module on Materials and Activities available for Child Stimulation draw attention to the need for stimulation in children's developmental process. These and previously mentioned findings point to the need for more research to investigate the associations between children's nutrition, stimulation and mental development.

Of the measures used to assess mental development in young children in sub-Saharan Africa, the most common is a mother's report of the developmental milestones attained by the child.[4,11] The advantages of using a milestones measure are the lack of special training needed to administer the measure and ease of collecting data, especially by enumerators. The World Health Organization (WHO) has supported the use of milestone measures by promoting a gross motor milestone test for infants that has previously been used in Ghana.[12] Other development measures require direct testing of the child, such as the Bayley Scales of Infant and Toddler Development[13] which requires special training to administer, and a more recent test (Malawi Developmental Assessment Tool) developed for a rural sample of Malawian children.[14]

Two interrelated studies are described herein. The first study objective was to investigate infants' home environment and the provision of nutrition and psychosocial stimulation. The second objective was to validate a measure of mental development milestones to determine associations of mental development with nutrition and stimulation.

## STUDY 1: HOW CONDUCIVE IS THE HOME ENVIRONMENT TO MENTAL DEVELOPMENT?

The objective of study 1 was to assess the health, nutrition and stimulation of a sample of rural Ghanaian children with a view to examining conditions in the home.

## METHOD

### Setting and sample

Project staff conducted a household enumeration across the Upper Manya Krobo District in Ghana's Eastern Region to generate a sampling frame. Three subdistricts of different sizes were randomly selected to participate in the survey. All households ($N = 1081$) with children between the ages of 0 and 12 months were recruited and enrolled. Mothers signed consent. Ethics approval for the study was received from McGill University and University of Ghana.

### Measures

Twenty local research assistants were trained to administer the full survey to infants' caregivers in their homes between November 2013 and August 2014.

#### Socio-demographic and General Health

A comprehensive list of questions was asked of the mother to obtain information about the child and the family (e.g., child illness in past two weeks, sleeping under bed nets, and vaccinations).

#### Nutrition Indicators

Children's weight and length were directly measured and translated into *z* scores using the WHO growth standards.[15] The past 24-hour dietary intake of the child was reported by the mother using a food frequency questionnaire and converted to a dietary diversity score defined as the number (0–7) of food groups (grains/tubers, legumes, meat/fish, eggs, vitamin A rich fruits and vegetables, non-vitamin A rich fruits and vegetables, and dairy) eaten by the child and the number (0–3) of animal-source food groups (meat, eggs and dairy) eaten.[16] A sample of blood each from the child and the mother was analyzed for hemoglobin using a portable HemoCue®.

#### Psychosocial Stimulation Indicators

Psychosocial stimulation was assessed with 6 mother-reported items concerning the presence of play materials taken from the MICS.[17] The Self-Reporting Questionnaire (SRQ-20),[18] a measure of maternal depressive symptoms, was used to assess the mother's emotional availability to provide support for the child. Mothers responded *yes* or *no* to each of the 20 symptoms based on their experiences over the last 30 days. The total score was the number of symptoms to which the mother responded affirmatively. A cut-off score of 11 or more was used to identify high levels of depressive symptoms.[18]

### Analysis

We conducted secondary analyses of data from $N = 1081$ households with a response rate of 97.0%. The analyses provided descriptive statistics on child variables by age (birth to 5 months, 6–12 months) before examining correlates of child growth and health. This is a natural division by age, given that up to 6 months, children are mostly exclusively breastfed and not independently mobile. Statistical comparisons were made using Student's *t*-tests, chi-square tests and Pearson's correlations, controlling for age where necessary. In preparation for Study 2, with its emphasis on predictors of mental development, we conducted multiple linear regressions on the two strongest candidates, namely length-for-age and stimulation, to determine whether family SES or child's diet best predicted them.

## RESULTS AND DISCUSSION

### Age and sex differences

Of the $N = 1081$ households sampled, $N = 573$ had an infant <6 months old, with an overall mean age of 5.85 months (Table 1). Approximately half (51.5%) of the infants were male. On average, the SRQ-20 scores of mothers of children aged 6–12 months were 13% higher, their hemoglobin levels were 4% higher, their diets were 13% more diverse, and they were more likely to have income-generating activities (59.8% vs. 50.3%) compared to mothers of younger children. Additionally, maternal depressive symptoms were negatively correlated with family assets and maternal education, regardless of child's age (see Table 2). Children differed significantly by age group on all child variables, except sex. Thus, as expected, the diets of older children were 89% more diverse and their scores of psychosocial stimulation 82% higher than those of children younger than 6 months. However, their length-for-age scores were 41% lower, their weight-for-age scores 59% lower, and they were more likely to have been ill in the past two weeks (26.7% vs. 14.0%) compared to younger children. With respect to sex differences, girls had lower hemoglobin levels

**Table 1.** Family environment, maternal and child variables according to child's age group (*N* varied between 1070 and 1081)

| Variables (theoretical range) | Under 6 months (*N* = 573) | 6–12 months (*N* = 508) | *t*-value (*p*) or chi-square (*p*)* | Total sample (*N* = 1081) |
|---|---|---|---|---|
| | *M* (SD) or % | *M* (SD) or % | | *M* (SD) or % |
| Household variables | | | | |
| Household size | 6.70 (2.52) | 6.64 (2.81) | 0.34 (0.73) | 6.67 (2.66) |
| WASH (0–4)† | 2.42 (0.78) | 2.42 (0.78) | 0.01 (0.99) | 2.42 (0.78) |
| Assets (0–17)‡ | 4.13 (1.36) | 4.15 (1.37) | 0.19 (0.85) | 4.14 (1.35) |
| Ownership of agricultural land | 56.0% | 58.3% | 0.75 (0.39) | 57.1% |
| Ownership of farm animals | 78.4% | 79.7% | 0.49 (0.48) | 79.0% |
| Maternal variables | | | | |
| SRQ-20 (0–20) | 7.07 (5.14) | 8.09 (5.29) | 3.19 (0.002) | 7.55 (5.23) |
| Age | 27.42 (7.28) | 27.31 (7.89) | 0.25 (0.80) | 27.4 (7.56) |
| Hemoglobin (g/L) | 121.2 (15.6) | 125.6 (14.9) | 4.58 (<0.0001) | 123.3 (15.4) |
| Dietary diversity (0–7)§ | 1.99 (1.38) | 2.30 (1.45) | −3.59 (0.0003) | 2.13 (1.42) |
| Number of antenatal visits | 1.02 (0.14) | 1.02 (0.15) | 0.10 (0.75) | 1.02 (0.15) |
| Education (0 = no school, 1 = primary, 2 = secondary, 3 = tertiary) | 1.18 (0.77) | 1.16 (0.77) | 0.51 (0.61) | 1.17 (0.77) |
| Income-generating activity (yes) | 50.3% | 59.8% | 9.98 (0.002) | 54.8% |
| Child variables | | | | |
| Age | 3.04 (1.91) | 9.02 (1.73) | 53.66 (<0.0001) | 5.85 (3.50) |
| Sex (girls) | 50% | 47% | 1.00 (0.32) | 48.5% |
| Weight-for-age score | −0.36 (1.22) | −0.88 (1.39) | 6.58 (<0.0001) | −0.60 (1.33) |
| Length-for-age score | −0.56 (1.56) | −0.95 (1.86) | 3.75 (0.0002) | −0.75 (1.72) |
| Weight-for-length score | 0.16 (1.34) | −0.34 (1.67) | 5.43 (<0.0001) | −0.07 (1.53) |
| Hemoglobin (g/L) | 111.7 (18.7) | 106.1 (14.5) | 53.1 (<0.0001) | 109.0 (17.0) |
| Anemia (Hb <110.0) | 49.5% | 62.3% | 16.69 (<0.0001) | 55.7% |
| Dietary diversity | 0.26 (0.76) | 2.39 (1.60) | 27.91 (<0.0001) | 1.27 (1.63) |
| Minimum adequate dietary diversity | – | 24.4% | – | – |
| Number of animal-source foods (0–3)‖ | – | 0.73 (0.77) | – | – |
| BMI | 16.14 (2.12) | 16.44 (2.30) | 2.25 (0.02) | 16.28 (2.21) |
| Child illness past 2 weeks | 14.0% | 26.7% | 26.80 (<0.0001) | 20.1% |
| Preventive health (0–10)¶ | 5.94 (1.70) | 6.51 (1.44) | 5.98 (<0.0001) | 6.21 (1.61) |
| Slept under bed net | 56.4% | 54.9% | 0.18 (0.67) | 55.6% |
| BCG vaccination | 81.8% | 89.0% | 10.84 (0.001) | 85.9% |
| Polio vaccination | 63.0% | 88.4% | 92.37 (<0.0001) | 75.7% |
| DPT vaccination | 63.0% | 87.8% | 87.48 (<0.0001) | 75.4% |
| Vitamin A drops | 20.8% | 77.2% | 343.61 (<0.0001) | 47.3% |
| Deworming | 6.5% | 24.4% | 68.46 (<0.0001) | 14.9% |
| Stimulation (0–6)** | 0.31 (0.61) | 1.75 (0.94) | 30.25 (<0.0001) | 0.99 (1.07) |

Note: *M* = mean; SD = standard deviation; SRQ = self-reporting questionnaire; BMI = body mass index; BCG = Bacillus Calmette–Guerin; DPT = diphtheria, pertussis and tetanus.

* *T*-tests were used to analyze continuous variables, and chi-square tests to analyze frequencies.

† WASH is a composite score including 4 hygienic facilities (e.g., toilet, water, soap, and hand-washing) of each household.

‡ Assets is a composite score reflecting ownership of commodities (e.g., radio, bicycle, television, refrigerator, etc.).

§ Defined as the number of food groups out of 7 (grains/tubers, legumes, meat/fish, eggs, vitamin A rich fruits and vegetables, non-vitamin A rich fruits and vegetables, dairy) consumed in the past 24 hours.

‖ Number of animal source foods: meat, eggs, and dairy.

¶ Preventive health is a composite score of 10 preventive health practices (vaccinations, water, latrine, hygiene, vitamin A, and deworming).

** Stimulation is a composite score assessing the number of books and play objects each child has.

($t = 3.15$, $p = 0.002$) and a higher percentage of them were anemic ($\chi^2 = 15.06$, $p = 0.0001$) than boys. On the other hand, girls were taller for their age ($t = 2.23$, $p = 0.03$) and had higher body mass index scores ($t = 3.91$, $p = <0.0001$) than boys.

### Nutrition, health and stimulation

The nutrition indicators correlated well with one another (Table 3). Children who were shorter and underweight for their age also tended to have lower levels of hemoglobin and a less diverse diet (if over 6 months of age). However, hemoglobin and diet did not correlate significantly with one another. Recent child illness did not correlate with preventive health practices but was related to mother's depressive symptoms, more stimulation and lower hemoglobin. Stimulation, an indicator of a developmentally supportive environment, was unrelated to the mother's depressive symptoms and child hemoglobin, but positively correlated with all the other nutrition and health variables, even after controlling for child's age.

### Family environment, nutrition and stimulation

Pearson's correlations are presented in Table 2. Households with a greater number of assets had more diverse diets and practiced more preventive health behaviours (e.g., hand-washing, use of mosquito nets). Mother's education was significantly correlated with several child variables, including weight-for-age (WAZ) scores, dietary diversity, and preventive health practices. Less educated mothers had more depressive symptoms. None of the family-level variables was correlated with the level of stimulation, which was overall very low.

### Multiple regressions

Children's age and their dietary diversity were significantly associated with the amount of stimulation they received and their LAZ scores: older children received more stimulation but had lower LAZ scores, whereas dietary diversity was positively associated with both stimulation and LAZ scores. Additionally, LAZ was positively associated with preventive health practices and

**Table 2.** Pearson's correlations between children's nutritional status, health, mother's education, and family assets (*N* varied between 1070 and 1081)

| | Weight-for-age *z* score | Length-for-age *z* score | Child's hemoglobin (g/L) | Dietary diversity | Number of animal-source foods | Child illness past 2 weeks | Preventive health practices | Stimulation | Mother's SRQ score |
|---|---|---|---|---|---|---|---|---|---|
| Assets* | 0.05† (0.09) | 0.03 (0.38) | 0.03 (0.27) | 0.15 (0.0001) | 0.13 (0.004) | −0.02 (0.43) | 0.13 (<0.0001) | 0.05 (0.14) | −0.12 (<0.0001) |
| Ownership of agricultural land | −0.05 (0.08) | −0.07 (0.03) | 0.01 (0.81) | 0.09 (0.04) | 0.08 (0.06) | −0.04 (0.17) | −0.02 (0.61) | 0.02 (0.48) | −0.03 (0.27) |
| Ownership of farm animals | −0.06 (0.06) | −0.05 (0.13) | −0.02 (0.52) | 0.05 (0.22) | 0.01 (0.87) | 0.02 (0.52) | −0.01 (0.74) | −0.02 (0.51) | 0.03 (0.30) |
| Mother's education | 0.10 (0.0009) | 0.05 (0.13) | −0.05 (0.13) | 0.15 (0.0006) | 0.18 (<0.0001) | −0.05 (0.13) | 0.08 (0.01) | 0.02 (0.49) | −0.19 (<0.0001) |

* Child's age was not controlled for in these correlations because it was not significantly correlated with any family variables. Only the dietary diversity score for children 6 months and older were used in these correlations.
† Numbers represent Pearson's correlation coefficient (*p*-value).

**Table 3.** Pearson's correlation between children's nutritional status, health, home environment and mother's depressive symptoms (*N* varied between 1070 and 1081)

| | Child age (months) | Weight-for-age *z* score | Length-for-age *z* score | Child's hemoglobin (g/L) | Dietary diversity | Child illness in past 2 weeks | Preventive health practices | Stimulation |
|---|---|---|---|---|---|---|---|---|
| Child age (months)* | | | | | | | | |
| Weight-for-age *z* score | −0.26† (<0.0001) | | | | | | | |
| Length-for-age *z* score | −0.19 (<0.0001) | 0.72 (<0.0001) | | | | | | |
| Child's hemoglobin (g/L) | −0.22 (<0.0001) | −0.06 (0.05) | −0.11 (0.0009) | | | | | |
| Dietary diversity | 0.25 (<0.0001) | 0.12 (0.004) | 0.18 (<0.0001) | −0.05 (0.32) | | | | |
| Child illness in past 2 weeks | 0.15 (<0.0001) | −0.04 (0.2) | 0.02 (0.55) | −0.12 (<0.0001) | 0.003 (0.94) | | | |
| Preventive health practices | 0.25 (<0.0001) | 0.15 (<0.0001) | 0.14 (<0.0001) | −0.14 (<0.0001) | 0.17 (0.0001) | −0.03 (0.38) | | |
| Stimulation | 0.67 (<0.0001) | 0.16 (<0.0001) | 0.20 (<0.0001) | 0.01 (0.71) | 0.18 (<0.0001) | 0.12 (<0.0001) | 0.06 (0.05) | |
| Mother's SRQ scores | 0.12 (<0.0001) | −0.01 (0.71) | −0.008 (0.79) | −0.04 (0.23) | −0.06 (0.20) | 0.25 (<0.0001) | −0.04 (0.25) | 0.02 (0.54) |

* Because stimulation, dietary diversity and preventive health practices were all so highly correlated with age, age was controlled for when these variables were correlated with each other. Only the dietary diversity score for children 6 months and older was used in these correlations.
† Numbers represent Pearson's correlation coefficient and (*p*-value).

**Table 4.** Multiple linear regression models of associations between family SES and child diet and stimulation and length-for-age *z*-scores ($N = 1081$)

| Predictors | Beta (SE) | *t*-value (*p*) | Standardized beta |
|---|---|---|---|
| Stimulation | | | |
| Child's age | 0.17 (0.01) | 17.25 (<0.0001) | 0.55 |
| Assets | 0.02 (0.02) | 0.86 (0.39) | 0.02 |
| Mother's education | 0.03 (0.03) | 0.95 (0.34) | 0.02 |
| Dietary diversity | 0.11 (0.02) | 5.52 (<0.0001) | 0.17 |
| Child's hemoglobin (g/L) | 0.01 (0.02) | 0.46 (0.66) | 0.01 |
| Mother's SRQ score | 0.01 (0.01) | 1.13 (0.26) | 0.03 |
| Preventive health practices | 0.03 (0.02) | 1.60 (0.11) | 0.04 |
| Length-for-age *z* score | | | |
| Child's age | −0.17 (0.02) | −8.40 (<0.0001) | −0.35 |
| Assets | 0.01 (0.04) | 0.16 (0.88) | 0.01 |
| Mother's education | 0.06 (0.07) | 0.84 (0.40) | 0.03 |
| Dietary diversity | 0.21 (0.04) | 4.91 (<0.0001) | 0.20 |
| Child's hemoglobin (g/L) | −0.10 (0.03) | −3.00 (0.003) | −0.10 |
| Mother's SRQ score | 0.01 (0.01) | 0.45 (0.65) | 0.01 |
| Preventive health practices | 0.11 (0.04) | 3.03 (0.003) | 0.10 |

Note: SE = standard error.

negatively associated with children's hemoglobin (Table 4). In summary, although family assets and maternal education were correlated with child's diet and health and maternal depression, they were not the main predictors of children's length-for-age or stimulation. Independent of the child's age, the best predictor was the child's diet. Consequently, Study 2 focused on length-for-age, stimulation, diet and anemia as predictors of mental development.

To examine the mental development of these children, we expanded and validated an existing measure used in sub-Saharan Africa.[4] The second study examined mental development in relation to nutritional status and stimulation in a subsample of these children one year later.

## STUDY 2: COGNITIVE AND LANGUAGE MILESTONES IN RURAL GHANA

The objective of this study was to examine the associations between children's nutrition and psychosocial stimulation and their mental development.

## METHOD

### Setting and sample

Data were collected from a subsample ($N = 330$) of participants who were part of Study 1. This subsample consisted of mother–child pairs living in randomly selected communities that were accessible for 12 months of the year and had enough households to participate in the larger Nutrition Links study. Data were collected from February to April 2015 when the children were 10–25 months old.

### Measures

#### Child Development

The Ghana Milestones Measure was used to assess mental development. The measure consisted of items assessing receptive language (10 items), expressive language (10 items), and cognitive (7 items) development. Language items were based on existing milestone measures, namely the Developmental Milestones Checklist II,[4] and new cognitive items were generated from the Bayley Scales of Infant Development.[13] It took approximately 10 minutes to administer to the mother.

Preliminary data were collected in another location to assess concurrent and convergent validity of the measure with a sample of 30 children aged 6–37 months in rural Kintampo, Ghana. Ethics approval was received from the Kintampo Health Research Centre and McGill University. The milestones were administered to mothers in an interview format. Mothers were asked to respond (*yes*, *no*, or *don't know*) to each item, such as: "Does your child understand when told 'no'?", "Does your child look for objects that disappear from his/her sight?", "Does your child use one definite, real word for an object or activity?" "Don't know" responses were found to be "no" in all cases. This is a common problem with reports of milestones. We noticed that "don't know" was in all cases reported when the mother had reported "no" for less mature behaviours, suggesting that she had not seen the more mature one because the child was not capable of performing it. Each subscale received a score based on the number of items to which the mother answered affirmatively. Evidence for concurrent validity came from correlations of the three milestones subscale scores with age ($r = 0.81$–$0.87$, $p < 0.0001$); they correlated positively but not reliably with mother's education ($r = 0.31$–$0.36$, $p \geq 0.076$). Convergent validity was supported by significant correlations of cognitive and receptive language milestones with cognitive Bayley scores partialling age ($r = 0.42$ and $0.46$ respectively, $p < 0.05$). However, expressive language milestones did not correlate with any Bayley score. Although the milestone measure worked well in this context, the language Bayley testing suffered from lack of local translation, meaning that mothers had to translate from Twi into various other local languages for children who did not understand. Therefore, results from the language Bayley test were not analyzed. This was a limitation of the preliminary testing and points to the need to adapt tools to the mother tongue of very young children. Consequently, there was good concurrent validity between all the milestones and good convergent validity between the cognitive and receptive language milestones and their Bayley counterparts.

#### Psychosocial Stimulation

The 10-item brief version of the HOME inventory[19] (a slightly modified version of the MICS module on Materials and Activities available for Child Stimulation) was used to assess opportunities for stimulation and learning in the home environment. The first 6 items on the stimulation measure consisted of multiple questions about whether the child had play objects, drawing materials, and books in the home. The last 4 items assessed the mother's stimulating interactions with the child over the last week, such as singing and telling stories with the child. Each item received a point for a total of 10.

#### Child Characteristics

Measures of child nutrition included mother's report of the child's age and past 24-hour food frequencies of child's diet (dietary diversity), direct assessment of the child's hemoglobin levels, weight and length to determine anemia, and LAZ and WAZ scores standardized for the child's age and sex.[15]

### Procedure

Twenty local research assistants were trained to administer the milestones, stimulation and nutrition assessments to participants in their homes.

## RESULTS

All three milestones were significantly correlated with each other (Table 5), as well as with stimulation and nutritional status (Table 6). All three milestones and the home stimulation were significantly correlated with age; therefore, age was controlled in subsequent correlations.

Linear regression models were conducted to identify predictors of mental development derived from the Ghana Milestones Measure. Predictors were variables measuring nutrition and stimulation as shown in Table 7. Children's length-for-age *z* scores were positively associated with their milestone scores: for every 1.1 increase in LAZ, children's receptive milestone score increased by 0.32 points and their expressive score increased by 0.55 points. The amount of psychosocial stimulation received in the home was also positively associated with mental development. An increase of 1.3 in the psychosocial stimulation score was associated with a 0.24 increase in receptive, a 0.55 increase in expressive, and a 0.31 increase in cognitive milestone score. Dietary diversity, WAZ and child's hemoglobin were not associated with mental development in regression analyses. As in Study 1, stimulation scores were significantly correlated with all nutrition variables, but not with children's hemoglobin levels.

## DISCUSSION

The objectives of this paper were to investigate infants' home environment and the provision of nutrition and psychosocial stimulation, and to prepare a valid measure of mental development milestones to determine associations of mental development with nutrition and stimulation. We found that two socio-demographic indicators, namely family assets and maternal education, were positively associated with children's health, nutrition and psychosocial stimulation. Overall, psychosocial stimulation was low in our first study. The lack of books and play items, as well as high levels of maternal depressive symptoms, suggest that the mental development of these children may not increase at the rate expected. Maternal depressive symptoms were higher among mothers of older children and were associated with recent illness in the child but not nutrition or stimulation. Nutritional status and psychosocial stimulation, however, were independently associated with cognitive and language milestones as measured by our Ghana Milestones Measure.

### Home environment and child health, nutrition and stimulation

In our first study, the number of family assets and mother's level of education were two aspects of the family environment that were associated with the most child variables. Children living in higher resourced households had more diverse diets, ate more animal-source foods (if older than 6 months), and had parents who engaged in more preventive health practices. Maternal education was positively associated with these same variables. These two socio-demographic indicators are commonly found to be determinants of children's well-being and are generally more strongly related to health and diet practices than to nutritional status such as height and weight in our sample.[1,2,20] Only mother's education was related to children's weight status. Although maternal education and family assets cannot be easily modified, they are goals of livelihood projects such as the agriculture activities being promoted as part of the Nutrition Links Project. More modifiable are the child-directed practices with which they are sometimes associated, measured here such as preventive health, dietary diversity and child stimulation. A recent study by Prado and colleagues identified two of these modifiable practices – variety of play materials and activities with caregivers, and dietary diversity – as consistent predictors of acquisition of developmental milestones in samples of 18-month-old infants in Ghana, Malawi and Burkina Faso.[21]

**Table 5.** Inter-correlations among milestones partialling out age (except for bottom row) ($N$ = 330)

| | Receptive milestones | Expressive milestones | Cognitive milestones | Means (SD) |
|---|---|---|---|---|
| Receptive milestones (0–10) | | | | 6.99 (2.0) |
| Expressive milestones (0–10) | 0.54* (<0.0001) | | | 5.22 (2.6) |
| Cognitive milestones (0–7) | 0.41 (<0.0001) | 0.45 (<0.0001) | | 4.97 (1.3) |
| Child's age (months) | 0.50 (<0.0001) | 0.58 (<0.0001) | 0.27 (<0.0001) | |

* Numbers represent Pearson's correlation coefficient and (*p*-value) unless otherwise specified.

**Table 6.** Pearson's correlations between children's milestone scores, nutritional status, health and psychosocial stimulation in the home ($N$ = 330)

| | Receptive milestones | Expressive milestones | Cognitive milestones | Means (SD) |
|---|---|---|---|---|
| Dietary diversity | 0.09* (0.10) | 0.10 (0.07) | 0.14 (0.01) | 4.42 (1.45) |
| Number of animal-source foods | 0.02 (0.72) | 0.03 (0.61) | 0.13 (0.02) | 1.48 (0.77) |
| Weight-for-age *z* score | 0.10 (0.08) | 0.13 (0.01) | 0.10 (0.08) | −0.95 (1.00) |
| Length-for-age *z* score | 0.14 (0.01) | 0.20 (0.0003) | 0.13 (0.02) | −1.17 (1.12) |
| Child's hemoglobin (g/L) | −0.02 (0.64) | 0.03 (0.65) | −0.08 (0.15) | 105.40 (12.9) |
| Stimulation | 0.16 (0.003) | 0.27 (<0.0001) | 0.27 (<0.0001) | 2.83 (1.3) |

* Numbers represent Pearson's correlation coefficient and (*p*-value) unless otherwise specified.

**Table 7.** Regression models of association between children's nutritional status, health and psychosocial stimulation in the home and Ghana Milestones Measure scores ($N$ = 316)

| Predictors | Beta (SE) | *t*-value (*p*) | Standardized beta |
|---|---|---|---|
| Receptive milestones | | | |
| Child's age | 0.26 (0.03) | 9.70 (<0.0001) | 0.49 |
| Dietary diversity | 0.08 (0.07) | 1.13 (0.26) | 0.06 |
| Weight-for-age *z* score | −0.11 (0.15) | −0.73 (0.47) | −0.06 |
| Length-for-age *z* score | 0.27 (0.13) | 2.05 (0.04) | 0.16 |
| Child's hemoglobin (g/L) | −0.36 (0.08) | −0.48 (0.63) | −0.02 |
| Stimulation | 0.20 (0.08) | 2.51 (0.01) | 0.13 |
| Expressive milestones | | | |
| Child's age | 0.39 (0.03) | 12.06 (<0.0001) | 0.56 |
| Dietary diversity | 0.07 (0.08) | 0.89 (0.38) | 0.04 |
| Weight-for-age *z* score | −0.22 (0.18) | −1.18 (0.24) | −0.08 |
| Length-for-age *z* score | 0.48 (0.16) | 2.96 (0.003) | 0.21 |
| Child's hemoglobin (g/L) | 0.02 (0.09) | 0.27 (0.79) | 0.01 |
| Stimulation | 0.44 (0.09) | 4.63 (<0.0001) | 0.21 |
| Cognitive milestones | | | |
| Child's age | 0.08 (0.02) | 4.36 (<0.0001) | 0.24 |
| Dietary diversity | 0.08 (0.05) | 1.85 (0.07) | 0.10 |
| Weight-for-age *z* score | −0.08 (0.10) | −0.77 (0.44) | −0.06 |
| Length-for-age *z* score | 0.16 (0.09) | 1.82 (0.07) | 0.15 |
| Child's hemoglobin (g/L) | −0.08 (0.05) | −1.58 (0.11) | −0.08 |
| Stimulation | 0.23 (0.05) | 4.37 (<0.0001) | 0.24 |

Note: SE = standard error.

Our results also provide new information concerning maternal depressive symptoms. These were moderately high, with 26.1% above the threshold of 12. Our findings are consistent with other studies in LMICs where elevated maternal depressive symptoms have been associated with malnutrition, illness and poorer language outcomes in children.[6,22,23] Maternal depression, though often seen as an indicator of the mother's availability for support, had stronger associations here with her child's recent illness than with amount of stimulation available in the home.

### Mental development and the Ghana Milestones Measure

Our second study is one of the first to have validated a milestone measure in Ghana; in particular, one that included cognitive as well as language milestones. Prado and colleagues have previously used a language inventory in Ghana.[24] Given the importance of cognition as part of mental development, we added cognitive items and some language items to ones already included in other measures.[4,13] As expected, older, taller children and children with higher scores on a stimulation measure attained higher milestone scores. A possible explanation for the association between length-for-age and stimulation is that children who look older might elicit more sophisticated stimulation.

Our results are in line with previously validated milestone measures in sub-Saharan Africa. Studies using these measures found that children who were malnourished or had less educated mothers performed poorly on the milestone measures compared to their counterparts.[4,11,25] A study in rural India found that household stimulation mediated the association between dietary diversity and children's (aged 12–18 months) mental development.[26] Note that the association between dietary diversity and milestones in our study was lost when children's length-for-age and stimulation were accounted for. This is consistent with the idea that length-for-age and stimulation may both mediate the relation between diet and mental milestones, given their association with diet in Study 1. Interestingly, a number of studies have found high correlations between dietary diversity and home stimulation, which cannot be fully explained by family assets or maternal education; in Study 1, both assets and education correlated with diet but not with stimulation.[6,27] Variety is an underlying feature of both measures. Mothers who have a tendency to seek out variety are more likely to provide both a diverse diet and variety of stimulation.[28]

These results provide support for the view that children's mental development is strongly associated with both stimulation and nutrition. They validate our measure of cognitive and language milestones as an appropriate measure of child development in a sample of rural Ghanaian children. Stimulation scores were positively correlated with milestones. This is consistent with previous research which suggests that receiving stimulation in the home environment is significantly associated with children's mental development.[2]

### Strengths and limitations

Both of our studies rely on bivariate analyses of cross-sectional data. These limitations caution against the over-interpretation of the findings and do not permit us to infer causation in the associations observed. We were unable to connect the milestone data collected in the subsample with data collected during infancy which limited our ability to examine associations between mental development and early growth data. However, because most of these variables will be stable over time, contemporaneous values most likely reflect early data. Prado and colleagues have extended language items from their milestone measure for assessment in older children.[4] More work needs to be done on the milestone measure to include cognitive milestones for older children.

## CONCLUSION

The Ghana Milestones Measure is a useful measure for assessing children's (10–24 months) mental development and does not require any special training for administration. We administered the measure in a sample of rural Ghanaian children and found that language and cognitive development were positively associated with their nutritional status and psychosocial stimulation in the home. The results of both studies provide an important building block for future researchers who seek to promote the mental development of young children in Ghana. Future research can build on this measure by extending its use for older children and including more cognitive items.

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## RÉSUMÉ

**OBJECTIFS :** Deux études ont évalué la nutrition et la stimulation psychosociale en milieu familial et ont examiné les associations entre le développement mental d'une part, et la nutrition et la stimulation d'autre part, à l'aide d'un indicateur validé des étapes de développement.

**MÉTHODE :** Pour la première étude, des analyses secondaires des données de santé et de nutrition de 1 081 couples mère-enfant (les enfants étant âgés de 0 à 12 mois) et de leurs ménages ont été menées dans la Région orientale du Ghana. La seconde étude a fait appel au Ghana Milestones Measure, un indicateur d'évaluation du développement cognitif et de l'acquisition du langage, pour évaluer le développement des enfants dans un sous-échantillon ($N = 330$) des participants de l'étude 1 un an plus tard (les enfants étant âgés de 10 à 24 mois). Les éléments de l'indicateur ont été déclarés par les mères et validés dans une autre communauté du Ghana. Les données ont été analysées par corrélation et par régression linéaire.

**RÉSULTATS :** L'actif familial et l'instruction maternelle ont été jugés être les facteurs clés du milieu familial. Ces deux variables étaient associées positivement aux pratiques sanitaires préventives ($r = 0,08$ à $0,13$, $p < 0,0001$ à $0,01$) et à la diversité alimentaire ($r = 0,15$, $p = 0,0001$ à $0,0006$), et associées négativement aux symptômes dépressifs maternels ($r = -0,19$ à $-0,12$, $p < 0,0001$). Le langage réceptif (coefficient normalisé [bêta] = 0,16; $p = 0,04$) et expressif (0,21; 0,003) des enfants de plus grande taille était plus développé, mais non leurs indices de développement cognitif (0,15; 0,07), et la stimulation psychosociale était associée positivement aux trois étapes (langage réceptif = 0,13, $p = 0,01$; langage expressif = 0,21, $p < 0,0001$; et développement cognitif = 0,24, $p < 0,0001$).

**CONCLUSION :** Notre étude, qui offre le premier indicateur validé du développement linguistique et cognitif des enfants au Ghana, établit des associations avec la nutrition et la stimulation. L'outil Ghana Milestones Measure peut être utilisé pour évaluer et contribuer à favoriser le développement mental des enfants.

**MOTS CLÉS :** développement de l'enfant; étapes cognitives et d'acquisition du langage; milieu familial; Ghana