# Associations among early stimulation, stunting, and child development in four countries in the East Asia-Pacific

## Abstract

This study examined associations among preschool attendance, home learning activities, stunting status, and early child development using data from the validation study of the East Asia-Pacific Early Child Development Scales (EAP-ECDS). Participants were children aged 3 to 5 years from Cambodia (n = 1178; 30% stunted), Mongolia (n = 1226; 11% stunted), Papua New Guinea (n = 1697; 50% stunted), and Vanuatu (n = 674; 44% stunted). Child development was directly assessed using the EAP-ECDS and children's preschool experiences and home learning activities were reported by parents. Preschool attendance, preschool duration, and home learning activities were positively related to child development for non-stunted and stunted children, demonstrating that stimulating interactions in the home environment and early childhood education serve as modifiable factors that can help to reduce the negative effects of stunting on children's cognitive and non-cognitive development, and highlighting the importance of "nurturing care" for the development of both non-stunted and stunted children.

**Keywords:** early child development, preschool, early stimulation, home learning activities, stunting

## Résumé

Cette étude examine les liens entre la fréquentation préscolaire, les activités d'apprentissage à la maison, le retard de croissance et le développement des jeunes enfants en faisant appel aux données de l'étude de validation des Échelles de développement de la petite enfance en Asie Pacifique de l'Est (EAP-ECDS). Les participants sont des enfants de 3 à 5 ans du Cambodge (n = 1 178 ; 30 % avec retard de croissance), de Mongolie (n = 1 226 ; 11 % avec retard de croissance), de Papouasie-Nouvelle-Guinée (n = 1 697 ; 50 % avec retard de croissance) et du Vanuatu (n = 674 ; 44 % avec retard de croissance). Le développement des enfants est évalué directement d'après les EAP-ECDS, et les expériences du préscolaire et les activités d'apprentissage à la maison des enfants sont rapportées par les parents. La fréquentation préscolaire, la durée de l'expérience préscolaire et les activités d'apprentissage à la maison sont liées de façon positive au développement des enfants avec ou sans retard de croissance. Ceci démontre que les interactions stimulantes dans l'environnement familial et l'éducation de la petite enfance constituent des facteurs modifiables qui peuvent contribuer à réduire les effets négatifs du retard de croissance sur le développement cognitif et non cognitif des enfants, et souligne l'importance de « soins attentifs » pour le développement des enfants qu'ils aient ou non un retard de croissance.

## Resumen

Este estudio examinó los nexos entre la asistencia prescolar, las actividades de aprendizaje en casa, la condición de retraso en el crecimiento y el desarrollo de la primera infancia utilizando datos del estudio de validación de la Escala de Desarrollo en la Primera Infancia de la región oriental del Pacífico Asiático (EAP-ECDS por su abreviatura en inglés). Los participantes fueron niños entre 3 y 5 años de edad de Camboya (n = 1178; 30% de retraso en el crecimiento), Mongolia (n = 1226; 11% de retraso en el crecimiento), Papua Nueva Guinea (n = 1697; 50% de retraso en el crecimiento), y Vanuatu (n = 674; 44% de retraso en el crecimiento). El desarrollo de los niños se evaluó directamente utilizando la escala EAP-ECDS y las experiencias preescolares de los niños, junto con actividades de aprendizaje en casa reportadas por los padres. La asistencia y duración de la escuela preescolar y las actividades de aprendizaje en casa tuvieron una relación positiva con el desarrollo de niños con y sin retraso en el crecimiento, lo que demuestra que las interacciones

de estimulación en el ambiente familiar y la educación infantil temprana sirven como factores modificables que pueden ayudar a reducir los efectos negativos del desarrollo cognitivo y no cognitivo de niños con retraso en el crecimiento, y a su vez resalta la importancia del "cuidado amoroso" para el desarrollo de ambos grupos de niños.

# Introduction

A burgeoning body of evidence has demonstrated the importance of investing in children's development and education in the early years, leading to more efforts to find ways to improve developmental outcomes and school readiness (Black et al. 2017). A consortium of influential international non-governmental organizations has recommended that governments adopt the Nurturing Care Framework to support the development and learning of young children (World Health Organization 2018). This Framework emphasises five important components: Good Health, Adequate Nutrition, Responsive Caregiving, Security and Safety, and Opportunities for Early Learning. The analyses presented in this article explore the relations among components of this Framework, namely Opportunities for Early Learning (assessed via preschool experiences), Responsive Caregiving (measured by home learning activities), Good Health and Adequate Nutrition (indexed by height for age) and child development. A key aspect of the cross-sectional analyses of data from the East Asia-Pacific Early Child Development Scales (EAP-ECDS) is a focus on the development of cognitive and non-cognitive skills of children who have experienced poor nutrition that results in stunting. This is impaired growth for age in early childhood that has long term consequences for cognition and poor educational performance.

Most of the studies on the role of preschool participation and home learning experiences on child development have been carried out in high-income countries, whereas only limited studies have been conducted in low- and middle-income countries (LMICs). This is despite the fact that 82% of the world's children are born in LMICs (UNESCO 2015). Investment in early stimulation and education programs in LMICs are justified by future social and economic returns in adulthood (Hoddinott et al. 2013a). Providing nurturing care to children, particularly in their early years, yields significant later benefits.

Preschool attendance has been shown to be positively associated with both cognitive and non-cognitive skills development (Weiland and Yoshikawa 2013; Rao et al. 2017). It has been demonstrated to be associated with both early academic skills and school readiness (Claessens and Garrett 2014), and the duration of exposure to preschool was shown to be a significant predictor of child development at school entry (Polat and Yavuz 2016).

Home learning activities have also been shown to be beneficial for child development. Differences in the level of stimulation at home were associated with child outcomes even after controlling for socioeconomic characteristics (Galasso et al. 2017). The home learning environment has been shown to predict not only competencies in early childhood but also outcomes at the end of elementary school (Niklas and Schneider 2017).

## Stunting

Stunting is the chronic restriction of a child's growth potential due to prolonged undernutrition. It affects an estimated 155 million children globally and puts them at risk of not reaching their developmental potential (UNICEF 2017; Black et al. 2017). Stunting rates are much higher in LMICs (36.2% in low- and 32.0% in lower-middle- income countries) compared to upper middle- or high- income countries (6.9% and 2.5%, respectively) (UNICEF 2017). A large body of evidence suggests that stunting impairs cognitive development and educational achievement throughout childhood and adolescence (Black et al. 2017), and the negative impacts continue into adulthood (Hoddinott et al. 2013b; Victora et al. 2008). Stunting in childhood can have negative effects on later earnings (Hoddinott et al. 2013a), and emerging evidence suggests that it may be associated with the intergenerational transmission of poor cognitive development (Walker et al. 2015).

## Preschool attendance, home learning environment and child development

Although preschool attendance and the home learning environment have been shown to be associated with positive developmental outcomes, much of the evidence has been obtained from countries with low stunting rates. In addition, it is unclear if the mechanisms underpinning these associations differ between stunted and non-stunted children. Stunted children may not be able to benefit from early stimulation and education to the same extent as non-stunted children. The home learning environment and stunting may interact, with some evidence suggesting that home learning can moderate negative associations between stunting and child development (Nguyen et al. 2018), and that relations between infants' height and receptive language development may vary depending on the home learning environment (Black et al. 2019). In addition, nutritional status may be a pathway through which preschool experience can influence child development (Ajayi et al. 2017).

Integrated nutrition and psychosocial interventions in LMICs have been shown to benefit children's development and learning outcomes (Yousafzai and Aboud 2014), but evidence is mixed for combining stimulation with nutrition intervention. A key area for future study is finding the most effective combinations of interventions for child development in LMICs with high prevalence of stunting (Perkins et al. 2017). Determining if preschool attendance and home learning activities are effective in enabling both non-stunted and stunted children to achieve their developmental potential would provide clear and actionable guidance for policymakers on implementing effective measures that complement food security programs, particularly in places with a high prevalence of stunting in early childhood.

Furthermore, it is important to understand whether such benefits of preschool attendance and the home learning environment vary between stunted and non-stunted children across different domains of development. Typically, preschool interventions have been designed to enhance children's cognitive outcomes, whereas only small associations have been found between preschool attendance and non-cognitive developmental domains (Rao et al. 2017). Most research into the relations between stunting and development have focused on cognitive competencies, with only a few studies looking at relations between stunting and other developmental domains (Miller et al. 2016).

Research on brain development suggests that maternal and child undernutrition can have detrimental effects on children's cognitive and socio-emotional abilities (Black et al. 2017). Non-cognitive skills can influence executive function and school readiness (Thompson and Raikes 2007), and both cognitive and non-cognitive skills at school entry have been shown to predict literacy and numeracy skills at ages 8, 10, and 12 years (Brinkman et al. 2013). Numerous validated direct assessment tools for evaluating cognitive skills have been used to analyze development in stunted children (Hamadani et al. 2014). However, few studies have looked at the socio-emotional development of stunted children; and in those that had, they typically used parent report rather than direct assessment to measure socio-emotional competencies (Worku et al. 2018).

## Country Background

The countries included in the analyses presented in this paper are Cambodia, Mongolia, Papua New Guinea, and Vanuatu. To give some context and background to each country, the descriptors used in the Human Capital Index (HCI) of the World Bank (2018) are presented below, which give an overview of the health and education status of each of these countries. This index is designed to capture the amount of human capital for a child born today and expectations for health and education at 18 years, and ranges theoretically between 0 and 1. A score of 1 indicates an economy in which a child born today can expect to achieve complete education and good health. Recent estimates range from 0.29 in Chad to 0.88 in Singapore. Indicators contributing to the index include a country's stunting rate, the number of years of school a child can expect to obtain by age 18 (ranging from 0 to 14 years), and a learning-adjusted indicator of expected years of schooling, intended to adjust for school quality, based on average years of schooling and the country's average scores in the Trends in International Mathematics and Science Study.

A short description of each of the four countries including the most recent population estimates from the World Bank (2020), together with their overall HCI scores, stunting rates, expectation for average years of schooling, and learning-adjusted years of schooling (World Bank 2018) is as follows:

- Cambodia is located in South-East Asia and shares a border with Vietnam, Lao, and Thailand. Cambodia's population is approximately 16.5 million, with around 31% under the age of 15 years. It has an overall HCI score of 0.49. A child born in Cambodia is expected to complete 9.5 years of school on average, and has a learning-adjusted score of 6.9 years. About 68% of children aged under 5 are not stunted.

- Mongolia is a landlocked country in East Asia that borders Russia to the north and China to the south. It has a population of around 3.2 million, of which approximately 31% are aged under 15 years. Its overall HCI score is 0.63. A child in Mongolia can be expected to complete 13.6 years of schooling, or 9.4 learning-adjusted years, and 89% of children under 5 years are not stunted.

- Papua New Guinea (PNG) is an independent state and makes up the eastern half of the island of New Guinea, located in Oceania, east of Indonesia and north of Australia. PNG's population is reported as 8.8 million, approximately 35% of whom are under the age of 15. It has an overall HCI score of 0.38. A child born in PNG can expect to complete 8.2 years of schooling, but only 4.7 learning-adjusted years of schooling. In PNG 50% of children under 5 years are not stunted. Consequently, the 50% of children who are stunted are at high risk of cognitive and physical limitations.

- Vanuatu is an island country in the South Pacific Ocean, located east of northern Australia. It has a small population of around 300,000, with 39% of the population aged under 15 years. Vanuatu has an overall HCI score of 0.47. A child can expect to complete 10.6 years of schooling, or 6.1 learning-adjusted years, and 72% of children under 5 years are not stunted.

## The Present Study

To improve social policies aimed at promoting preschool and home learning for the development of stunted children, we need a better understanding of whether relations between preschool participation and child development and associations between the home learning environment and child development are moderated by stunting status. In this study, we aimed to address these knowledge gaps by examining interactions among key components of the Nurturing Care Framework. We examined how good health and adequate nutrition (as indicated by stunting or non-stunting) interacted with Opportunities for Early Learning (assessed by preschool attendance) and with Responsive Caregiving (measured by home learning activities) in associations with developmental outcomes. Specifically, this study investigated:

(i) The relations between preschool attendance and early child development, and

(ii) The relations between the home learning environment and early child development, and whether these relations were moderated by the stunting status of children in four LMICs - Cambodia, Mongolia, Papua New Guinea, and Vanuatu.

Cognitive and non-cognitive development were directly assessed to analyze differences in children exposed and not exposed to preschool and home learning activities. We examined the extent to which these differences varied across three developmental domains, namely Cognitive Development, Language and Emergent Literacy, and Socio-emotional Development, and whether the differences were moderated by stunting status.

Based on the extant literature, we predicted that preschool attendance and home learning activities would be positively associated with cognitive and language development, and that stunting would be negatively associated with cognitive, language, and socio-emotional development. There is only a limited body of evidence on whether stunting and stimulation interact, and on the pathways that explain relations between stimulation, stunting, and children's outcomes, so our hypothesis that stunting may moderate relations between stimulation (preschool and home learning activities) and early child development was a tentative one.

# Method

## Participants

Cross-sectional data from a validation study of the East Asia-Pacific Early Child Development Scales (EAP-ECDS) (Rao et al. 2014) included 4,775 children (2,382 girls and 2,393 boys) aged 36 to 71 months from Cambodia (n = 1,178), Mongolia (n = 1,226), Papua New Guinea (PNG) (n = 1,697), and Vanuatu (n = 674) (Table 1). Population representative samples were selected in collaboration with the national statistics department in each of the four countries, using multilevel random sampling stratified by age, gender, and urban or rural residence, as described elsewhere (Weber et al. 2017; Rao et al. 2019).

The EAP-ECDS validation study also included samples from China and Timor-Leste, but these were not included in the current study because the China sample had a very low stunting rate (n=22, 1.2%) that precluded meaningful analysis and anthropometric testing in the Timor-Leste sample was not sufficiently rigorous.

## Measures

### *Child development*

We used data from the EAP-ECDS to investigate whether cognitive and non-cognitive developmental disadvantages were associated with stunting in these children. The EAP-ECDS is a tool that assesses the holistic development of children aged 3 to 5 years and was developed based on the Early Learning and Development Standards of seven countries across the East Asia-Pacific region. The assessments were administered to children in their local language in individual sessions by trained assessors and, prior to testing, inter-observer reliability between assessors and a supervisor was at least 85%, with reliability between assessors and the supervisor re-evaluated approximately every 20 test administrations (Rao et al. 2019).

To understand cognitive and non-cognitive developmental disadvantages associated with stunting, we utilized data from three domains of the EAP-ECDS: (i) Cognitive Development (21 items including number knowledge, concepts, sequencing, and reasoning); (ii) Language and Emergent Literacy (16 items including receptive language, expressive language, phonological awareness, and pre-writing); and (iii) Socio-emotional Development (15 items including emotional recognition, perspective taking, and sense of fairness). These domains have been shown to have satisfactory reliability ($\alpha > 0.93$ for all three domains) (Rao et al. 2014). Assessment items were adapted specifically for each country context and subsequently validated (Rao et al. 2014; Rao et al. 2019).

For comparisons across children of different ages, month-of-age adjusted z-scores were created for each domain to remove expected first-order age effects on performance.

Country-specific adjustments were performed to enable comparisons between same-age within-country peers, controlling for age and country differences as described previously (Lopez Boo 2016). A z-score of 0 indicated a child had a mean score equal to other children of his or her age (in months) from the same country, whereas a z-score of -1 or 1 indicated a score of 1 SD below or above the mean, respectively.

### *Anthropometry and stunting*

Concurrent with the administration of the EAP-ECDS, body height and weight measurements were also taken following the WHO Multicentre Growth Reference Study procedures (De Onis et al. 2004; Rao et al. 2014). The assessors attended multiple anthropometry training sessions, and were tested and retrained as necessary to ensure consistent and accurate anthropometric measurements. Body height was measured to the nearest 1 mm and body weight was measured to the nearest 0.1 kg (Weber et al. 2017). In this study we converted these anthropometric parameters into WHO child growth standards: height-for-age, weight-for-height, and weight-for-age z-scores. Stunting was defined as a height-for-age z-score < -2 (De Onis et al. 1993).

### *Preschool attendance*

A parental interview was conducted at the same time as the administration of the EAP-ECDS (Rao et al. 2014). Two indicators of preschool attendance were used based on this interview. The first binary variable indicating any preschool attendance was created based on a question asking whether the child had ever attended any organized learning or early childhood education program, including private or government facility such as kindergarten, community childcare, or drop-in center. The second continuous variable representing duration of preschool attendance (in months) was created based on a question about the length of time the child had been in the program.

***Home learning activities***

Information about 6 home learning activities was extracted from the responses in the parent questionnaire. These questions were based on those in the Multiple Indicator Cluster Surveys for children under 5 (UNICEF 2019). Binary variables indicated whether the mother, father, or another adult had (within the last 3 days): (1) “read books or looked at picture books with your child”; (2) “told stories to your child”; (3) “sang songs with your child”; (4) “took your child outside the home place”; (5) “played games with your child”; and (6) “spent time with your child in naming things or counting things or drawing”. A variable was created from the total of all six activities (ranging from 0 to 6 and treated as continuous). In addition, a binary variable was created to distinguish between children whose parent indicated they had been exposed to all 6 activities, and children whose parent indicated they had not been exposed to all 6 activities. We refer to these variables as home learning (continuous) and home learning (binary).

***Control variables***

Household asset index, maternal education, child age, urban or rural residence, and child sex, as well as the country-fixed effects were included as control variables. The parent interview included questions on household asset ownership (including electricity, radio, television, refrigerator, watch, mobile phone, bicycle, animal-drawn cart, agricultural land, livestock, etc.) rather than income or expenditure. We used the first component of a principal component analysis to construct a composite measure of household assets based on the indicators of household assets as described previously (Filmer and Pritchett 2001). Similar techniques have been used elsewhere to construct asset and wealth indices (Schady et al. 2015). We divided children in each country into quartiles of household assets based on their ranked household score.

Maternal education was reported as the highest level of education achieved (from nine levels: no formal education; preschool; primary; lower secondary; upper secondary; higher certificate, diploma or associate degree; bachelor's degree; and postgraduate). Household asset, maternal education, child age, and sex controls were based on information from the parent questionnaire, whereas urban or rural residence and country controls were determined by the area of residence.

### *Analysis Plan*

All analyses used the pooled sample of all four countries and were performed in Stata 14.2. First, we calculated polyserial correlations of each of the independent variables of preschool attendance, preschool duration, home learning (binary), home learning (continuous), and stunting status with the scores of each of the three domains of child development.

Second, we used regression analysis to examine associations between stunting and each of the three domains of child development. We controlled for household assets, maternal education, child age and sex, urban or rural residence, and country-fixed effects in all regression analyses. We used hierarchical linear modeling (HLM) with province as the level 2 variable, as our sample was clustered within provinces. This is a useful strategy when the data are inherently nested or when non-independence of observations is a concern (Ployhart 2005).

Third, we used HLM to evaluate associations between preschool attendance and early child development and between home learning activities and early child development after including the control variables. We ran 12 regressions in total: i) associations were analyzed between each of the two variables of preschool attendance (yes or no attendance and preschool duration) and each of the three developmental domains (Cognitive Development, Language and Emergent Literacy, and Socio-emotional Development); and ii) associations were analyzed between each of the two variables of home learning activities (continuous and binary home activities) and each of the three developmental domains.

Next, we used HLM with interaction terms between stunting and preschool attendance and between stunting and home learning activities to analyze whether the associations with development differed between stunted and non-stunted children. We ran 12 different regressions as above and tested for statistically significant differences in linear combinations of coefficients for stunted and non-stunted children to examine whether stunting status had a moderation effect on the associations between preschool attendance and development and between home learning activities and development.

### *Missing values*

Missing values were present in preschool attendance (n=33), preschool duration (n=33), home learning activities (continuous and binary, n=177), Cognitive Development (n=24), Language and Emergent Literacy (n=64), and Socio-emotional Development (n=155) data. Developmental scores more than 3 SD from the mean for month-of-age were set to missing (Cognitive Development, n=7; Language and Emergent Literacy, n=10; Socio-emotional Development, n=5). All missing values were imputed using the multiple imputation function in Stata 14.2. Sequential imputation with chained equations was used with linear and logistic regression to calculate 25 imputations for each missing value, analyses were run on all 25 datasets, and the estimates were combined to produce a single pooled set of estimates.

## Results

Participant descriptive statistics are presented by country in Table 1 and correlations between key variables are presented in Table 2. Stunting prevalence varied from 11.1% in

Mongolia to 50.3% in Papua New Guinea, preschool attendance varied from 2.8% in Papua New Guinea to 50.5% in Mongolia, and the mean number of home learning activities (six different types) that children were exposed to within a 3-day period ranged from 3.90 (SD=1.87) in Mongolia to 5.49 (SD=1.19) in Vanuatu. All preschool and home learning variables had positive correlations with all three developmental domains, with the largest correlation between preschool attendance and Language and Emergent Literacy (Rho = .24). Stunting was negatively correlated with Cognitive Development (Rho = -.09) and Language and Emergent Literacy (Rho = -.13).

In the regression analyses that examined associations between stunting and each of the three domains of child development, there were negative associations between stunting and children's development in all three domains (all coefficients are in SD units), with the largest negative association between stunting and Cognitive Development ($\beta$ = -.27; SE = .05; $p < .001$), closely followed by Language and Emergent Literacy ($\beta$ = -.27; SE = .05; $p < .001$), and then Socio-emotional Development ($\beta$ = -.15; SE = .05; $p < .01$) (results are not shown in a table).

In Table 3, the associations from the regression analysis between preschool attendance and children's development for the whole sample and by stunting status are presented. For the whole sample, preschool attendance (yes or no) and preschool duration (per 12 months) were associated with increased Cognitive Development ($\beta$ = .34 and .23, respectively), Language and Emergent Literacy ($\beta$ = .39 and .27, respectively), and Socio-emotional Development ($\beta$ = .30 and .18, respectively) scores (all *p*s < .001). When an interaction term between preschool and stunting was included in the model, preschool attendance and duration were associated with increased scores in all three domains for both stunted ($\beta$ ranged between .31 and .38) and non-stunted ($\beta$ ranged between .16 and .38) children (all $p < .001$). Stunting status moderated associations only between preschool duration and Socio-emotional Development (β = .16 larger for stunted children, $p = .04$).

In Table 4, the associations from the regression analysis between home learning activities and children's development for the whole sample and by stunting status are presented. For the whole sample, home learning activities (continuous and binary) were associated with higher Cognitive Development (β = .06 and .13, respectively) and Socio-emotional Development (β = .05 and .13, respectively) scores (all *p*s < .01), and home learning activities (continuous) were associated with higher Language and Emergent Literacy scores (β = .03, $p = .02$). Home learning activities (continuous) were associated with higher Cognitive Development and Socio-emotional Development scores for both stunted (β = .05 and .05, respectively) and non-stunted (β = .06 and .06, respectively) children (all $p < .05$), and with higher Language and Emergent Literacy scores for only non-stunted children (β = .03, $p < .01$). Home learning activities (binary) were associated with higher Cognitive Development and Socio-emotional Development scores (β = .15 and .14, respectively) for only non-stunted children ($p < .01$). Stunting status did not moderate any associations between home learning activities and developmental scores.

# Discussion

This study examined associations among preschool attendance, home learning activities, stunting status, and early child development in children from four LMICs in the East Asia-Pacific to determine whether the benefits of early childhood education and stimulation in the home environment vary between stunted and non-stunted children. This is key to guiding effective interventions that seek to mitigate the adverse effects of stunting on children's outcomes. To investigate this knowledge gap, the current study explored associations of children's cognitive and non-cognitive development with both preschool attendance and home learning activities for stunted and non-stunted children. The Nurturing

Care Framework served as a guide for investigating the individual effects of the two important contexts of preschool attendance and the home learning environment on children's developmental outcomes.

## Strengthening the evidence base in LMICs

The majority of previous research investigating the association between stunting and child development focused on the negative effects on cognitive abilities (Miller et al. 2016). In this study, the results suggested that stunting was associated with both poorer cognitive and non-cognitive skills, with the strongest associations found for children's cognitive and language development, but significant associations also found for socio-emotional development. Our study supports the emerging evidence regarding the negative influence of stunting on children's social and emotional development, and adds to the knowledge through the use of a validated, direct assessment tool for measuring children's abilities, rather than using parent report (Worku et al. 2018). Importantly, our results highlight the need for interventions aimed at improving developmental outcomes for stunted children by adopting a holistic developmental approach, such that interventions promoting both cognitive and non-cognitive abilities need to be considered.

Consistent with previous research (Rao et al. 2017), our overall results demonstrated significant positive associations of both preschool attendance and home learning activities with children's cognitive and non-cognitive development. The majority of existing evidence on these associations were established in HICs. Our findings on the benefits of early stimulation and education for the development of children strengthens this evidence and extends it to children from LMICs.

## Do stunted children reap the same benefits as their non-stunted peers?

Overall, the results suggest that stunting status does not influence the associations of both preschool attendance and home learning activities with children's cognitive and non-cognitive development. With one exception, we showed that the benefits of these early inputs for children's development do not vary between stunted and non-stunted children. Findings elsewhere have shown that height-for-age and the home environment did not interact in their relation with the child development of preschoolers in India, although an interaction was found for infants (Black et al. 2019); and a mediation effect of nutritional status on the relation between preschool and cognitive outcomes was not found among children in South Africa (Ajayi et al. 2017).

Our findings are broadly consistent with those from these studies, and expand the emerging evidence base by using data from four countries in the East Asia-Pacific, examining both preschool and the home learning environment, and including an analysis of children's socio-emotional as well as cognitive outcomes. The inclusion of the Socio-emotional Development domain is important because the notable exception to our overall results was that stunting significantly moderated the association between preschool duration and children's Socio-emotional Development scores. Specifically, stunted children who attended preschool for a longer duration saw significantly greater benefits in terms of their social and emotional skills compared with their non-stunted counterparts. Importantly, our findings highlight that both early childhood education and stimulating home environments serve as modifiable factors that could help to improve deficits experienced by stunted children, particularly in the four LMICs in the East Asia-Pacific.

Overall, our findings are encouraging for those working to improve the developmental deficits of disadvantaged children. Stunting is considered to be relatively irreversible after the age of 2-3 years, although there is emerging debate around the potential of stunted children catching up to the height of their non-stunted peers later in childhood (Alderman and Fernald 2017). This raises an important question as to whether stunted children can also catch up in terms of their cognitive and non-cognitive development (Georgiadis 2017) . It could be argued that developmental deficits due to stunting means these children are not able to engage in and learn from early stimulation and education to the same degree compared with non-stunted children. However, results from the current study add to this conversation by demonstrating that stunted children are able to gain benefits from early stimulation that are equal to, if not greater than, non-stunted children. This new information can help guide policy around interventions that are most effective in mitigating against the adverse effects of stunting.

## Limitations

The results should be interpreted with the following caveats. First, data used are from four LMICs in the region and, as such, caution should be taken in generalizing findings to other contexts. Nonetheless, the results make a valuable contribution to the existing evidence by highlighting associations between stunting, early stimulation and education, and early development in children from the East Asia Pacific, and warrants further investigations in other regions.

Second, there are likely additional confounders not measured in this study and not adjusted for in the statistical modeling, and we cannot definitively state that preschool and home environments alone are causal in influencing better developmental scores for both stunted and non-stunted children. For example, it is possible that parenting style also plays an important role in a child’s early stimulation and education experiences, which might influence the way these factors affect children’s outcomes. Indeed, recent experimental research exploring the impacts of early childhood education on children’s development in Indonesia demonstrated differential impacts on children’s outcomes according to selfreported parenting practices (Brinkman et al. 2017). Future research could be strengthened by the inclusion of parental influence on the associations between early stimulation and education, stunting, and children's development.

It is also important to note that information regarding preschool attendance and parental engagement was provided by children's primary caregivers, most often the mother, which could introduce the potential for social desirability bias, a typical problem with self-report measures. Additionally, these variables lacked details in terms of process, quality, and frequency, which limited the depth of analyses conducted. For instance, children's preschool attendance included any type of organized learning, and such varied early education programs means it is not possible to account for any differences between them.

Although information on preschool duration (months attending) was available and included in analyses, more specific aspects of preschool quality and total dose (i.e., sessions per week, length of sessions, and overall attendance duration) are likely to play an important role in the effects on children's development. Indeed, such information could help determine "optimal" early childhood education attendance, and whether this might differ for stunted and non-stunted children. For instance, we found that longer duration of preschool attendance was particularly important for the development of social and emotional skills among stunted children compared with non-stunted children, which raises the question of whether higher intensity of early childhood education would enhance stunted children's ability to catch up to their non-stunted peers. Such information would not only have significant policy implications, but also guide parents to access available support to best facilitate their children's development. More detailed information pertaining to these factors could strengthen future research to better understand how early stimulation and education could work to mitigate the negative impacts of stunting on children's development.

## Conclusions

Results presented in this study demonstrate that stimulating interactions in the home environment and early childhood education serve as modifiable factors that can help to reduce the negative effects of stunting on children's cognitive and non-cognitive development. This study reflects the underlying guiding principles of the Nurturing Care Framework that articulate the importance of responsive caregiving and early learning as important components of quality nurturing care to enhance children's developmental outcomes.

Based on decades of research and advocacy, we are now increasingly aware of the importance of investing in early childhood development, which is further supported by the recent worldwide endorsement of the United Nations Sustainable Development Goals (SDGs) (UN General Assembly 2014) that focus on a multitude of intertwined factors promoting global equity. Embedded within the goals are targets relating to children's health, nutrition, and early learning that constitute the global agenda for early childhood development (Britto 2017). In particular, SDG 4.2 is relevant as it calls for universal access to high-quality early childhood development, childcare, and pre-primary education. Indeed, investment in children's early development has been deemed a requisite to achieving a number of the SDGs, including the eradication of poverty, hunger, and malnutrition (Richter et al. 2017).

For many children, particularly those in LMICs, exposure to poverty early in life begins a cycle of poor nutrition and stimulation, inadequate access to quality childcare and education, stunted growth, sub-optimal cognitive and psychosocial development, and a lack of school readiness, which in turn lead to lower academic achievement and future earning potential. Encouragingly, interventions focused on improving child developmental outcomes, such as for stunted children, continue to produce promising results (Rao et al. 2017). Further studies are needed to better understand the most effective combinations of interventions for children's development in LMICs that are tailored to deficits in developmental domains and local risk factors (Perkins et al. 2017).

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# Tables

**Table 1.** *Composition of the study sample and descriptive statistics*

| Key Variables | CAMBODIA | MONGOLIA | PAPUA NEW GUINEA | VANUATU |
|---|---|---|---|---|
| Number of participants | 1,178 | 1,226 | 1,697 | 674 |
| Girls % | 49.9 | 50.0 | 50.3 | 48.7 |
| Age (months) - Mean (SD) | 53.81 (10.35) | 53.70 (9.90) | 53.00 (10.04) | 54.55 (9.50) |
| Urban % | 54.0 | 50.7 | 33.7 | 10.4 |
| Stunted % | 29.9 | 11.1 | 50.3 | 44.4 |
| Attends preschool % | 41.8 | 50.5 | 2.8 | 46.7 |
| Preschool duration (months) - Mean (SD) | 6.99 (4.31) | 16.72 (8.92) | 6.45 (6.39) | 6.16 (4.18) |
| Home learning activities - Mean (SD) | 3.99 (1.99) | 3.90 (1.87) | 4.92 (1.47) | 5.49 (1.19) |
| Maternal education - Mean (SD) | 3.40 (1.21) | 5.73 (1.21) | 3.16 (1.21) | 3.44 (0.95) |
| Wealth quartile - Mean (SD) | 2.49 (1.12) | 2.50 (1.12) | 2.49 (1.12) | 2.49 (1.09) |

**Note:** For each country the table shows: the total sample size, proportion of girls, mean (SD) age in months, proportion of urban residents, proportion stunted, proportion having ever attended preschool, mean (SD) duration of preschool attendance for those children having ever attended only, the mean (SD) number of home learning activities (ranging from 0 to 6) children had been exposed to within the last 3 days, the mean (SD) highest maternal education level (over 9 categories), and the mean (SD) country-specific wealth quartile score.

**Table 2.** *Polyserial correlations between independent variables and early child development outcomes*

| | **Cognitive Development** | | | **Language & Emergent Literacy** | | | **Socio-Emotional Development** | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***Rho*** | ***SE*** | ***p*** | ***Rho*** | ***SE*** | ***p*** | ***Rho*** | ***SE*** | ***p*** |
| Preschool attendance | 0.199 | 0.018 | < 0.001 | 0.240 | 0.018 | < 0.001 | 0.171 | 0.019 | < 0.001 |
| Preschool duration | 0.176 | 0.017 | < 0.001 | 0.223 | 0.017 | < 0.001 | 0.150 | 0.017 | < 0.001 |
| Home learning (binary) | 0.065 | 0.019 | < 0.001 | 0.045 | 0.019 | 0.016 | 0.114 | 0.019 | < 0.001 |
| Home learning (continuous) | 0.099 | 0.016 | < 0.001 | 0.084 | 0.016 | < 0.001 | 0.142 | 0.016 | < 0.001 |
| Stunting | -0.093 | 0.018 | < 0.001 | -0.128 | 0.018 | < 0.001 | -0.033 | 0.019 | 0.082 |

**Note:** The table shows polyserial correlations (Rho) with standard errors (SE) and probability values (*p*) between each developmental domain score and preschool attendance/duration, home learning (binary/continuous), and stunting (binary), for the whole sample.

**Table 3.** *Regression analyses showing associations between preschool and early child development for the whole sample and by stunting status*

| | **Cognitive Development** | | | **Language & Emergent Literacy** | | | **Socio-Emotional Development** | | |
|---|---|---|---|---|---|---|---|---|---|
| | *B* | *SE B* | *p* | *B* | *SE B* | *p* | *B* | *SE B* | *p* |
| ***Preschool attendance (yes or no)*** | | | | | | | | | |
| Whole sample | 0.338 | 0.059 | < 0.001 | 0.393 | 0.046 | < 0.001 | 0.297 | 0.033 | < 0.001 |
| Non-stunted | 0.310 | 0.057 | < 0.001 | 0.382 | 0.051 | < 0.001 | 0.273 | 0.037 | < 0.001 |
| Stunted | 0.383 | 0.101 | < 0.001 | 0.382 | 0.081 | < 0.001 | 0.351 | 0.075 | < 0.001 |
| Difference in preschool attendance coefficients: stunted vs. non-stunted | 0.072 | 0.094 | 0.445 | 0.000 | 0.091 | 0.997 | 0.077 | 0.085 | 0.364 |
| ***Preschool duration (each 12 months)*** | | | | | | | | | |
| Whole sample | 0.227 | 0.043 | < 0.001 | 0.274 | 0.048 | < 0.001 | 0.177 | 0.026 | < 0.001 |
| Non-stunted | 0.201 | 0.042 | < 0.001 | 0.256 | 0.051 | < 0.001 | 0.156 | 0.026 | < 0.001 |
| Stunted | 0.362 | 0.087 | < 0.001 | 0.347 | 0.064 | < 0.001 | 0.312 | 0.074 | < 0.001 |
| Difference in preschool duration coefficients: stunted vs. non-stunted | 0.161 | 0.087 | 0.066 | 0.091 | 0.088 | 0.301 | 0.157 | 0.077 | 0.042 |

**Note:** The table shows the results of 12 separate HLM regressions. For the whole sample, 6 regressions were run to calculate associations between preschool attendance (binary) and each of 3 developmental domains, and between preschool duration (continuous, each 12 months) and each of 3 developmental domains. Separate coefficients for stunted and non-stunted children were calculated by running a further 6 regressions with an interaction term between stunting status and the preschool variable. Linear differences in coefficients representing stunted and non-stunted children were tested for significance. In all regression analyses we controlled for household assets, maternal education, child age and sex, urban or rural residence, and country-fixed effects, and province was used as the level 2 variable.

**Table 4.** Regression analyses showing a*ssociations between home learning activities and early child development for the whole sample and by stunting status*

| | **Cognitive Development** | | | **Language & Emergent Literacy** | | | **Socio-emotional Development** | | |
|---|---|---|---|---|---|---|---|---|---|
| | *B* | *SE B* | *p* | *B* | *SE B* | *p* | *B* | *SE B* | *p* |
| ***Home learning activities (binary, all vs. not all activities)*** | | | | | | | | | |
| Whole sample | 0.131 | 0.042 | 0.002 | 0.008 | 0.044 | 0.848 | 0.130 | 0.041 | 0.001 |
| Non-stunted | 0.152 | 0.042 | < 0.001 | 0.027 | 0.046 | 0.555 | 0.144 | 0.046 | 0.002 |
| Stunted | 0.089 | 0.066 | 0.182 | -0.029 | 0.069 | 0.672 | 0.103 | 0.077 | 0.178 |
| Difference in top vs. bottom category of activities coefficients: stunted vs. non-stunted | 0.063 | 0.064 | 0.320 | 0.057 | 0.067 | 0.396 | 0.040 | 0.087 | 0.644 |
| ***Home learning activities (continuous, number of activities)*** | | | | | | | | | |
| Whole sample | 0.058 | 0.013 | < 0.001 | 0.028 | 0.012 | 0.021 | 0.054 | 0.011 | < 0.001 |
| Non-stunted | 0.064 | 0.013 | < 0.001 | 0.034 | 0.013 | 0.009 | 0.058 | 0.012 | < 0.001 |
| Stunted | 0.046 | 0.017 | 0.006 | 0.015 | 0.017 | 0.356 | 0.047 | 0.019 | 0.013 |
| Difference in number of learning activities coefficients: stunted vs. non-stunted | 0.018 | 0.016 | 0.261 | 0.018 | 0.017 | 0.292 | 0.011 | 0.021 | 0.611 |

**Note:** The table shows the results of 12 separate HLM regressions. For the whole sample, 6 regressions were run to calculate associations between home learning activities (binary) and each of 3 developmental domains, and between home learning activities (continuous, ranging 0 to 6) and each of 3 developmental domains. Separate coefficients for stunted and non-stunted children were calculated by running a further 6 regressions with an interaction term between stunting status and the home learning variable. Linear differences in coefficients representing stunted and non-stunted children were tested for significance. In all regression analyses we controlled for household assets, maternal education, child age and sex, urban or rural residence, and country-fixed effects, and province was used as the level 2 variable.