Predictors and pathways of language and motor development in four prospective cohorts of young children in Ghana, Malawi, and Burkina Faso.

Prado EL, Abbeddou S, Adu-Afarwuah S, et al. *Journal of Child Psychology and Psychiatrys.* 2017, doi:10.1111/jcpp.12751

Introduction

Developmental delays in early life may prevent children from reaching their full potential and may reduce quality of life in adulthood[1]. Child development in the first 1,000 days is a dynamic process, involving the maturation of several interrelated functions, including motor and language capabilities. Adequate nutritional status, along with an enabling and stimulating environment, is required to achieve optimal development[2]. Unfortunately, children in low and middle income countries are often exposed to multiple risk factors, including some originating from the socio-economic environment or from maternal and family characteristics. Other risk factors include children's nutritional and growth status. All of these risk factors may independently or collectively derail early childhood development. Evidence from prior reviews have identified 44 risk factors believed to negatively affect early childhood development[3,4]. In resource-limited settings, clear, causal pathway models are needed to inform the design of cost-effective early childhood development interventions.

This issue of NNA summarizes an article by Prado et al[5], recently published in the *Journal of Child Psychology and Psychiatry*. The primary objectives of the analysis were:

1. To identify specific environmental, maternal, caregiving and child-level predictors of motor and language development at 18 months of age, and
2. To construct a pathway model depicting the direct and indirect pathways through which the identified predictors influence early childhood motor and language development.

Methods

Data from four prospective cohorts (from Burkina Faso[6], Ghana[7], and Malawi[8],[9]) were analyzed. In Burkina Faso, infants (n=3,220) were enrolled at 9 months of age whereas in Ghana, pregnant women (n=1,320) were enrolled before 20 weeks of gestation. Of the two cohorts from Malawi, one included pregnant women (n=869) enrolled prior to 20 weeks gestation (here after referred to as Malawi-M) whereas the second study included infants (n=1,932) enrolled at 6 months of age (hereafter referred to as Malawi-C). In each of the 4 trials, participants were randomly assigned to the intervention groups, who received different doses or formulations of lipid-based nutrient supplements (LNS) or to the control groups until 18 months of age. Only the Burkina Faso study reported an effect of study intervention on 18-month child development[10].

Assessment of outcomes and predictor variables:

In Ghana and Malawi, motor development was assessed by direct observation of the child using the Kilifi Developmental Inventory (KDI), whereas language development was assessed by caregiver report using a 100-word vocabulary checklist based on the MacArthur-Bates Communicative Development Inventory. In Burkina-Faso, motor and language development were assessed at 18 months of age using the Developmental Milestones Checklist-II (DMC-II), which comprises both caregiver interviews and child observations. Information on socio-economic indicators were collected at enrollment in all 4 cohorts. Data on infant feeding practices was collected at multiple time points, beginning at 9 months, and

repeated every three months until age 18 months. Maternal and child anthropometry were assessed at enrollment, birth, 6, 9, and 18 months as applicable to each trial. In all four trials, developmental stimulation, including the variety of play materials and activities through which adults engaged with the child, was measured at age 18 months using the Family Care Indicators (FCI) interview[11].

Variable selection for pathway construction and statistical analyses:
Forty-two indicator variables, derived from 34 environmental, maternal, caregiving and child-level factors were evaluated for evidence of direct or mediating associations with motor and language development scores. A multi-step approach was implemented in selecting variables used in the construction of pathways. In step 1, univariate models were used to select predictors that were significantly associated ($p<0.05$) with each developmental score (i.e. motor or language). In step 2, evidence of collinearity among the selected variables was ascertained, and in the case of collinearity, the predictors most strongly associated with the developmental outcomes were retained. Then, in step 3, for each developmental outcome, multivariate models were constructed to separately explore the associations of a) environmental factors (e.g. household assets, proximity to markets, water source), b) maternal factors (e.g. age, height, cognition), c) caregiving factors (e.g. play materials and activities, dietary diversity), and d) child-level factors (including morbidity and nutritional status, physical activity and child's behavior during assessment). In these multivariable models, predictors significantly associated with the developmental score were retained.

Once the final set of variables was determined for each outcome, mediators were considered according to a hypothesized path model. Each variable hypothesized to be a potential mediator was first tested for association with the independent variable. If this association was not significant, then the conditions for mediation were not met and the pathway was dropped. For each independent variable, a multiple mediation model was then tested including all mediators that were retained for that independent variable. If the indirect effect of the independent variable through the mediator was significant, then the pathway was retained. Finally, in step 4, pathway models were constructed separately for motor and language development using structural equation models based on the variables and pathways that had been retained in steps 1 through 3.

Results
The final pathway analyses included 1,122 children from Burkina Faso, 1,023 from Ghana, 675 from Malawi-M and 1,386 from Malawi-C, representing all children from Ghana, Malawi-M and Malawi C, and a random subsample of children from Burkina Faso, who participated in the developmental assessment at 18 months of age.

Overall, child and caregiving indicators showed a more consistent association with motor and language development, compared to maternal and environmental factors. Two child-level indicators, namely length-for-age z-score (LAZ) at birth, 6 months, and 9 months, and change in LAZ at 18 months, were significantly and directly associated with motor development in all four cohorts. The only factor associated with language development in all 4 cohorts was 18-month olds' variety of play material. In addition, in 3 of the cohorts, two-child level indicators (positive behavior during assessment and ponderal growth at 18 months) and two caregiving indicators (18-month variety of play materials and 18-month activity with caregivers) significantly and directly predicted motor development. No environmental or maternal characteristics directly predicted motor development in more than 1 cohort. Out of 9 environmental and maternal indicators retained in step 1, 5 directly predicted motor

development in individual cohorts. These included household assets (in Burkina Faso), paternal education (in Ghana), and distance to market (in Ghana), C-reactive protein (CRP) plasma concentration at 22 weeks gestation (in Ghana), and cortisol concentration in saliva at 36 weeks gestation (in Malawi). All of these associations were in the expected direction except maternal CRP, which showed that higher inflammation was associated with higher motor scores.

Additional indicators (namely LAZ at birth or enrollment, change in LAZ at 18 months, dietary diversity of the child, the child's hemoglobin/iron status and 18-month activity with caregiver) were significantly associated with language development scores in 3 cohorts (namely Burkina Faso, Ghana, and Malawi-C) but not in Malawi-M. For both motor and language development, the overall evidence for mediation was generally inconsistent across the 4 cohorts. Overall, direct effects were stronger and more prevalent than indirect effects. While the results for motor development were not consistent across cohorts, socio-economic disparities in language development were mediated to a greater extent by caregiving practices than by maternal or child factors.

Conclusions

The findings from these studies are consistent with results of previous meta-analyses and highlight the need for programs aimed at promoting caregiver activities with children and a variety of play materials, in addition to the existing program promoting adequate growth and nutrition.

Research and Policy Implication

Promotion of early childhood development is a key component of the United Nations Sustainable Development Goals. This is particularly important in low and middle income socio-economic groups, where several, coexisting environmental and nutritional risk factors adversely affect growth and development of young children. Evidence from this analysis highlights the potentially important causal pathways for delays in early childhood development, which may be targeted for intervention. However, because this was an observational study, additional evidence is needed from controlled trials or programs, to better understand the interplay between environmental and maternal or child nutritional factors, in modifying early childhood development.

NNA Editors' comments

This analysis by Prado et al. used data from 4 community-based intervention trials, all of which supplemented children with LNS until 18 months of age. In particular, the paper identified a positive association between linear or ponderal growth and motor development on one hand, and between caregiving practices (variety in child play material) and language development on the other hand. Thus, the results suggests that to achieve optimal motor and language developments, programs that promote adequate nutrition, while concurrently improving caregiver practices may be necessary.

In light of the primary findings of parent trials, the result of these analyses raises further questions for future research. In Burkina Faso, where a treatment effect on linear growth was observed[6], a positive effect on child development was also reported[10]. However, in Ghana, although maternal LNS supplementation was associated with increased birth size[7], no treatment effect on developmental scores were observed[12]. Therefore, additional evidence is needed to assess the optimal timing of nutrition interventions needed to improve early child development.

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