Beyond Wealth and Health: The Social Environment as a Protective Factor for Cognitive Development of Children in Nicaragua

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Publication date: January 2020

Journal of Cognition and Development

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Abstract

We examine the contributions of the environmental context on cognitive development in a representative sample of children (24-59 month-olds) in Nicaragua. Multivariate regression models revealed that children who experienced high levels of structure in the home, encountered more social interaction, and were enrolled in early education programs, exhibited higher cognitive skills. These factors were related to, but better accounted for, variability in children's skills than the socio-economic endowment of the home or maternal education levels – the two most commonly used proxies to quantify children's early contexts. Results from this study provide validation of the relation between children's proximal early social environment and cognitive outcomes in a novel context. The results also provide motivation for deeper empirical investigation in the specific aspects of the home environment that may be central to providing resilience to low wealth populations, and to reducing inequality in developmental skills.

Relevant keywords: home environment, social interaction, socio-economic status, cognitive development, cross-cultural

Introduction

Early childhood home environments are well understood to be foundational for cognitive development. Though, empirically in Low and Middle Income Countries (LMICs), these environments are often flattened to measures of socioeconomic status or access to early schooling (Heckman, 2006). This is partly due to the consequence of the limited cross-cultural measures, in addition to conceptual, technical and cultural challenges inherent to properly assessing variation in developmental trajectories in diverse cultures and settings (see Hamadani, Tofail, Hilaly et al., 2010; McCoy, 2016). Even more than in High Income countries, developmental research in LMICs frequently use easily quantifiable measures of health and wealth status (e.g., prevalence of stunting, absolute number of people living in poverty, or rates of mortality under five) as indicators for social context as they represent multiple biological and psychosocial risks and can be consistently defined across countries (Grantham-McGregor et al., 2007). While sometimes useful as proxies, they cannot provide clear information about the mechanisms by which the early social environment relates to cognitive outcomes.

In high income nations, there is vast evidence that aspects of early social context can play a role in children's cognitive development, including: early social interactions, access to linguistic input, children's relationship with caregivers, family structure, housing quality and neighborhoods, parenting strategies, parental education, and children's nutrition. Yet, the high covariation between many of these factors make their contributions difficult to parse (see Gopnik & Choi, 1990; Gottfried, 2013, Bhutta et al., 2013; Davis-Kean, 2005; Landry, Miller-Loncar, Smith et al., 2002; Rowe, Leech & Cabrera, 2017; Bradley and Corwyn, 2005; Walker, Wachs, Gardner et al., 2007). Moreover, with very different socialization norms for supporting young children in LMICs, prior research might suggest that these same variables relate to cognitive

skills in very different ways. Therefore, there are no globally-agreed indicators to assess factors in the home environment that affect cognitive development of children in developing countries (Hamadani et al., 2010), so these relations are not well understood.

This study provides a closer examination of specific aspects in children's home environments that are related to cognitive outcomes in one of the lowest income nations in Latin America, Nicaragua. While low economic resources tend to compound challenges for children's development through consequences such as limited access to high quality nutrition, health care, or high parental education, other characteristics of the home and social context may provide protective effects on children's development of cognitive skills (Paxson & Schady, 2005 in Ecuador; Behrman & Skoufias, 2004 in Bolivia; Verdisco, Naslund-Hadley, and Regalia, 2009). Using novel measures which were derived from existing developmental research and were adapted for this specific Latin American context, this study captures dimensions of the home environment as well as children's cognitive development in a representative sample of the nation's children. These rich data enable some disentangling of the mechanisms that affect cognitive development in a context where the wealth gradient is smaller across most families than in a high income nation (World Health Organization, 2013), and where family socialization norms may differ from the most highly represented families in developmental research – those from highly developed, high income nations.

Here, we asked if family care indicators which have been associated with development in both high and LMIC countries (Bradley and Corwyn, 1996; Bradley, Corwyn, Burchinal, et al., 2001; Lozoff, Park, Radan and Wolf, 1995; Hayes, 1997) could explain children's cognitive trajectories beyond well documented factors such as wealth and health status. Several models of human development have been proposed to highlight the interplay between children and their

environment. Bronfenbrenner (2005) is the most widely influential model, which suggests that the contextual influences both from the immediate family and school to the broader cultural and social values affect child development. Shonkoff (2010) also adds that having predictable and nurturing experiences, especially at an early age, facilitate development. Multiple factors such as characteristics of the child (e.g., age and gender), family characteristics (e.g., wealth, maternal education, and location of household residence; Rafferty & Griffin, 2010; Armistead, Forehand, Brody, & Maguen, 2002), and the broader social context (e.g., country's economic development) may all be independently influential as well (Luster & Okagaki, 2005). Some of these factors may play important roles in supporting children's resilience and in building skills regardless of their access to wealth (Beale-Spencer, Dupree & Hartmann, 1997).

Moreover, the role of wealth is complex, and may systematically impact children's cognitive development nonlinearly (Turkheimer, Haley, Waldron et al., 2003). In impoverished families, Turkheimer and colleagues (2003) showed that 60% of the variance in IQ was accounted for by the shared environment whereas the contribution of genes was close to zero. However, in affluent families, the result was the reverse (Turkheimer et al., 2003). Thus, the social context may differentially affect child outcomes, with context being the most impactful for those living in resource-limited environments both on a family level (e.g., poverty in high-income nations) and community or country level (e.g., poverty in LMICs).

While there is a growing number of studies that have examined characteristics in the home, there is a dearth of multinational data on family level characteristics in the home, especially in LMICs (Bornstein, 2012). Family level characteristics (e.g., maternal education, family wealth, and place of residence (urban/rural)), have been found to significantly predict parental engagement in cognitive activities (Sun, Liu, Chen, Rao, and Liu, 2016) yet these

characteristics often tend to be more stable and immutable, at least in the short term.

In contrast, this analysis focuses on aspects in the home environment that are malleable if in fact they explain variance in children's cognitive outcomes above and beyond factors of wealth, health, and immutable home characteristics. In 2010, Hamadani and colleagues drew on the well-established HOME measure (Bakermans-Kranenburg, Van IJzendoorn, & Bradley, 2005) to create a measure of resources in the home that would be meaningful in a LMIC, though their local context was vastly different. The current study utilized these subscales to assess a large-scale sample of Nicaraguan children's experience in their homes, collecting data on measurable items including: 'number of books in the home', 'use of rules and routines', 'health and hygiene practices', 'total activities such a singing, playing', and 'enrollment in early education'.

Nicaragua provides an ideal case to study the relations between wealth and the early social-environmental context due to its being one of the poorest countries in the world (WHO, 2010). Moreover, this study offers an opportunity to study the impact of an innovative and comprehensive Early Childhood Development model for access to education. This was implemented with support from the Inter-American Development Bank in 1996 to increase education, development and health standards across the country. The Comprehensive Childcare Program in Nicaragua (i.e., PAININ, the Spanish acronym) was developed to consolidate services that were previously separated (e.g., preschool education, referrals to health care system) and integrate them with new services (e.g., early childhood education) (Verdisco et al., 2009). PAININ were nongovernmental organizations which were strongly rooted in respective communities and targeted to children under the age of six. Over 90% of children aged 0-3 in Nicaragua received some form of Early Childhood Education (ECD) through services provided

by PAININ, mainly preschools, health, nutrition, and early stimulation. Services were provided through two different modalities: center-based which served densely populated areas and mobile services which were used in remote areas. The PAININ developed national standards to ensure that services were delivered with a uniform level of quality; it applied a standard curriculum to all children with the same supporting materials. This study therefore explores a context where poverty is widespread but social services (i.e., increased accessibility of preschool and basic health care) begin to reach a large portion of the population. More specifically, it explores the effects of the proximal home environment on cognitive development after access to resources expand on a country-wide level.

We therefore examine the relation between the local social-environmental context (i.e., using parent behavior measures and resources available) and cognitive outcomes in a representative sample of children in the low-income country of Nicaragua. Data were collected on children between the ages of two and five, prior to formal school entry in Nicaragua (Verdisco, Cueto, Thompson et al., 2015). Analyses compared the relative contributions of wealth and health measures to potential malleable factors of the home context in predicting cognitive developmental outcomes both broadly and on specific outcomes – language, number, executive functioning, and reasoning. Children's early language proficiency, number competence, relational and spatial reasoning, and executive functioning skills are highly tied to a wide array of adaptive outcomes among children from school readiness and academic success (Marchman & Fernald, 2008; Diamond & Lee, 2011) to later health and social outcomes (Duncan, Ziol-Guest, & Kalil, 2010; Cicchetti, 2002). Therefore, these data have the potential for immediate and long-term implications in policy and intervention.

Data

Participants

The sample consisted of 1,826 children aged 24-59 months (51% boys) from the Programa Regional de Indicadores De Desarollo Infantil (PRIDI) database in Nicaragua collected between 2009 and 2013. The sample was demographically, economically, and ethnically representative due to a three stage nationally-representative sampling strategy; data were consistent with summary statistics conducted on the individual level in Nicaragua (for more information see Verdisco, 2015; WHO, 2010). The sampling procedure consisted of three stages: 1) discrete geographic divisions of departments and regions covered in Nicaragua were created, 2) within these units, a randomly selected samples of houses were chosen, 3) to prevent clustering, one child between the ages of 24-59 months was randomly selected.

Measures

A select subset of measures developed and administered as part of the PRIDI study were analyzed in the current analysis. Included assessments are briefly described below. More details on development of instrumentation and validation can be found in the PRIDI Technical Annex (Verdisco et al., 2009).

*Cognitive Development***.** The Engle Scale (Verdisco et al., 2009) was developed through a rigorous process to maximize both cultural sensitivity and validity as well as rigor in assessing basic cognitive skills. The process was iterative, moving between the psychological literature on basic cognitive development measures of early skills (i.e., number, executive function, memory, language, and problem solving), and on the ground validation of measures across contexts in Nicaragua and neighboring countries'. Measures were adapted and validated with local

collaborators through extensive pilot testing (see PRIDI report for more details on this development process) to ensure standards for child development outcomes and alignment between local goals and literature-based research. The final Engle Scale assessed the ability to solve problems, categorize, sequence, recognize relationships between numbers and relationships between parts and whole, control attention, and exercise executive functioning skills. The aim of this scale was to create a measure that would provide valid and reliable data on children's development across local cultural and social context variations (including rural, urban, and language minority differences within Nicaragua as well as in nearby countries).

The Engle Scale consists of two separate evaluations: Form A and Form B, applied to 24-41 months and 42-59, respectively. Twelve anchor items are included in each form to allow for reporting as a single scale. Scores were calculated using the item response theory (IRT) where the probability of a response was modeled as a function of the difficulty of the item and the ability of the person (Verdisco, 2015). Internal consistency reliability for the IRT-based scores was acceptable: form A: $\alpha = .69$; Form B: $\alpha = .77$. The international mean of the Engle Scale is 50 ($SD = 5$). A confirmatory factor analysis also enabled separation of the measure into items designed to capture aspects of number skills, expressive and receptive language, spatial and relational reasoning, and executive function. These were not designed to be independently reliable because adequate testing time could not be feasibly added to include a range of tasks for each construct, but these items were examined separately in an exploratory fashion. The full measure with items flagged by construct are provided in supplemental materials.

*Participation in Formal Early Education***.** The mother or primary caregiver was asked if the child participated in formal early education programs. To qualify, a child (between 3-5 years-old) must have attended the program for at least 15 hours a week and must have participated in

the program for at least 6 months. If the child participated in more than one type of program, the administrator recorded the program which the child had the most time participating in.

Assessment of the Home-Environment, *The Family and Child Survey*: The administered tool was a parent report, survey version of the Home Observations for Measurement of the Environment (HOME), which is a previously identified, standardized, and validated assessment used to measure children's home environment and interactional experiences (Bakermans-Kranenburg, Van Ijzendoorn, & Bradley, 2005; Hamadani et al., 2010; Schady et al., 2014). Hamadani and colleagues (2010), validated a parent-report survey version of the tool in Tajikistan, also an LMIC. This measure was then adapted further to this context to create the Family and Child Survey. This index assessed the quality of stimulation and support available to a child in the home environment. In collaboration with the local community who are aware of the economic, social and educational systems in specific subpopulations, this measure was rigorously tested to ensure linguistic, functional, and metric equivalence across varied populations (Verdisco, Cuento & Thompson, 2016).

The Family and Child Survey, *the independent scales:* The original measure included six distinct, previously validated indices: 1) number of books in the home, 2) prior week frequency of specific activities known to be related to cognitive development in other contexts (e.g., reading, telling stories, singing, playing outside, naming things), 3) presence or absence of rules or routines (e.g., types of foods eaten, meal times, bed times, household chores), 4) hygiene practices followed in the home (e.g., brushing teeth, washing hands before eating, washing hands after the bathroom), 5) number of social partners that engaged with the child in the prior week, and 6) frequency of interaction with social partners in the prior week.

Previous research has collapsed data from these and closely related scales, defining the integrated construct as the level of *Nurturing* provided by the child's home context (see Hamadani et al., 2010; Schady et al., 2014). However, we were concerned that the collapsed construct would miss important variability across the scales, and it would be impossible to understand the mechanisms underpinning the relations between home and family characteristics and children's development. This is important in part to determine where future interventions and/or future investment might be best directed. Thus in this paper we conducted a factor analysis to separate the contributions of these variables on children's cognitive development score.

It is reasonable to suggest that within the nurturing construct, the choices of how parents rear and support their children's development are correlated. So we used a data-driven approach to answer these questions. We used principal axis factor analysis with promax rotation to examine the underlying structure of the home environment in the PRIDI data for the complete sample, and we conducted independent factor analyses of the Family and Child nurturing construct. In general, when analyses were conducted on the large group and separately by race/ethnicity and urban/rural subgroups, two dimensions emerged from the Family and Child nurturing construct, which we call *structure* and *social interaction*. This suggests that all aspects of parenting practices are common across all families in the sample regardless of their cultural affiliation or geographic residence and there exist two potentially separate mechanisms of impact. These findings are consistent with results reported by Bradley (1993).

The internal consistency for the Family and Child nurturing construct was $\alpha = .458$. The two dimensions that emerged had moderate internal consistency across the full sample and across subsamples by race/ethnicity and urban/rural groups: *structure* ($\alpha = .332$) and *social*

interaction (α = .471). The low alphas on the two dimensions could be due to the small number of questions that are in each dimension, item interrelatedness, and dimensionality due to the study design. As previously mentioned, the PRIDI measures attempted to capture the breath of developmental phenomena with as few questions as possible, thus there were few repetitions of same-construct items, and therefore we did not anticipate having high reliability scores.

Structure. This emergent factor reflected the resources made available to children to provide stimulation and structure in a home. These included the 1) availability of books in the home, 2) frequency of parent-child activities (e.g., reading, singing, story-telling), 3) rules/routines practice in the home, and 4) daily hygiene practices.

*Social Interaction***.** The second factor that emerged includes 1) the number of social partners and 2) the frequency of that interaction with parents, other adult family members, siblings, and peers on a typical basis. Some arguments have been made that although parent talk or resources in the home may be mitigated by high social interaction, different social partner relationships may provide an alternative source for high interaction.

*Wealth Index***.** Asset-based wealth indices have become widely used instruments for measuring socio-economic status of households in low and middle income countries where income is not always quantifiable and where assets tend to be strong indicators of long-term socio-economic position, living standard or material wellbeing of households (Howe, Hargreaves, & Huttly, 2008; Filmer & Pritchett, 1999). Following Schady (2014), the PRIDI team developed a wealth index that would capture family resources through a proxy of characteristics of the home environment. The index included: 1) infrastructure found in the home (i.e., natural materials, rudimentary materials such as bamboo, or finished materials such as cement for walls, roof and floor), 2) assets found in the home (e.g., refrigerator, stove, car,

television), (3) access to basic services (i.e., electricity, potable water and sanitation), and 4) the ratio of household members to bedrooms (Petter, Straub, & Rai, 2007).

Demographic Family Characteristics. Data were collected on family background via interviews conducted with mothers. Height was experimentally measured and the h*eight-for-age index* was calculated based on WHO 2006 tables for child nutritional status. Maternal report was used for *health rating of child.* Mothers reported on *her own education and age, language spoken in the home* (coded as Spanish or Miskito), and *child age* and *gender. Geographical region* reflected the recruitment site.

Data Analysis

Linear regression analyses predicted child cognitive outcomes from structure, social interaction, enrollment in early education, and age. As such, this analysis tested the extent to which cognitive development varied as a function of home factors and enrollment in early education. All measures described above were included in the predictors, and control variables included height-for-age index, heath rating of child, maternal education, maternal language spoken, maternal age, geographic region, and wealth, with weights included to account for sampling variance. T-tests were used in post hoc analyses to identify mean differences along the wealth, structure, social interaction and education continuum after finding overall regression effects. Due to the sampling procedures and post-hoc weighting, there were limitations in programing and statistical tests to accurately assess sample variances (i.e., these data are proprietary and have an analytic tool to incorporate weighting specific to the context which limited the analyses). Therefore, post-hoc analyses are restricted to t-tests across groups to remain unbiased, with significance levels corrected for multiple analyses. Key nurturing variables (i.e., structure, social interaction, access to education) were broken into quartiles and

crossed with wealth quartiles to assess first whether children's access to high nurturing co-varied with wealth, and secondly whether, for those children who experienced high nurturing but low wealth, wealth effects on cognitive development would be eliminated. Specifically, the highest and lowest levels of nurturing variables at the highest and lowest quartiles of wealth were compared to assess the relation to cognitive development scores.

Results

Descriptive statistics characterizing the sample are presented in Table 1, revealing that wealth was normally distributed, yet was adequate to provide almost all children with access to adequate housing and access to electricity, running water, and sanitation. The other sample statistics are consistent with population-level statistics conducted on the individual level in Nicaragua (WHO, 2010), and there was adequate variability in the cognitive development index to examine the predictors of interest. Data summarizing the measured factors of the home environment and enrollment in early education are presented in Table 2. Broadly, these data revealed that there was disparity in children's enrollment in early education programs and developmental experiences, enabling us to further analyze the relative contributions toward cognitive outcomes.

Table 3 reports the bivariate correlations between child outcomes, contextual variables of interests and key controls. Correlation of variables are reported for the entire sample, though enrollment in early education and its correlations are only reported for children aged 3-5 years. As expected, wealth and maternal education were correlated with cognitive development score, enrollment in early education, and structure in the home, yet these relations were fairly small and do not suggest isomorphic data.

Regression analyses were next used to evaluate the predictive relation of enrollment in preschool, structure, and social interaction on the cognitive development score of 3-5 year-olds in Nicaragua and all variables were entered simultaneously into the model. Height for age index, wealth, structure, and social interaction variables have been standardized and thus the betas should be taken into account when interpreting the findings. The regression coefficients, their standard errors, and the standardized coefficients are listed in the two columns of Table 4.

The regression indicated that all of the selected covariates were related to cognitive development: wealth ($B = 0.29$, SE = 0.11, $p < .05$); structure ($B = 0.32$, SE = 0.12, $p < .05$); social interaction ($B = 0.42$, SE = 0.16, $p < .05$); and enrollment in early education ($B = 0.97$, SE = .23, $p < .001$). Analyses were conducted to explore the overall effect of the Family and Child Survey and the independent effects of the *structure* and *social interaction* variables. When the variables were combined, the overall magnitude of the scale was small, so we ran the regressions to explore the independent effects of the separate constructs. We performed an exploratory analysis on each factor of the cognitive development score (i.e., executive functioning, expressive and receptive language, number skills, and spatial and relational reasoning). Table 5 reports that the results hold for the independent cognitive constructs when examined.

Data were analyzed continuously in initial regressions, but in order to better understand how the tails of the wealth distribution interacted with structure and social interaction in relation to cognitive development, scores we separated these into quartiles and we conducted post-hoc analyses. Due to the large number of groups in the quartiles, constraints in the sample size, and limitations in programing, only the highest and lowest quartiles of each nurturing factor (i.e., structure, social interaction, and early education) were analyzed. Significance levels were corrected for multiple analyses.

We ran four analyses examining how structure was related to children's cognitive development score within each quartile of wealth which led us to four post-hoc analyses. In three out of the four wealth quartiles, children who experienced high levels of structure had higher cognitive development scores compared to those who experienced low structure. The magnitude of the associations tended to be small but reliable, as illustrated in Figure 1. This figure shows the predicted cognitive score for children portioned by their structure-wealth quartiles. Poor children who experienced high levels of structure in the home had higher cognitive development score (M = 50.28, SE:0.57) compared to poor children who experienced less structure (M = 47.52, SE:0.33), $t(217) = 3.99$, $p < 0.001$. Additionally, high-income children who experienced high levels of structure in the home had higher cognitive development score (M = 50.78, SE:0.31) compared to high-income children who experience less structure (M = 47.49, SE:0.57), $t(263) = 4.06$, $p < 0.001$. Interestingly, high-income children who experience high levels of structure in the home do not have significantly higher cognitive development score compared to poor children who experience high levels of structure. Rather, structure in the environment explained cognitive development above and beyond family wealth status. It is important to note that it was more common for poor families to exhibit low levels of structure (n = 160) and for wealthier families to exhibit higher levels of structure (n = 211). However, this was not mutually exclusive; some poorer families (n = 58) exhibited higher levels of nurturance and some wealthier families exhibited lower levels of nurturance (n = 53).

The same post-hoc analyses were conducted to examine the interplay of social interaction and wealth on cognitive development scores. Figure 2 shows children's cognitive development score partitioned by their social partner-wealth gradients. The pattern of results suggests that wealthier children, regardless of the number of and frequency with social interaction, had higher

cognitive development scores. Wealthier children had significantly higher cognitive development scores on average (M = 49.87, SE:0.22) compared to the low-income peers (M = 48.83, SE:0.22), $t(922) = 2.51$, $p < 0.01$. Due to the minimal variation in number of and frequency with social interaction across the entire sample we do not see any strong effects of social interaction on cognitive development.

Figure 3 shows that 3-5-year-old children who enroll in preschool education have higher cognitive development scores compared to 3-5-year-old children who do not enroll in an early education program for all children regardless of wealth status (top quartile wealth enrolled: M = 52.70, SE: 0.27; top quartile wealth not enrolled: M = 49.91, SE:0.30, $t(301) = 6.98$, $p < 0.001$; third quartile wealth enrolled: M = 52.16, SE:0.28; third quartile wealth not enrolled: M = 49.49, SE:0.28, $t(312) = 7.38$, $p < 0.001$); second quartile wealth enrolled: M = 51.78, SE:0.30; second quartile wealth not enrolled: M = 49.25, SE:0.24, $t(307) = 5.50$, $p < 0.001$); and lowest quartile wealth enrolled: M = 51.39, SE:0.30; lowest quartile wealth not enrolled: M = 49.65, SE:0.25, $t(319) = 2.38$, $p < 0.01$). However, children in the top quartile of wealth and who were enrolled in preschool had higher cognitive development scores compared to children in the lowest quartile of wealth who were not enrolled in preschool, $t(304) = 2.03$, $p < 0.05$). Lastly, poorer children are enrolling in formalized preschool at the same rates as their wealthier peers, likely due .

Discussion and Conclusion

This study analyzed a uniquely large-scale and rigorous dataset to examine how early home environments relate to young children's cognitive development in the low-income country of Nicaragua, and it provides new insight into the relative contributions of home characteristics beyond wealth. The results of this study provide evidence that systematic inequities in development emerge as early as two years of age and persist into childhood, which is consistent

with countries around the world (Filmer & Pritchett, 1999). The results also suggest specific ways that a child's proximal social environment may powerfully facilitate their developmental potential, which is also in alignment with the broader literature focused on LMICs (Bronfenbrenner, 1999). More specifically, we found that the early social environment in which a child is raised, the consistency of parenting practices with rules and routines, the enforcement of hygiene practices, the availability and types of stimulating activities a child can and does engage in (e.g. book reading, storytelling, singing, playing and naming things), the frequency of social interaction a child has and the frequency in which they interact, as well as the enrollment into structured learning environments (e.g. preschool), have a meaningful impact on children's developmental potential.

Our data show that a highly structured environment may be one of the most influential mechanisms that support early childhood development. Structure was defined as consistent and frequent use of rules/routines/hygiene practices, varied and stimulating child activities, and access to books in the home. Children who experienced high levels of structure had higher cognitive development score compared to children who experience less structure, regardless of family wealth status. This suggests that, in this context where resources are limited on a national level, structure is a more powerful behavioral mechanism for cognitive development than family wealth in supporting children's cognitive development. While wealth is still a significant factor and has many roles in children's lives, we see that structure in the home plays a powerful role in ameliorating the effects of low wealth in the home. This is crucially important as structure is a factor that is able to be intervened on a large scale. The literature also supports this finding and posits that the proximal environment has a more direct influence compared to distal ecologies (e.g., culture or community) on children's ability to develop competently, especially in high-risk environments (Wyman et al., 1999; Cicchetti, 1993).

The standardized effects of social interactions are more strongly related to cognitive development scores than wealth which suggests that they are important across wealth groups. However, unlike home structure, social interaction does not wipe out the effects within wealth quartiles. Social-partners, interestingly, were less strongly related to children's cognitive development score than wealth status. This finding suggests that it is not the number or frequency of interaction with social partners that has high impacts on children's development in the early years but rather the type of engagement which here, is modeled through the structure factor (Heckman, 2011). This observation of social interactional partners and frequency may be unique to the low-income country of Nicaragua. Alternatively, this effect may be due to the lack of variation in social interaction between low and high-income children in Nicaragua. Future research should explore the relation between wealth and cognition with more nuanced and sensitive measures of social interaction to determine if there are specific quantities or qualities of social interaction that affect cognition like parent involvement, discipline practices, and parent expectations in this context.

In order to comprehensively capture children's early social environment, we also assessed whether enrollment in a formalized preschool for at least 15 hours of the week affects cognitive and social-emotional development. While the long-term effects of preschool enrollment are contentiously debated (Broman, Nichols, & Kennedy, 2017), the literature and evidence in developing nations supports claims that attending preschool benefits children's concurrent and primary school performance (Petrosino, 2012). Although our results cannot speak to the long-term effects of preschool education, we have strong evidence to suggest that enrollment is associated with immediate gains in cognitive development. In this sample, children attended preschool at similar rates regardless of family wealth. This is a testament to this context and the PAININ

program having successfully targeted and sustained enrollment in early education in low-resourced areas (Blanchfield & Browne, 2013) which is compared to many locations globally where access to education is closely tied to wealth. Our data only speak to the enrollment into early formalized schooling and more research is required to elucidate the specific aspects of the schooling environment in this context which supported cognitive and social-emotional development. Yet, it is still promising that simply enrolling children in stimulating environments outside of the home was associated with higher developmental development score.

This study has several possible limitations worth considering. First, it is important to note that assessing the home environment is a difficult task given the complexity of interactions, organizations, cultural norms, and time and budgetary constraints. While the PRIDI team stressed the importance of culturally relevant instruments, it is necessary to be cautious with the scale and its translation in the indigenous language (Verdisco, 2015). Second, while informative, parent report measures may reflect unintended parental bias as there may be systematic variation within the sample in unpredicted ways. Third, it was necessary to use the IEA International Database (IDB) Analyzer software for analyzing PRIDI data as it took into account sample bias and the stratification methods which were used in the data collection process. However, the program was limited in its capabilities which restricted the levels of analyses that we could conduct.

The findings from this project strengthen our understanding of the environmental mechanisms underlying children's cognitive development in Nicaragua. These results are the first to date to account for the context of the early social environment relating to children's developmental potential above and beyond wealth and health in a large-scale way within the region. The research here also suggests that encouraging access to early education programs and

supporting parent-training in culturally existing high structure home contexts may be a productive model for reducing inequality in cognitive development.

The independence of these contextual factors from wealth also suggest that micro-changes in the home environment may be effective, lasting, and achievable on a large scale in promoting developmental potential for children of all SES levels. In this sample, family income was only related to the frequency of families practicing high levels of structure in the household, but for those families with high home structure, even at the lowest quartiles of wealth, children showed higher cognitive development outcomes. These patterns suggest that structure and social interaction partners are not a proxy for wealth, but rather independent factors that may even help to mitigate the negative effects lower levels of wealth have on developmental domains. This provides further support for the theory that the home context may be one influential and malleable mechanism through which the environment affects cognitive development even in low-income context by using a measure designed to be culturally sensitive. Thus, our results imply that supporting families to make small changes in the home environment (i.e., increase structure and enrollment in early education), seems to have a profound effect on developmental potential for all children in Nicaragua, but may be especially important for children reared in lower resourced environments.

Funding

This work was supported by the Institute of Education Sciences, National Center for Education Research [R305B140048]. The opinions expressed are those of the authors and do not necessarily represent views of the Institute of Education Sciences.

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Appendix

Table 1

Descriptive Statistics: Home Environment Characteristics (n=1,834)

Factor	%
Geographic Region	
Urban household	56
Wealth Construct: 4 Factors	
Infrastructure of the home	
Finished walls, floor, or roof	96.7
Rudimentary wall, floor and roof	3.0
Natural wall, floor, and roof	0.3
Assets found in the home (e.g., refrigerator, stove, car)	
0-2 assets	21.8
3-5 assets	36
6-9 assets	37.4
10 + assets	4.8
Access to basic services in the home (e.g., electricity, potable water and sanitation)	
No access	11.9
Access to 1 service	24.4
Access to 2 services	36.6
Access to all 3 services	27.1
Ratio of household members to bedrooms	
< 2:1	30.5
< 4:1	51.1
> 5:1	18.4

Table 2

Descriptive Statistics: Structure and Social Partner Characteristics (n=1,834)

Factor	%
Structure Construct: *4 Factors*	
Number of Children's Books in the Home	
6 or more books	3.7
1-5 books	26
0 books	70.2
Basic Hygiene Practices	
Washes hands before eating/ going to the bathroom, brushing teeth after eating	86.1
2 behaviors practiced	12.2
0-1 behavior practiced	1.8
Rules/ Routines Implemented at Home	
Foods eaten, meal times, bed times, household chores	9.5
2-3 behaviors practiced	56.7
0-1 behaviors practiced	33.8
Number of Activities	
Reading, storytelling, singing, playing, playing and naming things, and drawing	22
4-5 behaviors practiced	35.7
2-3 behaviors practiced	28.0
0-1 behaviors practiced	14.2
Social Partner Construct: 2 Factors	
People who Interact	
Mother, father, other relatives and friends	57.8
3 categories	31.5
2 or fewer categories	10.7
Frequency of Interaction	
Everyday	93.5
3-4 times per week	4.5
Less than 1-2 times per week	2.0
Early education (excluding 2 year olds)	
Enrolled in 3-5 preschool	41.6

Table 3
Bivariate Correlations Among Developmental Outcomes and Home Environment (n=1,834)

	Cognitive Quotient	Early Education	Structure	Social Interaction	Wealth	Maternal Education	Maternal Language
Cognitive Quotient	1	0.34**	0.21**	0.05*	0.07**	0.02	0.04
Early Education		1	0.16**	0.07*	0.12**	0.07*	-.03
Structure			1	0.04**	0.39**	0.01	-0.01
Social Interaction				1	0.00	-0.01	-0.17**
Wealth					1	0.07**	-0.18**
Maternal education						1	0.12**
Maternal language							1

Note: *p < .05; ** p < .01

Table 4

Predicting Cognitive Quotients from Various Weighed Models of Childhood Outcomes (n=1,834)

	β	*SE β*
Age of child	2.99	0.19**
Height-for-age Index	0.31	0.09**
Health rating of child	0.05	0.30
Maternal education	-0.55	0.33*
Maternal language 0 = Spanish 1 = Miskito	1.68	0.35**
Maternal age	0.0	0.01
Geographic region 0 = Urban 1 = Rural	-0.15	0.34
Wealth	0.29	0.11*
Enrollment in early education 0 = Not-enrolled 1 = Enrolled	0.97	0.23**
Structure	0.31	0.12*
Social Interaction	0.42	0.16*

Note: Italicized variables are standardized.

*p < .05; ** p < .01

Table 5

Standardized Regression Coefficients from Various Weighed Models of Cognitive Outcomes (n=1,834)

Variable	*EF*		*Expressive Language*		*Receptive Language*		*Numeracy*		*Reasoning*	
	β	*SE β*	*β*	*SE β*	*β*	*SE β*	*β*	*SE β*	*β*	*SE β*
Age of child	0.47	0.07**	0.48	0.06**	0.20	0.08*	0.25	0.07**	0.37	0.07**
Height-for-age Index	0.05	0.04	0.09	0.04*	0.07	0.05	0.11	0.04*	0.04	0.02*
Health rating of child	-0.06	0.10	0.02	0.14	0.11	0.09	-0.04	0.11	-0.11	0.07
Maternal education	-0.20	0.09*	-0.07	0.12	-0.26	0.21	-0.06	0.13	-0.14	0.13
Maternal language	0.16	0.13	0.11	0.15	0.55	0.14**	0.39	0.13**	0.57	0.13**
Maternal age	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0
Geographic region	0.15	0.11	-0.16	0.10	0.03	0.09	-0.09	0.10	-0.17	0.08*
Wealth	0.06	0.05	0.12	0.06*	0.0	0.04	0.02	0.06	0.09	0.03*
Enrollment in early education	0.18	0.07*	0.28	0.09**	0.19	0.12	0.17	0.11*	0.24	0.10*
Structure	0.13	0.04**	0.12	0.04*	0.03	0.04	0.04	0.05	0.06	0.03*
Social Interaction	0.10	0.08	0.08	0.04*	0.12	0.04**	0.10	0.04*	0.08	0.03**
R_2	0.16		0.23		0.07		0.06		0.15	

Note: Italicized variables are standardized.
*$p < .05$; ** $p < .01$

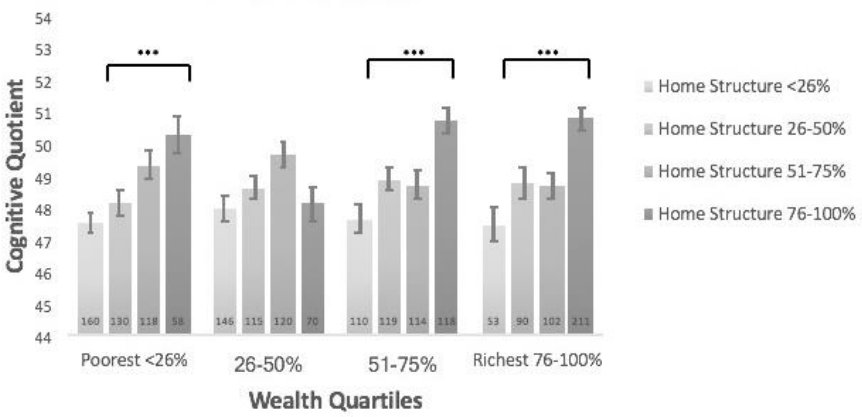

Figure 1. Preschool Enrollment Predicts Cognitive Development Better than Wealth
Note: using two-way t-tests, comparisons were made within wealth quartiles between low and high home structure, *** $p < .001$, 95% confidence intervals.

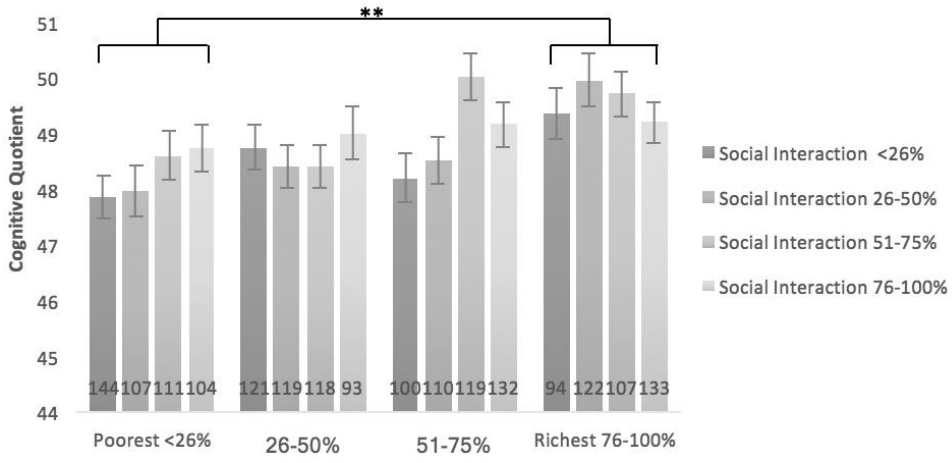

Figure 2. Wealth Predicts Cognitive Development Better than Social Interaction
Note: using two-way t-tests, comparisons were made between low and high wealth as there was no statistical difference in the effect of social interaction within wealth quartiles, ***$p < .001$, 95% confidence intervals.

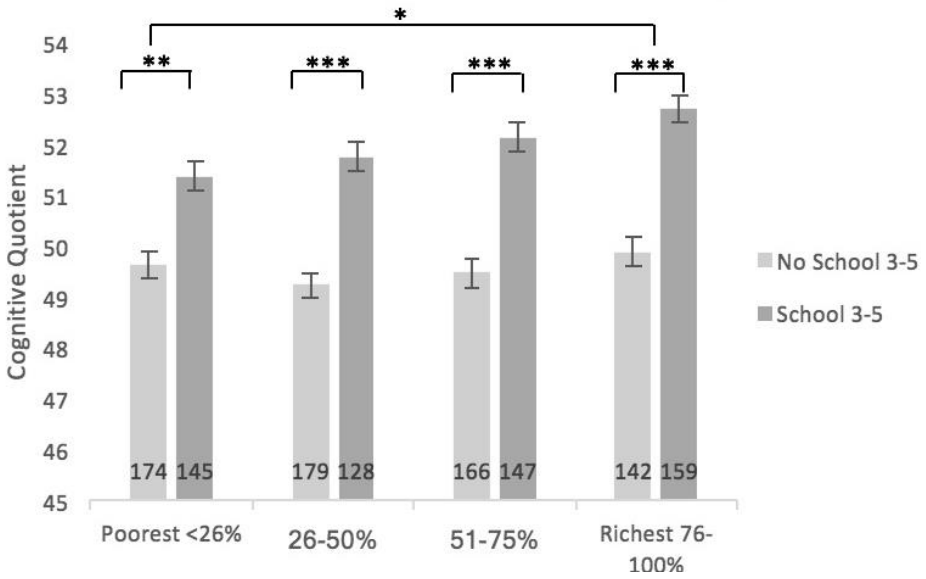

Figure 3. Preschool Enrollment Predicts Cognitive Development Better than Wealth
Note: using two-way t-tests, comparisons were made within wealth quartiles between those enrolled and not enrolled within each question quartile, $^{**}p < .01$, $^{***}p < .001$, 95% confidence intervals.