Associations between poverty, maternal experience of intimate partner violence, and developmental delay among 12-23 month-old children in Nicaragua

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Abstract

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Background: As under-five mortality rates decrease in Nicaragua there is an increased urgency to understand the health of this young population, including factors that affect their developmental trajectories. Delays in early child development (ECD), including language, socio-emotional, motor and cognitive domains, can impact an individual's ability to thrive throughout the life course. ECD trajectories are influenced by numerous biologic, genetic, social and environmental factors. Poverty and maternal experience of intimate partner violence (IPV) are risks of particular interest in Nicaragua, as more than 40% of Nicaraguans live in poverty and an estimated 40% of Nicaraguan women have experienced IPV. This study aims to evaluate the associations between poverty, maternal experience of IPV and ECD outcomes.

Methods: This study utilizes Nicaragua's 2006/2007 Demographic and Health Survey (DHS) data, which includes data from an early child development module. The study population consists of 1,115 children age 12-23 months. Logistic and ordered probit regressions were used to evaluate associations between predictors of interest and developmental delay, taking into account the sampling design.

Findings: In 2006/2007, 41.8% of 12-23 month-old children in Nicaragua had some level of developmental delay, including 21.3% with delays in two or more domains. Poverty is positively associated with presence of any developmental delay and with severity of delay. Maternal experience of IPV is also associated with developmental delay and with severity of delay; this association does not vary by poverty status or child's sex.

Discussion: This study reveals a high prevalence of detectable developmental delay among 12-23 month-old children in Nicaragua. Poverty and maternal experience of IPV are associated with presence and severity of developmental delay in children as young as 12-23 months old in Nicaragua. Early child development interventions are needed to address the current prevalence of delay among young children in Nicaragua. Interventions for impoverished communities or communities with high rates of IPV may be particularly important. Additional research is needed to further explore factors associated with ECD delay among young children in Nicaragua.

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Introduction

Evidence suggests that Nicaragua is on track to meet Millennium Development Goal 4 (MGD4), the goal to reduce child mortality by two-thirds from 1990 levels by 2015 (1,2). As more children are surviving, it is critical to understand the conditions in which these young children are living and the potential health burden this population may face. Child health can be defined as "the extent to which children are able or enabled to develop and realize their potential, satisfy their needs, and develop the capacities that allow them to interact successfully with the biological, physical and social environment" (3). This definition includes functional, social, emotional and cognitive development as critical parts of child health. Early child development (ECD) in these domains can determine a child's ability to remain healthy and to succeed and thrive throughout the life course (4). Children with ECD delays often have lower IQs, lower wages earned over their lifetime, acquire less education, and are more frequently incarcerated than their peers (4,5). Thus, ECD has implications not only for young children, but also for future population health.

ECD is influenced by numerous biologic, genetic, social and environmental factors (6). Risks often co-occur, causing multiple and cumulative risks (6). For instance, poverty may influence early cognitive, functional and socio-emotional development through numerous pathways, including stress and lack of stimulation (7–13). Figure 1 is a conceptual framework that illustrates the main pathways through which poverty influences risk and protective factors (6). This framework is not exhaustive and illustrates only a few key factors as an example of the complexity of these relationships.

Against this backdrop, the effects of violence are increasingly recognized as risk factors for delayed ECD (6,14). A child's direct experience of violence in the household is a known risk factor for delayed ECD (15), but less extreme ongoing stressors that result from a caregiver's experience of violence – such as a lack of warmth among family members or maternal depression – may also impact ECD trajectories (10,12). Evidence increasingly shows that a woman's experience of intimate partner violence (IPV) may affect the development of her children, as an abused or chronically stressed mother may experience difficulty forming healthy bonds with her children (11,16).

Investigating population-level trends in early child development in relation to these risk factors could inform policy and programming decisions to support the healthy development of young children. Despite the importance of ECD to a country's health and economic well-being, national statistics on young children's functional, cognitive, and social-emotional development are not available for most developing countries (17). Lack of commitment to child development is recognized as a community-level risk factor for poor ECD outcomes (18). Gaps in measurement of developmental delays in these domains contributes to the invisibility of the global problem of poor early child development (17,19).

In 2005, the Inter-American Development Bank (IDB) received a grant from the Canadian Technical Cooperation to collect data on child health. One aim was to explore the feasibility of measuring early developmental delay in a household survey. An ECD module was developed to identify children with developmental delays by asking mothers of children 7 to 59 months of age a series of five questions related to the child's functional, cognitive, and social-emotional development. A template of questions was developed and adapted to Honduras, Chile and

Nicaragua. Country-specific iterations of the module were implemented in Honduras and in Chile in 2005 and 2006 (20,21). Nicaragua's ECD Module was validated and implemented alongside the 2006/2007 Demographic and Health Survey (DHS) (22).

In Nicaragua, as in other developing countries, poverty and exposure to violence are risk factors of particular interest. Although poverty decreased by about 4% between 1993 and 2005, as of 2009 42.5% of Nicaraguans still lived below the national poverty line (23,24), and in rural areas about 68% of the population lives in poverty (23). IPV is also significant public health problem in Nicaragua (16,25). A study in León, Nicaragua found that 40% of women of reproductive age were exposed to physical violence by a partner (26). Recent studies from Nicaragua have particularly investigated the effect of IPV on child health outcomes (16,25). One study showed that maternal lifetime experience of IPV is associated with increased child mortality (16). Another revealed that maternal exposure to IPV during pregnancy is associated with a lower mean height-for-age Z-score among young girls (but not young boys) (25). These studies expose the serious adverse effects of maternal exposure to IPV on their children. However, they only explore the deleterious effects on child growth and physical development, missing other domains of early child development.

This study aims to evaluate population-level associations between poverty, maternal experience of IPV and ECD delay in 12-23 month-old children using data from the ECD Module and the DHS. Our hypothesis is that both poverty and maternal experience of IPV are associated with higher prevalence of developmental delay among 12-23 month-old children in Nicaragua. We also hypothesize that the association between maternal experience of IPV and delay is greater for impoverished children, and is greater for young girls than young boys.

Methods

Data

The current study analyzes data from Nicaragua's 2006/2007 DHS. The DHS is a nationally representative household survey conducted by trained interviewers with the informed consent of the interviewee, and follows international protocols for consent and privacy of information (27). Additional precautions around safety and ethical procedures are taken when the domestic violence module is implemented, to ensure the safety of the respondent. In Nicaragua's 2006/2007 DHS, the primary sampling unit was census tracts within each department, where census tracts were randomly selected with sampling probability proportional to size for 320 urban and 318 rural census tracts. The secondary sampling stage was the selection of 30 households within the census tract, and the final sampling stage randomly select one woman of reproductive age (age 15 to 49) within the household to interview (27). For women with children, an additional set of questions is asked about one, randomly selected child under age five, to gather key information about child health. Anthropometric measures are taken of this child, using standard DHS protocols across all countries (28). The ECD Module is administered to the mother or caregiver with regards to the selected child under age five in the 2006/2007 DHS.

The Nicaragua 2006/2007 DHS had a 94% response rate, resulting in a sample of 14,221 women and 34,055 children (27). The ECD Module was administered to mothers of more than 5,000 children 7-59 months of age. The ECD Module performs best for children age 12-23 months

(sensitivity: 79%, specificity: 100%) so the analysis is restricted to this sub-group (22). A total of 1,125 12-23 month-old children comprise the study population.

Key variables

Early child development

Early child development was measured in Nicaragua using the aforementioned ECD Module (22). Regarding children in the 12-23 month age group, a DHS interviewer asks a mother the following five questions:

- *Does ____ play with other children?*
- *Does ____ identify one or more parts of the body, such as eyes, nose, mouth or ears?*
- *Does ____ walk on their own?*
- *Does ____ follow simple orders, of just one action, such as "Pass me the cup/plate"?*
- *Does ____ show you what they want with actions and words such as "Give me that," or "Take this"?*

These questions capture socio-emotional, cognitive, gross motor and language development, and complex communication (22). The ECD module results in an ordered categorical outcome, in which the number of negative responses serves as an indicator of severity of developmental delay. For the purposes of this study, we define the following ECD Module outcomes:

Typical development:	All positive responses to the ECD Module
Any delay:	One or more negative responses
Emerging delay:	Only one negative response
Established delay:	Two or more negative responses

The ECD module is not a screening tool and does not diagnose young children with developmental delay. Rather, the ECD module identifies population-level patterns in developmental trajectories and allows for population-level estimation of trends in prevalence of delays (22).

Poverty

For this analysis, "poverty" was defined as classification in the lowest wealth quintile. Wealth quintile is a standard variable in the DHS. It is constructed with asset-based wealth index that aims to approximate socio-economic status in a more meaningful way than simply a measure of household income or quantifiable assets. The index is constructed using principal components analysis (29).

Intimate partner violence

A domestic violence module was added to DHS in 1998 and is included in most DHS surveys around the world, including the 2006/2007 DHS in Nicaragua (27,30). Women are asked a series of questions about experiences of physical or sexual violence with their current and past partners, both over their lifetime and over the past year. Lifetime experience of IPV was included in all models; experience of IPV in the past year will be evaluated as a sensitivity

analysis. These classifications are consistent with other studies that have evaluated IPV using DHS and survey data (16,25,31).

Other predictors

All models were adjusted for additional variables that are associated with child development, consistent with other literature in this field (6,18). Models were adjusted by region (Pacific region [Chinandega, León, Managua, Masaya, Granada, Carazo, and Rivas departments], North-Central region [Boaco, Chontales, Jinotega, Matagalpa, Estelí, Madriz, and Nueva Segovia departments], and Atlantic region [Río San Juan department, Autonomous North-Atlantic Region, and Autonomous South Atlantic Region]), urban/rural residence (designated by census tracts), maternal age, maternal education (completion of primary school), high parity (four or more children), child's age in months, child's sex, stunting (two standard deviations less than the height-for-age Z-score by WHO standards (28)), and premature birth (less than nine months gestation). Low birthweight and breastfeeding were not included because these variables in the DHS are constructed using maternal recall and may not be reliable (27).

Statistical analysis

Data cleaning

In the 2006/2007 Nicaragua DHS, the ECD Module was applied to 1,125 children age 12-23 months. Ten of these children did not have a complete module and were dropped from the analysis, leaving 1,115 children in the full study dataset. IPV variables were missing for 59 children and anthropometry measures, used to calculate stunting, were missing for 62 children. One child was missing data on premature birth. There were 993 children in a restricted dataset of only complete observations (no missingness) (see Figure 2). The full and restricted datasets were compared, and crude associations between each predictor of interest and ECD Modules outcomes were evaluated (see Table 1 and Appendix A). No substantial differences were found; thus, imputation was not used. All following analyses were conducted using the restricted dataset.

Analysis

Two types of regression were used to evaluate the relationships between poverty and maternal experience of IPV and ECD delay: logistic regression to assess the presence or absence of delay and ordered probit regression to assess the full gradient of possible ECD Module outcomes. All models include poverty and maternal lifetime experience of IPV as the predictors of interest. Models were adjusted for geographic variables: region and urban/rural residence; maternal variables: maternal age group, maternal education, and parity; and child-level variables: premature birth, stunting, child's sex and child's age in months. Adjusting by child's age in months is important because children develop quickly between 12-23 months of age, and older children in this age group have reached substantially more developmental milestones than younger children in this age group.

Logistic regression was used to evaluate the presence of developmental delay as a binary outcome using two different thresholds for ECD delay. The lower threshold evaluated was presence of any ECD delay, which captures any child who has not met all five criteria in the

module at the time of the interview. The higher threshold evaluated was presence of established developmental delay, which captures children who have not met two or more criteria in the module. Predictors listed above were included in all models. In addition, interaction terms between maternal experience of IPV and poverty and between maternal experience of IPV and child's sex were evaluated to asses whether the effect of maternal experience of IPV is different among poor versus non-poor children, or among young boys versus young girls.

An ordered probit regression model was then used to evaluate the full gradient of possible ECD outcomes. Ordered probit models predict ordered categorical outcome variables – in this case the number of negative responses to the ECD Module. For the purposes of this study, this analysis reveals whether a predictor is associated with the severity of developmental delay. Estimates from the ordered probit model indicate whether a change in a specific variable is associated with a change along the gradient of possible outcomes for a single observation (in this case, a child). The ordered probit model assumes the relationship:

$$P_n(1) = \phi\ (\alpha_1 - \beta_j X_n)$$

$$P_n(j) = \phi\ (\alpha_1 - \beta_j X_n) - \phi(\alpha_{j-1} - \beta_j X_n), j = 2, \ldots, j-1$$

$$P_n(J) = 1 - \sum_{j=1}^{J-1} P_n\ (j)$$

In this model, $P_n(J)$ is the probability that subject n belongs to category j, α_j is an alternative specific constant, X_n is a vector for measurable characteristics specific to subjects, β_j is a vector of estimable coefficients, and ϕ is the cumulative standard normal distribution function. In this study, this model assumes the standard normal distribution for F. For all probabilities to be positive, we must have $\alpha_1 < \alpha_2 < \ldots < \alpha_{J-1}$ (32).

Alternative model specifications

All models were also run using maternal experience of IPV in the past year as a predictor, rather than lifetime experience of IPV.

All analyses were conducted using Stata SE 13, taking into account the sample frequency weights provided by the DHS to reproduce the national population.

Results

Descriptive results

In the study population, 30.7% of the children were from households in the lowest wealth quintile. A slight majority of mothers were in the youngest maternal age group (50.7% of mothers were 15-24 years old), and 47.5% of mothers never finished primary school. Prevalence of lifetime experience of IPV was lower in the study population than in other studies in Nicaragua. In the current study, 23.5% of mothers reported lifetime experience of IPV and 9.7% had experienced IPV in the past year.

In this population, 41.8% of children had some level of developmental delay, and 21.3% had an established delay. The question in the ECD module that was most frequently missed was Question 2 (Can ____ identify one or more parts of the body, such as eyes, nose, mouth or ears?). See Table 2 for a breakdown of ECD module responses by question, and Table 3 for ECD modules responses by number of negative responses, indicating severity of developmental delay.

Model results

Logistic regression

Logistic regression for any developmental delay estimates the change in the odds of any developmental delay (a negative response to any of the five questions in the ECD Module) associated with the presence of the model predictors. Factors that are associated with higher odds of any developmental delay include poverty (adjusted odd ratio [OR] 2.01, 95% CI 1.16 to 3.47), lifetime maternal exposure to IPV (OR 1.89, 95% CI 1.21 to 2.97), and stunting (OR 1.01, 95% CI 1.00 to 1.01). In comparison to the Pacific region, being a resident in the North-Central region is associated with higher odds of delay (OR 1.89, 95% CI 1.20 to 3.00), but the Atlantic region is not significantly different from the Pacific region. Full results are in Table 4.

Logistic regression for established developmental delay estimates the change in the odds of established developmental delay (a negative response to two or more questions in the ECD Module) associated with the presence of the model predictors. Stunting is associated with higher odds of established developmental delay (OR 1.01, 95% CI 1.01 to 1.02). In comparison to the Pacific region, the North-Central region is associated with higher odds of delay (OR 1.73, 95% CI 1.07 to 2.79), but the Atlantic region is not significantly different from the Pacific region. Full results are in Table 4.

No significant interactions were found between maternal experience of IPV and child's sex, or maternal experience of IPV and low wealth quintile. This result indicates that the association between maternal lifetime experience of IPV and ECD delay is similar across poverty groups and sexes (data not shown).

Ordered probit regression

Poverty, lifetime experience of IPV, high parity, and stunting are associated with greater likelihood of higher categories of developmental delay, indicating that these variables are associated with severity of ECD delay. In comparison to the Pacific region, the North-Central region is associated with a greater likelihood of higher categories of developmental delay, but the Atlantic region is not significantly different from the Pacific region. Full results are in Table 5.

Alternative model specifications

The effect of experience of IPV in the past year was not substantially different than the effect of lifetime experience of IPV in any of the models (see Appendix B).

Discussion

This study aimed to evaluate population-level associations between poverty, maternal experience of IPV, and early developmental delay. With these data, Nicaragua is among the first countries in Latin America to have nationally representative data on early child development (ECD) at a population level for children under age three (20–22). Thus, one of the most critical findings of this study is simply the high, previously unknown prevalence of developmental delay in this very young population in Nicaragua. This study indicates that 41.8% of children age 12-23 months had detectable ECD delay in 2006/2007. The ECD Module is highly specific (sensitivity: 79%; specificity: 100%), and may underestimate the true prevalence of delay. Understanding the factors that influence early developmental trajectories is even more urgent in this high-prevalence context.

Poverty is associated with both the presence and severity of developmental delay among 12-23 month-old children in Nicaragua, consistent with our hypothesis. These analyses control for a number of predictors that are often associated with poverty, including stunting, low maternal education, and rural residence, indicating that poverty is independently associated with worse developmental outcomes. This is consistent with evidence that other pathways, such as lack of stimulation or toxic stress, may be important in the relationship between poverty and adverse developmental outcomes (7,11,33,34). These results also suggest that inequities in developmental trajectories related to poverty emerge early in life. The detrimental effects that poverty has on child development make early child development interventions especially critical for impoverished communities.

In this population, maternal experience of IPV is correlated with developmental delay in children 12-23 months of age. The strength and direction of this association is similar to the association between poverty and developmental delay. This analysis also indicates that the effect of maternal experience of IPV on ECD does not vary significantly between poor and non-poor families. This suggests that IPV has a deleterious effect on ECD regardless of wealth.

Similarly, the effect of maternal experience of IPV on ECD does not vary significantly between young boys and young girls in this age group. This is counter to the original hypothesis that maternal experience of IPV may be associated with adverse ECD outcomes only in young girls. Other literature from Nicaragua suggests that child's sex is associated with variations in the effect IPV on child growth outcomes (25). Future research is needed to investigate the mechanisms by which a child's sex affects their development in the presence of other risk factors (such as maternal experience of IPV), and to investigate the age at which variations by gender emerge. It is possible that gender disparities do not emerge in this young age group, or that gender disparities affect some developmental outcomes but not others.

Maternal experience of IPV is an important factor associated with ECD delay, even in child as young as 12-23 months of age. In this study, more than 20% of women have experience IPV in their lifetime, and other studies suggest that 40% of Nicaragua women have experienced IPV in their lifetime (16,26). Women who experience IPV also experience related emotional distress (35), which may affect the ability to bond with and care for their children (16).The deleterious effects of IPV on child health have been shown to affect child growth outcomes (25). The current study suggests that there may be an additional, independent association between maternal experience of IPV and ECD delay, beyond that which could be explained by child

growth. Further research is needed to understand the strength and timeliness of the relationship between IPV and child health in Nicaragua. The relationship between maternal experience of IPV and ECD outcomes tend to vary across geographies, suggesting that the pathways of effect differ depending on contextual factors (31).

Consistent with other literature in this field, this analysis indicates that a variety of both distal and proximal factors are associated with early child development outcomes (6). It is notable that these models include numerous possible risk and protective factors, yet few of these conventionally measured factors were significantly associated with ECD delay. This suggests that the high prevalence of ECD delay in this population is not fully explained by these variables. There may be other factors contributing to the high burden of ECD delay in Nicaragua. Future work should further explore factors associated with ECD delay in this population.

Limitations

Causative relationships between associated factors and developmental outcomes cannot be established because this is a cross-sectional study. The ECD module was only implemented in Nicaragua in 2006/2007; the more recent DHS in 2010/2011 did not include this module. Thus, this study provides only a baseline description of ECD and key associated factors. Additional research is needed to assess causality and timeliness of presentation of developmental delays related to these risk factors. Though many of the relationships between these variables have been described in other countries, social determinants and family influences in particular are known to vary in their associations with child health and development outcomes in different contexts (34,36). Therefore, studies such as this one are important to understanding context-specific relationships among these factors so that appropriate policies and interventions can be targeted to local needs.

Response bias may affect some of the predictors in this study. For instance, low birthweight is associated with adverse development outcomes in young children. However, the DHS measures low birthweight for this age group via maternal self-report, which is unreliable. This variable was excluded from this analysis in favor of more reliable measures. In addition, misreporting and underreporting of IPV may be present. Other studies in Nicaragua suggest that 40% of women experience IPV in their lifetime, where the current study shows that 23.5% of women interviewed reported lifetime experience of IPV (16,26). Numerous studies indicate that women tend to minimize episodes of violence due to self-blame, fear, a desire to protect the abuser, and numerous other factors (26). In addition, there tends to be a great reluctance among rural women and women of higher socioeconomic status to disclose violence, which may further cloud the results (26). However, although IPV may be underreported in this study it is likely underreported among all women, and any effect is likely nondifferential.

Finally, the ECD Module used is a high-performing tool for estimating population-level ECD outcomes, but the module's performance characteristic must also be considered in the interpretation of results. The ECD module is 79% sensitive and 100% specific among children age 12-23 months, which is highly acceptable as a tool for evaluating trends in population health (22). Given these performance characteristics, it is likely that the ECD Module actually underestimates the prevalence of ECD delay in this age group. We can assume that this underestimation is random, and that the effect is nondifferential.

Conclusions

Understanding early child development in Nicaragua is an important step toward developing policies and interventions that can support child health. This study provides a first look at associations between developmental delays, poverty, and maternal experience of IPV among 12-23 month-old children in Nicaragua. It is sobering that in 2006/2007, 21.3% of one year-olds in Nicaragua had established developmental delay, and an additional 20.5% showed emerging developmental delay.

This study confirms that poverty is independently associated with developmental delay in this young Nicaraguan population. This study also illuminates the association between maternal experience of IPV presence and severity of delay even in children as young as 12-23 months, adding to recent studies form Nicaragua on the deleterious effects of maternal experience of IPV on child health.

Notably, these analyses include many conventionally studied risk factors for developmental delay, but few of them were significantly associated with developmental delay in the study population. These variables do not explain the high prevalence of ECD delay in Nicaragua. This finding suggests that population-level determinants of early developmental delay for this age group are not yet well understood in the Nicaraguan context.

These finding provide a call to action for policymakers and the stakeholders in maternal and child health in Nicaragua. Effective and accessible early child development interventions are needed to address the prevalence of delay among young children in Nicaragua. Interventions for impoverished communities or communities with high rates of IPV may be particularly important. Additional studies to explore context-specific risk and protective factors for children in this age group will be critical to shaping early child development policies and programs that are appropriate to the Nicaraguan context and other countries in the region. The WHO Commission on Social Determinants of Health recognizes that “social and economic policies addressing early child development can affect whether children develop to their potential or experience a constrained life-course trajectory,” (4). Addressing ECD inequalities and the high prevalence of ECD delays has important implications for the future health and economic stability of Nicaragua, as these early developmental trajectories influence population health for years to come.

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TABLES AND FIGURES

Table 1. ***Descriptive statistics of study population, including full and restricted datasets.***

		Full dataset* (n=1115)	Restricted dataset◆ (n=993)
Variable		**% (N)✚**	**% (N)✚**
Wealth quintile	Highest	15.3 (122)	14.2 (102)
	4	14.4 (161)	15.1 (144)
	3	17.4 (195)	16.7 (172)
	2	22.9 (268)	23.2 (245)
	Lowest	30.0 (369)	30.7 (330)
Rural Indicator	Urban	49.8 (473)	48.1 (405)
	Rural	50.2 (642)	51.9 (588)
Region	Pacific	50.4 (460)	50.1 (413)
	North-Central	34.1 (442)	34.5 (392)
	Atlantic	15.5 (213)	15.4 (188)
Maternal age group	15-24	51.9 (549)	50.7 (482)
	25-34	39.1 (452)	39.8 (408)
	35+	9.0 (114)	9.5 (103)
Low maternal education[1]	No	53.9 (583)	52.4 (512)
	Yes	46.1 (532)	47.6 (481)
High parity	No	78.2 (903)	76.5 (783)
	Yes	21.8 (222)	23.5 (210)
Lifetime experience of IPV[2]	No	76.5 (808)	76.4 (758)
	Yes	23.5 (251)	23.6 (235)
	Missing	*-- (56)*	--
IPV in the past year	No	90.4 (959)	90.3 (901)
	Yes	9.6 (100)	9.7 (92)
	Missing	*-- (56)*	--
Child's sex	Female	50.2 (559)	50.5 (495)
	Male	49.8 (556)	49.5 (498)
Premature[3]	No	95.9 (1075)	96.0 (959)
	Yes	3.9 (39)	4.0 (34)
	Not sure	*0.2 (1)*	--
Stunting[4]	No stunting	82.7 (874)	82.1 (826)
	Stunting	17.2 (172)	17.9 (167)
	Missing	*-- (69)*	--

** Full dataset includes all 12-23 months old with a complete ECD module; N for specific values may vary due to missingness*

◆ *Restricted dataset includes only children with no missing values in any of the covariates under study*

✚ *Percentages are weighted using DHS sampling weights.*

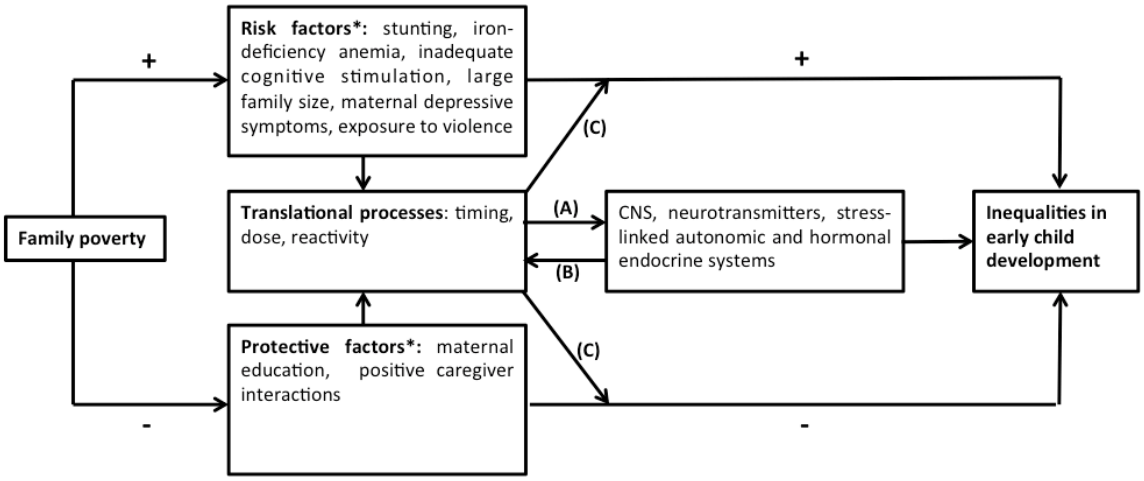
[1] *Did not complete primary school*

[2] *IPV: intimate partner violence; includes physical and sexual abuse by a spouse or partner*

[3] *Defined by maternal recall, whether a child reached nine months gestations*

[4] *Height-for-age Z-score two standard deviations away from the mean, by World Health Organization standards.* (28)

Figure 1: ***Pathways linking poverty, risk and protective factors, and inequalities in early child development (adapted from Walker et al. 2011*** (6)***)***



** Risk and protective factors listed represent only a small sample of some conventionally studied factors related to ECD. These are not exhaustive lists, and serve only to illustrate the complexity of these relationships*

(A) Timing, dose, and differential reactivity influence how individual exposure to risk and protective factors translate into individual different in brain function and structure

(B) Brain structure and function influence the degree of differential reactivity shown

(C) Timing and dose of exposure, and differential reactivity moderate the effect of risk and protective factors on early child development

Figure 2. ***Study profile.***

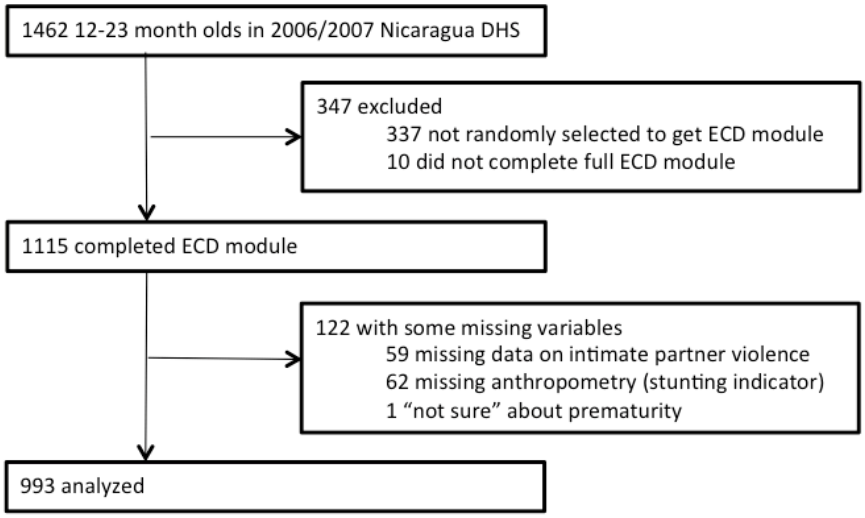


Table 2. ***ECD module responses by question.***

	Full dataset* (n=1115)	Restricted dataset◆ (n=993)
Question	**Negative response % (N)✚**	**Negative response % (N)✚**
Q1. Does ____ play with other children?	6.0 (67)	5.8 (58)
Q2. Can ____ identify one or more parts of the body, such as eyes, nose, mouth or ears?	25.7 (287)	25.3 (251)
Q3. Can ____ walk on their own?	15.8 (176)	16.3 (162)
Q4. Can ____ follow simple orders, of just one action, such as "Pass me the cup/plate"?	17.9 (200)	18.1 (180)
Q5. Can ____ show you what they want with actions and words such as "Give me that," or "Take this"?	11.0 (123)	10.9 (108)

** Full dataset includes all 12-23 months old with a complete ECD module; N for specific values may vary due to missingness*

◆ *Restricted dataset includes only children with no missing values*

✚ *Percentages are weighted using DHS sampling weights.*

Table 3. ***Number of negative responses to ECD modules.***

	Full dataset * (n=1115)	Restricted dataset◆ (n=993)
Number of negative responses⊙	**% (N)✚**	**% (N)✚**
0	58.1 (648)	58.2 (578)
1	20.8 (232)	20.5 (204)
2	11.7 (130)	11.7 (116)
3	5.7 (64)	6.0 (60)
4 or 5[1]	3.7 (41)	3.5 (35)

** Full dataset includes all 12-23 months old with a complete ECD module; N for specific values may vary due to missingness*

◆ *Restricted dataset includes only children with no missing values*

✚ *Percentages are weighted using DHS sampling weights.*

⊙ *Number of negative responses is a proxy for severity of developmental delay.*

[1] *Only 5 children in the full dataset and 3 in restricted had 5 negative responses in the ECD module; thus the highest category of negative responses is grouped as 4 or 5 negative responses.*

Table 4. ***Odds ratios for ECD delay, analyzed with logistic regression and adjusted by all covariates listed.***

		Any delay◆		Established delay✚	
Variable		**OR**	**95% CI**	**OR**	**95% CI**
Lowest wealth quintile		2.01**	1.16, 3.47	1.54	0.90, 2.64
Rural indicator		1.02	0.59, 1.76	1.56*	0.93, 2.60
Region[1]	**North-Central**	1.89***	1.20, 3.00	1.73**	1.07, 2.79
	Atlantic	0.86	0.49, 1.50	1.26	0.73, 2.20
Maternal age group[2]	**15-24**	1.34	0.84, 2.13	1.32	0.75, 2.32
	35+	2.05	0.76, 5.53	0.90	0.39, 2.06
Low maternal education[3]		0.79	0.45, 1.38	0.79	0.44, 1.41
High parity		1.50	0.87, 2.60	1.69	0.84, 3.39
Lifetime experience of IPV[4]		1.89***	1.21, 2.97	1.35	0.77, 2.37
Age in months		0.75***	0.69, 0.80	0.67***	0.61, 0.74
Male		1.17	0.77, 1.77	1.33	0.83, 2.12
Premature birth[5]		0.52	0.19, 1.39	0.57	0.14, 2.27
Stunting[6]		1.01***	1.00, 1.01	1.01***	1.01, 1.02

◆ *One or more negative responses on the ECD module; lowest threshold for ECD delay*

✚ *Two or more negative response on the ECD module; higher threshold for ECD delay*

** = p-value < 0.1; ** = p-value <0.05; *** = p-value<0.01*

[1] *Pacific region is reference group*

[2] *Age 25-34 is reference group*

[3] *Did not complete primary school*

[4] *IPV: intimate partner violence; includes physical and sexual abuse by a spouse or partner*

[5] *Defined by maternal recall, whether the child reached 9 months gestation*

[6] *Height-for-age Z-score two standard deviations away from the mean, by World Health Organization standard* (28)

Table 5. ***Estimates of associations with severity of developmental delay, analyzed with an ordered probit regression and adjusted by all covariates listed.***

		Ordered probit regression results	
Variable		**Coefficient◆**	**95% CI**
Lowest wealth quintile		0.313**	0.050, 0.575
Rural indicator		0.061	-0.223, 0.346
Region[1]	**North-Central**	0.356***	0.123, 0.589
	Atlantic	0.012	-0.266, 0.289
Maternal age[2] group	**15-24**	0.195*	-0.037, 0.427
	35+	0.284	-0.139, 0.707
Low maternal education[3]		-0.079	-0.362, 0.204
High parity		0.314**	0.042, 0.585
Lifetime experience of IPV[4]		0.214**	0.001, 0.427
Age in months		-0.176***	-0.211, -0.140
Male		0.125	-0.084, 0.334
Premature birth[5]		-0.267	-0.815, 0.280
Stunting[6]		0.005***	0.003, 0.007
Thresholds		**Coefficient◆**	**95% CI**
α1		-2.122***	-2.816, -1.427
α2		-1.314***	-1.998, -0.629
α3		-0.652*	-1.320, 0.015
α4		-0.136	-0.766, 0.493
Parameters			
F (13, 443)	15.74		
Prob >F	0.0000		

◆ *Magnitude of coefficients is not directly interpretable; direction and statistical significance of result estimate how predictors are associated with an individual's likelihood of higher (positive estimates) or lower (negative estimates) categories of developmental delay.*

** = p-value < 0.1; ** = p-value <0.05; *** = p-value<0.01*

[1] *Pacific region is reference group*

[2] *Age 25-34 is reference group*

[3] *Did not complete primary school*

[4] *IPV: intimate partner violence; includes physical and sexual abuse by a spouse or partner*

[5] *Defined by maternal recall, whether the child reached 9 months gestation*

[6] *Height-for-age Z-score two standard deviations away from the mean, by World Health Organization standards* (28)

APPENDIX A: CRUDE ASSOCIATIONS FOR KEY VARIABLES

Table A: Crude associations between predictors of interest and ECD module outcomes, estimated using logistic regression.

		Full dataset		Restricted dataset	
Variable		**OR**	**95% CI**	**OR**	**95% CI**
Poverty		1.99**	1.43, 2.77	2.10**	1.48, 2.99
Rural indicator		1.47**	1.07, 2.03	1.84**	1.28, 2.67
Region[1]	**North-Central**	1.95**	1.37, 2.77	1.90**	1.27, 2.84
	Atlantic	1.45	0.95, 2.21	1.93**	1.22, 3.05
Maternal age group[2]	**15-24**	1.07	0.74, 1.54	1.01	0.68, 1.52
	35+	1.89**	1.04, 3.44	1.14	0.60, 2.16
Low maternal education[3]		1.33	0.97, 1.82	1.43	0.99, 2.08
High parity		1.60	1.11, 2.31	1.55	0.99, 2.41
Lifetime experience of IPV[4]		1.38	0.96, 1.97	0.99	0.62, 1.60
Experience of IPV in past year[4]		1.36	0.79, 2.32	1.10	0.57, 2.12
Age in months		0.79***	0.74, 0.84	0.79***	0.74, 0.84
Male		1.13	0.81, 1.58	1.30	0.86, 1.96
Premature birth[5]		0.35	0.15, 0.83	0.31	0.12, 0.79
Stunting[6]		1.01**	1.00, 1.01	1.01***	1.00, 1.01

** = p-value < 0.1; ** = p-value <0.05; *** = p-value<0.01*

[1] *Pacific region is reference group*

[2] *Age 25-34 is reference group*

[3] *Did not complete primary school*

[4] *IPV: intimate partner violence; includes physical and sexual abuse by a spouse or partner*

[5] *Defined by maternal recall, whether the child reached 9 months gestation*

[6] *Height-for-age Z-score two standard deviations away from the mean, by World Health Organization standard (28)*

APPENDIX B: MODELS USING MATERNAL EXPERIENCE OF IPV IN THE PAST YEAR

Table B1. Odds ratios for ECD delay, analyzed with logistic regression and adjusted by all covariates listed.

		Any delay◆		Established delay✚	
Variable		**OR**	**95% CI**	**OR**	**95% CI**
Lowest wealth quintile		1.97**	1.16, 3.37	1.53	0.90, 2.61
Rural indicator		1.03	0.60, 1.77	1.59*	0.96, 2.64
Region[1]	**North-Central**	1.86***	1.18, 2.95	1.72**	1.07, 2.78
	Atlantic	0.85	0.48, 1.49	1.25	0.72, 2.17
Maternal age group[2]	**15-24**	1.29	0.81, 2.06	1.27	0.72, 2.23
	35+	2.13	0.82, 5.56	0.90	0.39, 2.07
Low maternal education[3]		0.82	0.47, 1.45	0.82	0.46, 1.46
High parity		1.51	0.89, 2.59	1.71	0.85, 3.42
Experience of IPV in past year[4]		1.95**	1.07, 3.56	1.66	0.74, 3.74
Age in months		0.75***	0.70, 0.80	0.67***	0.61, 0.74
Male		1.15	0.76, 1.74	1.32	0.83, 2.12
Premature birth[5]		0.50	0.18, 1.36	0.56	0.15, 2.19
Stunting[6]		1.01***	1.00, 1.01	1.01***	1.01, 1.02

◆ *One or more negative responses on the ECD module; lowest threshold for ECD delay*

✚ *Two or more negative response on the ECD module; higher threshold for ECD delay*

** = p-value < 0.1; ** = p-value <0.05; *** = p-value<0.01*

[1] *Pacific region is reference group*

[2] *Age 25-34 is reference group*

[3] *Did not complete primary school*

[4] *IPV: intimate partner violence; includes physical and sexual abuse by a spouse or partner*

[5] *Defined by maternal recall, whether the child reached 9 months gestation*

[6] *Height-for-age Z-score two standard deviations away from the mean, by World Health Organization standard* (28)

Table B2. Estimates of associations with severity of developmental delay, analyzed with an ordered probit regression and adjusted by all covariates listed.

		Ordered probit: All module outcomes	
Variable		**Coefficient**	**95% CI**
Lowest wealth quintile		0.309**	0.050, 0.569
Rural indicator		0.058	-0.228, 0.344
Region[1]	**North-Central**	0.348***	0.115, 0.581
	Atlantic	0.003	-0.275, 0.281
Maternal age[2] **group**	**15-24**	0.181	-0.054, 0.417
	35+	0.289	-0.127, 0.706
Low maternal education[3]		-0.054	-0.339, 0.230
High parity		0.317**	0.049, 0.585
Experience of IPV in past year[4]		0.230	-0.048, 0.507
Age in months		-0.174***	-0.210, -0.139
Male		0.118	-0.091, 0.328
Premature birth[5]		-0.275	-0.825, 0.276
Stunting[6]		0.005***	0.003, 0.007
Thresholds		**Coefficient**	**95% CI**
α1		-2.143***	-2.836, -1.450
α2		-1.337***	-2.020, -0.654
α3		-0.675**	-1.339, -0.010
α4		-0.157	-0.785, 0.471
Parameters			
F (13, 443)	13.93		
Prob >F	0.0000		

◆ *Magnitude of coefficients is not directly interpretable; direction and statistical significance of result estimate how predictors are associated with an individual's likelihood of higher (positive estimates) or lower (negative estimates) categories of developmental delay.*

** = p-value < 0.1; ** = p-value <0.05; *** = p-value<0.01*

[1] *Pacific region is reference group*

[2] *Age 25-34 is reference group*

[3] *Did not complete primary school*

[4] *IPV: intimate partner violence; includes physical and sexual abuse by a spouse or partner*

[5] *Defined by maternal recall, whether the child reached 9 months gestation*

[6] *Height-for-age Z-score two standard deviations away from the mean, by World Health Organization standards* (28)