Published by Oxford University Press on behalf of the International Epidemiological Association *International Journal of Epidemiology* 2010;**39**:285–294

doi:10.1093/ije/dyp272

# Child development in a birth cohort: effect of child stimulation is stronger in less educated mothers

**Aluísio J D Barros,[1]* Alícia Matijasevich,[1] Iná S Santos[1] and Ricardo Halpern[2]**

**Accepted** 7 July 2009

**Background** Child health has improved in many developing countries, bringing new challenges, including realization of the children's full physical and intellectual potential. This study explored child development within a birth cohort, its psychosocial determinants and interactions with maternal schooling and economic position.

**Methods** All children born in Pelotas, Brazil, in 2004, were recruited to a birth cohort study. These children were assessed at birth and at 3, 12 and 24 months of age. In this last assessment involving 3869 children, detailed information on socio-economic and health characteristics was collected. Child development was assessed using the screening version of Battelle's Development Inventory. Five markers of cognitive stimulation and social interaction were recorded and summed to form a score ranging from 0–5. The outcomes studied were mean development score and low performance (less than 10th percentile of the sample).

**Results** Child development was strongly associated with socio-economic position, maternal schooling and stimulation. Having been told a story and owning a book were the least frequent markers among children with score 1. These children were 8.3 times more likely to present low performance than those who scored 5. The effect of stimulation was much stronger among children from mothers with a low level of schooling—one additional point added 1.7 on the child's development for children of low-schooling mothers, whereas only 0.6 was added for children of high-schooling mothers.

**Conclusions** Our stimulation markers cannot be directly translated into intervention strategies, but strongly suggest that suitably designed cognitive stimulation can have an important effect on children, especially those from mothers with low schooling.

**Keywords** Child development, cognitive stimulation, social determinants of health, social inequalities, birth cohort, child, Brazil

[1] Centro de Pesquisas Epidemiológicas, Universidade Federal de Pelotas, Pelotas, Brazil.
[2] Departamento de Pediatria e Puericultura, Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, Brazil.
* Corresponding author. Centro de Pesquisas Epidemiológicas, R. Mal. Deodoro, 1160 3° piso, 96020-220 Pelotas, RS, Brazil. E-mail: barros.aluisio@gmail.com

## Introduction

Children's health has clearly improved over the last few decades. A decline in infant mortality has been registered in most countries along with lower rates of morbidity from infectious diseases and improved access to health care. However, low-income countries are facing both the unfinished agenda of communicable diseases (like diarrhoea) and the growing burden of non-communicable diseases like obesity and mental health problems.[1]

Following the concept of health as a positive resource and incorporating development as a key factor, children's health has been defined as 'the extent to which children are able or enabled to (i) develop and realize their potential, (ii) satisfy their needs and (iii) develop the capacities that allow them to interact successfully with their biological, physical and social environments'.[2] Development influences the biological and behavioural processes that determine health capacities. Developmental trajectories are determined by interactions between biological and environmental factors during the lifetime,[3] and their importance continues beyond childhood, since early development has been linked to school achievement in adulthood,[4,5] and school achievement is an important determinant of socio-economic position (SEP) and income.[6]

Compelling evidence suggests that children's development is influenced both by their families and by the social forces and cultural values that exist in the society in which they live. Early maternal as well as paternal influences are crucial in children's development, emphasizing how sensitive the early years are and how central child development and behaviour are for subsequent health.[7,8]

A review of proximal risk factors for child development in the context of developing countries[9] identified those that were consistent throughout the literature. Inadequate cognitive stimulation was the most important psychosocial determinant along with maternal depression and exposure to violence. The other risk factors for impaired child development were biological: stunting, iodine and iron deficiencies, malaria, intrauterine growth retardation and exposure to metals (such as lead and arsenic).

The above review did not focus on poverty, which has consistently been found to be a determinant of delayed child development.[10,11] Studies looking for factors mediating its effect found that cognitive stimulation was the most important mediator of poverty on child cognitive development.[12,13] An inverse trend between poverty and level of cognitive stimulation was also described.[13] Along with poverty, low maternal education has been identified as an important distal determinant of delayed child development both in a developed (Canada)[14] and in a developing country setting (Brazil).[15]

The aims of the study were to examine child development at 2 years of age and its psychosocial determinants, especially those related to child stimulation and possible interactions with maternal schooling and SEP, in order to identify potential strategies to promote children's health.

## Methods

A birth cohort study was started in 2004, in the city of Pelotas, Southern Brazil, following two other birth cohorts that had started in 1982 and 1993. Pelotas is a city with approximately 340 000 inhabitants [according to estimates for 2004 based on the 2000 Demographic Census, Instituto Brasileiro de Geografia e Estatística (IBGE)], located in the Southern state of Rio Grande do Sul. The climate is subtropical and humid, with mean temperature ranging from 23.3°C in January to 12.2°C in July. Major economic activities are agriculture and commerce. The Pelotas region has not been growing economically at the same pace as the entire state of Rio Grande do Sul. In 2002, the per capita gross domestic product (GDP) in Pelotas was R$5739 (US$2732 at current exchange rate), 58% of the average GDP for the state, whereas in 1999 it was as high as 70%. Per capita GDP in Pelotas is lower than Brazil's average GDP, which was R$7631 (US$3633) in 2002.

From 1 January to 31 December 2004, all five of the city hospitals were visited on a daily basis by a team of interviewers especially trained for the task. Eligible mothers—those living in the urban area of Pelotas and in the adjacent neighbourhood called Jardim América (presently part of Capão do Leão town)—were interviewed within 24 h after delivery. A total of 4231 children were successfully recruited to the study (only 32 mothers refused to participate). Non-hospital deliveries (20 in total) were also included in the cohort, since mothers would normally seek a maternity ward following delivery, thus being recruited to the study at this time. The interview involved collection of detailed information about socio-economic conditions of the family, lifestyle, gestational history and birth conditions. The baby was measured (weight, length, head, thorax and abdominal circumference) and had its gestational age assessed. The same children were re-visited at 3, 12 and 24 months of age. A detailed account of the cohort methods is given elsewhere.[16,17]

The current analysis uses data from the 24-month assessment of the 2004 Cohort. During 2006, all participants were sought within ±30 days of their birthday. Carers of participants were asked to complete a questionnaire containing six sections: child care and feeding; child's health; household characteristics plus parents' schooling and occupation; health; out-of-pocket expenditure; and mother's health and reproductive history. The child and mother were weighed and measured. Head and abdominal circumference was also measured for the child. Development was assessed through the screening version of

Battelle's Developmental Inventory (BDI). This is a standardized tool largely used to evaluate child development that includes several domains: personal, social, adaptive, fine and gross motor, communication and cognitive.[18] Note that the screening version of the test does not allow for separate domain assessment. Given that this tool has not been adapted to Portuguese (or any other development screening test), the instrument was translated into Portuguese from the Spanish version, and the resulting text was pre-tested with interviewers for clarity and revised by the investigators for fidelity to the original meaning.

The test was performed by seven interviewers with at least 11 years of schooling who were trained by a paediatrician specialized in child development (R.H.). Training involved becoming familiar with the tests and related procedures, understanding what were the aspects under study in each test and performing the assessment in groups with children in the same age range, until all interviewers achieved the desired skill and the group as a whole had a standard approach to each test. Interviewers went through retraining sessions at every 2 months aimed at maintaining a high level of standardization. The assessments were carried out at the child's home, in the presence of the mother or caregiver.

The psychosocial determinants studied at the time of the interview were maternal schooling (years of complete formal education), SEP (quintiles of the National Economic Indicator with reference to the Pelotas population[19]), whether the social father (biological or adoptive) was living with the child, whether the mother had a paid job during the second year of the child's life, whether the social father had an alcohol problem (as reported by the mother) and whether the child was cared for out of home.

In the 24-month questionnaire, given the inclusion of a full instrument to measure the home environment and cognitive stimulation was not feasible, five questions related to child stimulation were selected. They were intended to be markers of cognitive stimulation, parent–child interaction and more general interpersonal interactions. The activities chosen related to the week previous to the interview: whether someone read or told a story to the child; whether child went to a park or playground; whether the child went to some other people's houses; and whether the child watched TV. It was also asked whether the child had a story book. A simple score was derived by summing the number of positive answers obtained for these five questions, with values ranging from 0 to 5. The choice of such indicators is supported by the literature that shows the importance of literacy practices,[20,21] and the role played by social interaction.[22] Also, cumulative risk factors better explain development outcomes than the magnitude of each individual risk.[23,24]

In this analysis, we did not use standard cut-off points for the original reference population to classify child development level as recommended by guidelines of the Battelle screening test. The actual scores were used to study means for subgroups defined by the variables of interest. The scores were dichotomized to define a low-performance group. This categorization was done using the cut-off point for the 10th percentile, separately for boys and girls. Thus, low performance (belonging to the first decile) will not show an association with sex, as observed with mean score.

Despite the fact that our analyses were not concerned with biological factors related to child development, we checked how our results would change when controlling for prematurity (gestational age $<37$ weeks), low birthweight ($<2500$ g) and stunting at 2 years of age (height-for-age $Z$-score $<-2$ based on the WHO standard). Interviewer effect on BDI score was also assessed.

For the analyses of the continuous score $t$-test, ANOVA and linear regression were used, and residual analysis performed for model checking. Independent predictors of development score were identified by a backward selection process, where variables with a $P$-value $\geqslant 0.05$ were eliminated from the model. Analyses of low performance involved calculation of chi-squares and Poisson regression to allow for the direct estimation of prevalence ratios (PRs).[25] As before, variables independently associated with low performance in the test were selected by backward elimination. Adjusted values from Poisson models were evaluated to check whether impossible values for probabilities ($>1$) were produced.

All visits to the 2004 Pelotas Cohort were approved by the Federal University of Pelotas Medical School Research Ethics Committee. Mothers were fully informed about the study procedures, general objectives, the voluntary condition of their participation, their right not to participate, their right not to answer specific questions and their right to confidentiality of information given. If willing to participate, they signed a consent form of which they kept a copy.

## Results

A description of the children under study is given in Table 1. A total of 3855 children were included in the analysis, from 3869 assessed in the Pelotas 2004 Cohort 24-month visit. Twelve children with a development score of $<50$ were excluded from the analysis because they presented severe mental deficit due to problems such as cerebral palsy and Down syndrome. Another two did not perform the development test.

There was a slight predominance of boys in the study group (52 vs 48%). About 8% of the mothers had $<4$ years of education, whereas over one-third had completed intermediate school (11 years of education). Nearly half of the mothers were employed during the second year of life of the cohort children.

**Table 1** Frequency distribution of predictor variables for development and respective mean development score and percentage of low performance (<10th percentile)—2004 Pelotas Birth Cohort, Brazil, 2006

| | | | BDI[a] | | |
|---|---|---|---|---|---|
| | *n* | % | Mean score | SD | Percentage of low performance[b] |
| **Sex** | | | $P<0.001$ | | $P=0.799$ |
| Male | 1999 | 51.9 | 77.7 | 5.2 | 10.7 |
| Female | 1856 | 48.2 | 79.1 | 5.5 | 10.5 |
| **Economic reference quintiles[c]** | | | $P<0.001$ | | $P<0.001$ |
| 1 (poorest) | 900 | 23.3 | 76.5 | 5.6 | 18.0 |
| 2 | 796 | 20.6 | 77.9 | 5.4 | 13.1 |
| 3 | 860 | 22.3 | 78.8 | 5.3 | 8.6 |
| 4 | 608 | 15.8 | 79.5 | 4.6 | 4.9 |
| 5 (richest) | 692 | 18.0 | 79.8 | 4.9 | 5.5 |
| **Mother's schooling (years)** | | | $P<0.001$ | | $P<0.001$ |
| 0–3 | 301 | 7.8 | 75.7 | 5.5 | 21.9 |
| 4–7 | 1264 | 32.8 | 77.2 | 5.6 | 15.4 |
| 8–10 | 933 | 24.2 | 78.9 | 5.1 | 7.8 |
| >11 | 1356 | 35.2 | 79.7 | 4.8 | 5.5 |
| **Mother with paid job** | | | $P<0.001$ | | $P<0.001$ |
| No | 1959 | 51.3 | 77.8 | 5.6 | 12.8 |
| Yes | 1858 | 48.7 | 79.0 | 5.1 | 8.0 |
| **Father[d] lives with child** | | | $P=0.040$ | | $P=0.085$ |
| No | 785 | 20.5 | 78.0 | 5.6 | 12.1 |
| Yes | 3049 | 79.5 | 78.5 | 5.3 | 10.0 |
| **Father[d] drinks too much** | | | $P<0.001$ | | $P=0.156$ |
| No | 3282 | 85.9 | 78.5 | 5.3 | 10.1 |
| Yes | 139 | 3.6 | 76.8 | 5.3 | 14.4 |
| Ignored or no answer | 400 | 10.5 | 77.9 | 5.3 | 12.0 |
| **Out-of-home day care** | | | $P<0.001$ | | p = 0.086 |
| No | 3129 | 81.2 | 78.2 | 5.4 | 11.0 |
| Yes | 726 | 18.8 | 79.1 | 5.3 | 8.8 |
| **Child stimulation score[e]** | | | $P<0.001$[f] | | $P<0.001$ |
| 0 | 27 | 0.7 | 71.3 | 6.8 | 40.7 |
| 1 | 220 | 5.7 | 75.0 | 5.4 | 24.1 |
| 2 | 777 | 20.2 | 76.9 | 5.8 | 18.1 |
| 3 | 1154 | 30.0 | 78.3 | 5.1 | 9.8 |
| 4 | 1125 | 29.3 | 79.4 | 4.9 | 6.5 |
| 5 | 543 | 14.1 | 80.4 | 4.6 | 2.9 |

[a]Screening version.
[b]Children below sex-specific cut-off points for the 10th percentile of development score.
[c]'Indicador Econômico Nacional', an asset-based wealth indicator with cut-off points for quintiles derived for the general population of Pelotas, RS.
[d]Either biological or social father.
[e]Score derived by summing activities reported by child in the past week: someone read or told stories, went to park, visited other people, watched TV, has book at home.
[f]ANOVA and Kruskall–Wallis rank tests yielded similar results despite difference in SDs across groups.
SD = standard deviation.

**Table 2** Percentage of children reporting activities or having a book in each category of stimulation score—2004 Pelotas Birth Cohort, Brazil, 2006

| | Percentage of children reporting each activity[a] | | | | |
|---|---|---|---|---|---|
| **Stimulation score** | Visit | TV | Book | Story | Park |
| 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1 | 52.9 | 36.3 | 2.7 | 3.1 | 4.9 |
| 2 | 83.1 | 76.1 | 15.0 | 13.4 | 12.5 |
| 3 | 89.7 | 83.3 | 49.3 | 45.4 | 32.3 |
| 4 | 96.4 | 92.6 | 80.7 | 77.2 | 53.1 |
| 5 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[a]Visit, child went to someone else's place; TV, watched TV for any amount of time; Book, child owns a story book; Story, someone told or read a story to the child; Park, child was taken to park or playground. All activities are relative to a reference period of 1 week prior to the interview.

About one-fifth of the children did not have their fathers (either the biological or step-father) living with them, and a similar number were cared part- or full-time out of the home.

The stimulation score created indicates the number of activities each child was involved in the week previous to the interview and whether she/he had a book—<1% (27 children) had a 0 score. The scores with the highest frequencies were 3 and 4, including ~60% of the children, whereas 14% had a score of 5 (Table 1). The most common activities for children with score 1 were going to someone else's house (53%) and watching TV (36%), whereas the least common was having a book. The least common activity for children with score 4 was going to a park or playground, which was more common than having a book and being told a story for children with a score 1 (Table 2).

The effects of individual stimulation items are presented in Table 3, along with the prevalence of each item. The most common items were visiting someone and watching TV. Adjustment was done for the other items in the table. All stimulation items presented an independent effect. Adjusted effects, as expected, were smaller than crude ones. The strongest effects observed were related to having a book and having been told a story. Children positive to either of such items had a 50% lower risk of showing low performance in the test.

The development score presented a distribution that was similar in shape for boys and girls, with a long left tail (Figure 1). The overall mean was 78.4 with SD 5.4. Mean score was higher for girls than for boys (79.1 vs 77.7, $P < 0.001$). All social variables presented an association with mean development score in the crude analysis (Table 1). Being cared for out of home was also positively associated with the development score. Child stimulation presented a very strong association with development; the less stimulated children lagging 9 points behind the most stimulated, on average.

On the one hand, the analysis of low performance in the test (less than the 10th percentile) showed a similar result for SEP, mother's schooling and employment. On the other hand, no association was found with living with the father, the father drinking and out-of-home care. Low performance was also strongly associated with stimulation. Just <3% of the more stimulated children presented low performance compared with 41 and 24% in the bottom groups of stimulation (Table 1). Figure 2 shows the crude effect of child stimulation on both mean development score and low performance.

There was an effect of interviewer on BDI score, where the most extreme interviewer mean was 1.7 above the overall mean (31% of the SD). Therefore, the possible confounding effect of interviewer was assessed in the adjusted analyses.

A linear regression model with development score as the outcome was adjusted to investigate independent predictors, which were identified by backward selection. Table 4 presents the variables significantly associated with development score: sex, SEP, mother's schooling, mother's employment and child stimulation. Despite some reduction in its effect, due to adjustment for covariates, stimulation remained a very strong predictor of development score. This model was adjusted for interviewer effect, despite changes in coefficients due to the adjustment were small.

Compared with the most prevalent score 3, children with score 0 had, on average, 6.1 points less, and children with score 1, 2.5 points less. At the other extreme, children with score 5 had 1.2 points more, on average, than those with score 3. Maternal schooling also had a strong effect, with children from mothers from the highest schooling group presenting 2.1 points more, on average, than those with mothers from the lowest schooling group.

Further adjustment of the previous model for three biological predictors of child development—prematurity, low birthweight and stunting—led to negligible changes in the psychosocial determinants' coefficients. For child stimulation score, the greatest change was observed for level 0, the coefficient of which was reduced by 6.7% (below the usual 10% confounding threshold).

Residuals from the model presented in Table 3 were assessed in residual vs predicted plot for heterocedasticity and non-linearity and in a half-normal plot for non-normality. Neither graph suggested problems with the model fit.

One of our hypotheses to be tested was whether the effect of child stimulation was different for different levels of mother's schooling. Given the large number of interaction terms (15) involved if both variables were taken as categorical, we explored their linear effect (as grouped variables, but fit as continuous).

**Table 3** Effects of individual items used in the stimulation score

| Activity[a] | *n* | % | BDI[b] mean score | | Percentage of low performance[b] | |
|---|---|---|---|---|---|---|
| **Visit** | | | | | | |
| Yes | 3434 | 89.1 | 78.6 | | 10.0 | |
| No | 422 | 10.9 | 76.6 | | 15.4 | |
| | | | Diff. = 2.0 | $P < 0.001$ | PR = 0.65 | $P < 0.001$ |
| | | | Adj. diff. = 1.6 | $P < 0.001$ | Adj. PR = 0.76 | $P = 0.023$ |
| **TV** | | | | | | |
| Yes | 3224 | 83.6 | 78.5 | | 9.8 | |
| No | 632 | 16.4 | 77.7 | | 14.7 | |
| | | | Diff. = 0.8 | $P < 0.001$ | PR = 0.66 | $P < 0.001$ |
| | | | Adj. diff. = 0.6 | $P = 0.010$ | Adj. PR = 0.74 | $P = 0.004$ |
| **Book** | | | | | | |
| Yes | 2147 | 55.7 | 79.5 | | 6.3 | |
| No | 1708 | 44.3 | 77.0 | | 16.0 | |
| | | | Diff. = 2.5 | $P < 0.001$ | PR = 0.39 | $P < 0.001$ |
| | | | Adj. diff. = 2.0 | $P < 0.001$ | Adj. PR = 0.49 | $P < 0.001$ |
| **Story** | | | | | | |
| Yes | 2046 | 53.2 | 79.4 | | 6.2 | |
| No | 1802 | 46.8 | 77.2 | | 15.6 | |
| | | | Diff. = 2.2 | $P < 0.001$ | PR = 0.39 | $P < 0.001$ |
| | | | Adj. diff. = 1.6 | $P < 0.001$ | Adj. PR = 0.49 | $P < 0.001$ |
| **Park** | | | | | | |
| Yes | 1624 | 42.1 | 78.9 | | 8.0 | |
| No | 2231 | 57.9 | 78.0 | | 12.5 | |
| | | | Diff. = 0.9 | $P < 0.001$ | PR = 0.64 | $P < 0.001$ |
| | | | Adj. diff. = 0.5 | $P = 0.004$ | Adj. PR = 0.75 | $P = 0.005$ |

Crude results and adjusted results for the other items (obtained through linear and Poisson regression) are presented—2004 Pelotas Birth Cohort, Brazil, 2006. Diff., crude difference; adj. diff., adjusted difference for the other items in the table; PR, crude prevalence ratio; adj. PR, adjusted prevalence ratio for the other items in the table.

[a]Visit, child went to someone else's place; TV, watched TV for any amount of time; book, child owns a story book; story, someone told or read a story to the child; park, child was taken to park or playground. All activities are relative to a reference period of 1 week prior to the interview.

[b]Screening version.

Reduction in the adjusted $R^2$ was minimal and we went on to test the interaction in a model including sex, SEP, mother's employment plus mother's schooling and child stimulation score as continuous variables and an interaction term calculated as the product of the last two. The interaction term presented a *P*-value of <0.001. Given the complex nature of interaction results, we fitted a simpler model including only mother's schooling and child stimulation score as continuous variables and the interaction term in order to make it easier to understand the relationship found. This result is shown in Figure 3, where one can see that the effect of stimulation is much stronger with mothers of low schooling. In this group, every step in stimulation adds 1.7 points to the development score. Among mothers with high schooling, each step in stimulation adds 0.6 points to the development score. The regression model fitted can be represented as:

$$\text{Development score} = 69.3 + 2.12 \times \text{Stimulation score} + 2.05\ \text{Mother's schooling} - 0.38 \times \text{Interaction}$$

where stimulation score varies from 0 to 5, mother's schooling from 1 to 4 and the interaction term is the product of the two variables. All variables had *P*-values <0.001 and the model adjusted $R^2$ was 10.5%.

A similar model was developed with the dichotomized score indicating low performance in the test (score less than the 10th percentile) using Poisson regression. The variables independently associated with low performance are shown in Table 3. Here, only SEP,

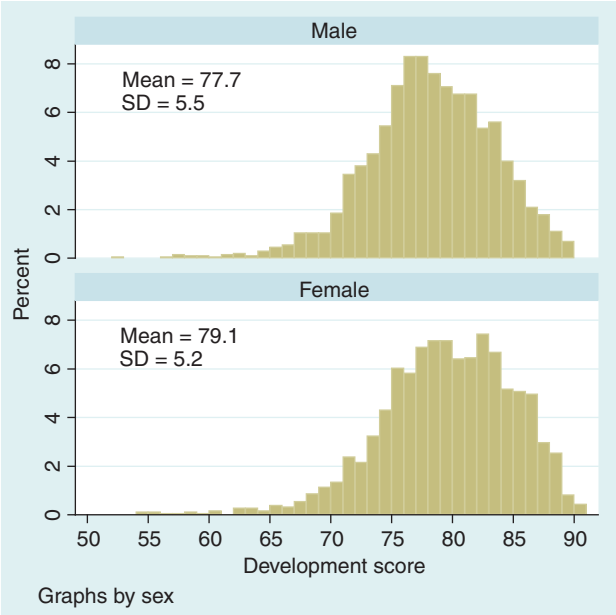


**Figure 1** Development score distribution by sex

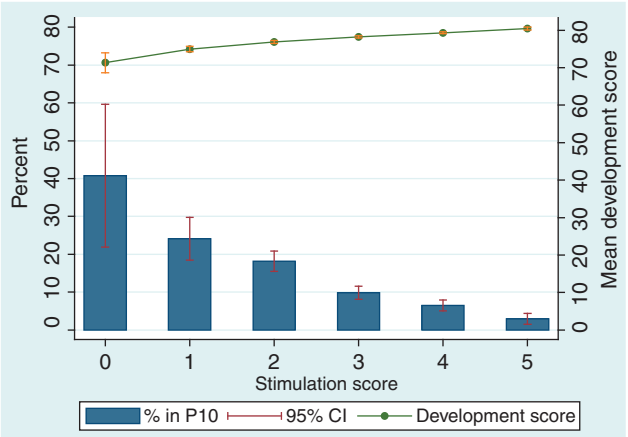


**Figure 2** Crude effect of stimulation score on both continuous development score and low performance in development test (less than 10th percentile)
CI = confidence interval.
P10 = 10th percentile.

mother's schooling and child stimulation were significant. The interaction between the last two was not present. Children with stimulation score 0 and 1 were 3.3 and 2.0 times, respectively, more likely to present a low performance than children with score 3. Those with a score 5 had a reduction of 60% in the probability of presenting low performance compared with the reference group.

The interaction between stimulation and economic status was also explored and presented an effect which was no longer important when the interaction between stimulation and maternal schooling was added to the model.

## Discussion

The present work is a cross-sectional analysis of a longitudinal study, carrying the limitations of the cross-sectional design. Most importantly, reverse causality may play a role in the results since failure to provide the children with the activities used as stimulation markers could be partially due to the child's refusal or lack of interest resulting from mental impairment. On the one hand, the exclusion of children with severe mental deficit aimed at minimizing this issue. On the other hand, the large sample size and the restricted age range resulting from the original design of the study are important positive points.

Early development is recognized as a policy priority since 'the early child period is considered to be the most important developmental phase throughout an individual's lifespan'.[26] Several studies have assessed risk factors for child development, both in terms of biological and psychosocial determinants.[9] Our results firmly agree with the available literature, showing that male sex, poverty, low maternal schooling, maternal unemployment and low stimulation are all associated with worse development scores. The same risk factors appear, with small variations, in studies from Canada,[14] India[27] and Brazil.[15]

Studies on the causal pathways of poverty on development have found cognitive stimulation to be one of the most important mediating variables.[12,13] In both cases, the Home Observation for Measurement of the Environment (HOME) instrument[28] was used to assess child stimulation. From a different perspective, poor stimulation came first in a list of nine risk factors for impaired child development resulting from a comprehensive literature review.[9] Here, along with magnitude of association, the large proportions of children exposed to inadequate cognitive stimulation (estimated to vary from 59 to 90%) and the proven benefits of interventions, make this determinant a priority for policy.

In our study, child stimulation was explored through five markers of stimuli and attention given to the children as we did not have a detailed evaluation of the home environment and parent–child interactions. Having a book and being told a story are the closest markers of cognitive stimulation. These are also the variables that make the most difference between children with average scores (2–3) and those scoring high (4–5). Going to a park or playground showed the biggest difference between scores 4 and 5, and may represent the large social barrier existing in the study setting where very few parks are available and playgrounds present a cost not affordable for most of the population. Going to someone else's place and watching TV were more homogeneous across levels of stimulation score.

Watching TV for long hours has been associated with poverty, low stimulation and lower development achievement.[29] In our study, however, our variable

**Table 4** Results of adjusted analyses for development score (linear regression) and low performance (less than 10th percentile; Poisson regression)—2004 Pelotas Birth Cohort, Brazil, 2006

| | Linear regression for mean BDI score | | | Poisson regression for belonging to P10 | | |
|---|---|---|---|---|---|---|
| | Coefficient | SE | *P*-value | PR | SE | *P*-value |
| **Sex** | | | <0.001 | | | |
| Male | 1.00 | – | | | | |
| Female | 1.42 | 0.16 | | | | |
| **Economic reference quintiles**[a] | | | <0.001 | | | <0.001 |
| 1 (poorest) | 1.00 | – | | 1.00 | – | |
| 2 | 0.82 | 0.24 | | 0.91 | 0.10 | |
| 3 | 1.22 | 0.25 | | 0.67 | 0.10 | |
| 4 | 1.69 | 0.28 | | 0.45 | 0.09 | |
| 5 (richest) | 1.40 | 0.29 | | 0.66 | 0.12 | |
| **Mother's schooling (years)** | | | <0.001 | | | <0.001 |
| 0–3 | 1.00 | – | | 1.00 | – | |
| 4–7 | 1.07 | 0.32 | | 0.79 | 0.10 | |
| 8–10 | 2.08 | 0.34 | | 0.54 | 0.09 | |
| >11 | 2.05 | 0.35 | | 0.54 | 0.09 | |
| **Mother with paid job** | | | <0.001 | | | 0.017 |
| No | 1.00 | – | | 1.00 | – | |
| Yes | 0.48 | 0.17 | | 0.80 | 0.08 | |
| **Child stimulation score**[b] | | | <0.001 | | | <0.001 |
| 0 | –6.12 | 0.98 | | 2.74 | 0.63 | |
| 1 | –2.51 | 0.37 | | 1.85 | 0.28 | |
| 2 | –1.04 | 0.23 | | 1.66 | 0.19 | |
| 3 | 1.00 | – | | 1.00 | – | |
| 4 | 0.56 | 0.21 | | 0.82 | 0.12 | |
| 5 | 1.22 | 0.27 | | 0.46 | 0.12 | |

[a]'Indicador Econômico Nacional', an asset-based wealth indicator with cut-off points for quintiles derived for the general population of Pelotas, RS.
[b]Score derived by summing activities reported by child in the past week: someone read or told stories, went to park, visited other people, watched TV, has book at home.
SE = standard error.

indicated no TV time at all vs any TV exposure. Since watching TV does provide some degree of cognitive stimulation, it is not surprising that this variable was positively associated with development either individually (results not shown) or as part of the stimulation score.

Despite its simplicity, our stimulation score presented a very strong association with development, as seen in the other studies that used more sophisticated measures.[12,13] Its crude effect dropped from a 9-point difference between lowest and highest score to a 7.5-point difference in the adjusted analysis; a small reduction, which is expected from a proximal determinant when adjusted for more distal ones. The adjusted effect corresponds to 1.4 SD of the development score—thus, a large effect.

The most interesting result, however, is the strong interaction between stimulation and maternal schooling. Evidently, the way the model was built, using continuous variables, contributes to the linearity and symmetry shown in Figure 3. But the similarity of the models using categorical and continuous versions of the variables of interest in terms of adjusted $R^2$ indicates that this is a fair picture of the actual relationship. The interpretation of such effect modification is rather important in terms of policy. On the one hand, general improvement of maternal education would make stimulation interventions much less important and reduce its potential effect. On the other hand, it may be a useful tool for targeting cognitive stimulation interventions, since maternal schooling is an indicator very easy to measure.

Given the simplicity of the stimulation markers used in this work, it is clear that interventions cannot be built upon giving children books or making them watch TV. For that there is a large body of knowledge on cognitive stimulation and successful interventions.[30–32] Specifically in Brazil, a successful

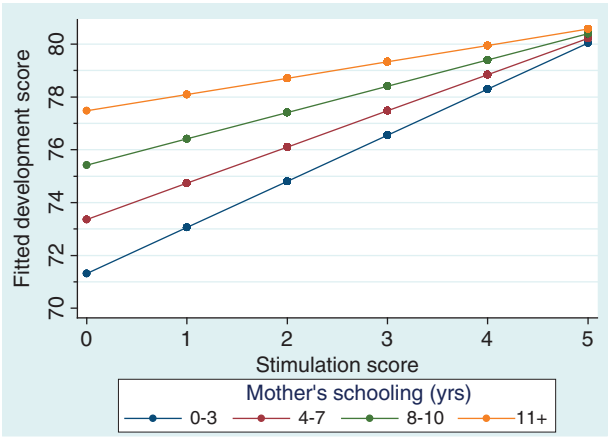


**Figure 3** Interaction between stimulation score and maternal schooling in a linear regression model with development score as outcome, not controlled for other variables

intervention was carried out in four towns in the state of Pernambuco, Northeast region, in an area where poverty is widespread.[33] Using very simple strategies, mothers of children belonging to a birth cohort aged 13 months were taught to play and stimulate their children. After 5 months, intervention children had a clear advantage in mental and psychomotor development. Despite the remarkable progress in terms of maternal education achieved in this country,[17] the size of the gap between better-off children (here the ones born to more educated mothers and more stimulated) and the worse-off is substantial. Immediate action to reduce it is needed, and the magnitude of change is potentially a big one. Focussing on less-educated mothers may be a valuable and strategic starting point. We believe that this is the case in several countries of low and middle income.

## Funding

Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul, FAPERGS (Pronex 04/0882.7). Funding to pay the Open Access publication charges for this article was provided by the Post-graduate Program in Epidemiology, Federal University of Pelotas, Pelotas, Brazil.

## Acknowledgements

This study involved the work of a large number of persons, including interviewers, supervisors, data entry clerks, whom we thank for the dedication and hard work. We also thank the children and their mothers who generously have dedicated time and attention to this project at each follow-up wave. Finally we thank Drs Cesar G Victora and Fernando C Barros who gave important contributions to the designing of this study and to the construction of the instruments used in this 2-year follow-up visit.

**Conflict of interest:** None declared.

**KEY MESSAGE**

- A very simple cognitive stimulation indicator showed strong and independent association with child development in a developing country setting. Furthermore, a clear interaction between stimulation and maternal schooling was found, indicating not only that stimulation has a stronger effect in children of the less-educated mothers, but also that by effectively stimulating these children they can achieve a very similar result to those who are more stimulated and have high schooling mothers.

## References

[1] Marshall S. Developing countries face double burden of disease. *Bull World Health Organ* 2004;**82:**556.

[2] Committee on Evaluation of Children's Health NRC. *Children's Health, The Nation's Wealth: Assessing and Improving Child Health*. Washington, DC; 2004.

[3] Halfon N, Hochstein M. Life course health development: an integrated framework for developing health, policy, and research. *Milbank Q* 2002;**80:**433–79, iii.

[4] Rantakallio P, von Wendt L, Makinen H. Influence of social background on psychomotor development in the first year of life and its correlation with later intellectual capacity: a prospective cohort study. *Early Hum Dev* 1985; **11:**141–48.

[5] Taanila A, Murray GK, Jokelainen J, Isohanni M, Rantakallio P. Infant developmental milestones: a 31-year follow-up. *Dev Med Child Neurol* 2005;**47:** 581–86.

[6] Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B. Developmental potential in the first 5 years for children in developing countries. *Lancet* 2007;**369:**60–70.

[7] Ramchandani P, Stein A, Evans J, O'Connor TG. Paternal depression in the postnatal period and child development: a prospective population study. *Lancet* 2005;**365:** 2201–5.

[8] Rutter M. Multiple meanings of a developmental perspective on psychopathology. *Eur J Dev Psy* 2005;**2:** 221–52.

[9] Walker SP, Wachs TD, Gardner JM *et al*. Child development: risk factors for adverse outcomes in developing countries. *Lancet* 2007;**369:**145–57.

[10] National Institute of Child H, Human Development Early Child Care Research N. Duration and developmental timing of poverty and children's cognitive and social development from birth through third grade. *Child Dev* 2005;**76:**795–810.

[11] Larson CP. Poverty during pregnancy: Its effects on child health outcomes. *Paediatr Child Hea* 2007;**12:**673–77.

[12] Linver MR, Brooks-Gunn J, Kohen DE. Family processes as pathways from income to young children's development. *Dev Psychol* 2002;**38:**719–34.

[13] Guo G, Harris KM. The mechanisms mediating the effects of poverty on children's intellectual development. *Demography* 2000;**37:**431–47.

[14] To T, Guttmann A, Dick PT *et al*. Risk markers for poor developmental attainment in young children: results from a longitudinal national survey. *Arch Pediatr Adolesc Med* 2004;**158:**643–49.

[15] Santos DN, Assis AM, Bastos AC *et al*. Determinants of cognitive function in childhood: a cohort study in a middle income context. *BMC Pub Hea* 2008;**8:**202.

[16] Barros AJ, Santos IS, Victora CG *et al*. The 2004 Pelotas birth cohort: methods and description. *Rev Saúde Pública* 2006;**40:**402–13.

[17] Barros AJ, Santos IS, Matijasevich A *et al*. Methods used in the 1982, 1993, and 2004 birth cohort studies from Pelotas, Rio Grande do Sul State, Brazil, and a description of the socioeconomic conditions of participants' families. *Cad Saúde Pública* 2008;**24:**s371–80.

[18] Newborg J, Stock JR, Wnek L, Guidabaldi J, Svinicki J. *Battelle Developmental Inventory*. Itasca, IL: Riverside Publishing, 1988.

[19] Barros AJ, Victora CG. A nationwide wealth score based on the 2000 Brazilian demographic census. *Rev Saúde Pública* 2005;**39:**523–29.

[20] Simcock G, Dooley M. Generalization of learning from picture books to novel test conditions by 18- and 24-month-old children. *Dev Psychol* 2007;**43:**1568–78.

[21] Roberts J, Jurgens J, Burchinal M. The role of home literacy practices in preschool children's language and emergent literacy skills. *J Speech Lang Hear Res* 2005;**48:**345–59.

[22] Carpendale JI, Lewis C. Constructing an understanding of mind: the development of children's social understanding within social interaction. *Behav Brain Sci* 2004; **27:**79–96.

[23] Sameroff AJ. Models of development and developmental risk. In: Zeanah CH (ed.). *Handbook of Infant Mental Health*. New York: Guilford Press, 1993, pp. 120–42.

[24] Barocas R, Seifer R, Sameroff AJ. Defining environmental risk: multiple dimensions of psychological vulnerability. *Am J Community Psychol* 1985;**13:**433–47.

[25] Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 2003;**3:**21.

[26] Irwin LG, Siddiqi A, Hertzman C. *Early Child Development: A Powerful Equalizer. Final Report for the World Health Organization's Comission on the Social Determinants of Health*, 2007; http://www.who.int/child_adolescent_health/documents/ecd_final_m30/en/index.html (8 Feb 2009, date last accessed).

[27] Nair MK, Radhakrishnan SR. Early childhood development in deprived urban settlements. *Indian Pediatr* 2004; **41:**227–37.

[28] Caldwell B, Bradley R. *Home Observation for Measurement of the Environment (HOME)*. Revised Edition ed. Little Rock, University of Arkansas, 1984.

[29] Evans GW. The environment of childhood poverty. *Am Psychol* 2004;**59:**77–92.

[30] Engle PL, Black MM, Behrman JR *et al*. Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world. *Lancet* 2007; **369:**229–42.

[31] Bonnier C. Evaluation of early stimulation programs for enhancing brain development. *Acta Paediatr* 2008;**97:** 853–58.

[32] Maulik PK, Darmstadt GL. Community-based interventions to optimize early childhood development in low resource settings. *J Perinatol* 2009; doi:10.1038/jp.2009.42 [E-pub 30 April 2009].

[33] Eickmann SH, Lima AC, Guerra MQ *et al*. Improved cognitive and motor development in a community-based intervention of psychosocial stimulation in northeast Brazil. *Dev Med Child Neurol* 2003;**45:**536–41.

Published by Oxford University Press on behalf of the International Epidemiological Association *International Journal of Epidemiology* 2010;**39**:294–296

doi:10.1093/ije/dyp316

# Commentary: Early stimulation and child development

**Susan P Walker**

Epidemiology Research Unit, Tropical Medicine Research Institute, The University of the West Indies, Mona, Kingston 7, Jamaica. E-mail: susan.walker@uwimona.edu.jm

**Accepted** 21 September 2009

Large numbers of disadvantaged children in low- and middle-income countries do not attain their developmental potential.[1] In this issue of the journal, Barros *et al*.[2] report on the development of a birth