

# Early Childhood Stimulation Benefits Adult Competence and Reduces Violent Behavior

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## KEY WORDS

child development, behavior, educational status, intelligence, undernutrition

## ABBREVIATIONS

ECD—early child development  
CHW—community health worker  
WAIS—Wechsler Adult Intelligence Scale  
ICC—intraclass correlation coefficient

Drs Walker, Chang, and Grantham-McGregor were responsible for the conceptualization and design of the study; Drs Chang and Walker were responsible for the conduct of the study; Drs Walker, Grantham-McGregor, and Vera-Hernández analyzed and interpreted the data; Dr Walker drafted the manuscript; and all authors participated in critical revision of the manuscript and have approved the final version.

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**WHAT'S KNOWN ON THIS SUBJECT:** Approximately 178 million children younger than 5 years in developing countries are growth-retarded (stunted) and generally do not attain their developmental potential. Early child development programs benefit concurrent development, but there is no information on adult benefits.



**WHAT THIS STUDY ADDS:** Early psychosocial intervention in growth-retarded children benefits adult educational attainment and psychological functioning and reduces violent behavior. This has important policy implications and indicates that both beneficiaries and society will gain from early child development programs in developing countries.

## abstract

**OBJECTIVE:** An estimated 178 million children younger than 5 years in developing countries experience linear growth retardation and are unlikely to attain their developmental potential. We aimed to evaluate adult benefits from early childhood stimulation and/or nutritional supplementation in growth-retarded children.

**METHODS:** In Kingston, Jamaica, 129 growth-retarded children aged 9 to 24 months took part in a 2-year trial of nutritional supplementation (1 kg milk-based formula per week) and/or psychosocial stimulation (weekly play sessions to improve mother-child interaction). We assessed IQ, educational attainment, and behavior at 22 years old in 105 participants. We used multivariate regressions, weighted to adjust for loss to follow-up, to determine treatment benefits.

**RESULTS:** We found no significant benefits from supplementation. Participants who received stimulation reported less involvement in fights (odds ratio: 0.36 [95% confidence interval (CI) 0.12–1.06]) and in serious violent behavior (odds ratio: 0.33 [95% CI: 0.11–0.93]) than did participants with no stimulation. They also had higher adult IQ (coefficient: 6.3 [95% CI: 2.2–10.4]), higher educational attainment (achievement, grade level attained, and secondary examinations), better general knowledge, and fewer symptoms of depression and social inhibition.

**CONCLUSIONS:** Early psychosocial intervention had wide-ranging benefits in adulthood that are likely to facilitate functioning in everyday life. The reductions in violent behavior are extremely important given the high levels of violence in many developing countries. The study provides critical evidence that early intervention can lead to gains in adult functioning. *Pediatrics* 2011;127:849–857

Experiences in early childhood can have long-term effects on brain function and cognitive and psychosocial functioning.<sup>1</sup> In developing countries, an estimated 219 million children younger than 5 years do not attain their developmental potential because of poverty and associated risk factors such as undernutrition and inadequate stimulation.<sup>2,3</sup> Poor early development is predictive of lower educational attainment and subsequent lower adult income, and poor parenting, thus continuing the poverty cycle.<sup>2</sup> Studies from developing countries show concurrent benefits to development from early child development (ECD) programs for undernourished or disadvantaged children.<sup>3,4</sup> However, there are few data on adult benefits of ECD programs in developing countries and none that we are aware of with growth-retarded children.

Our study of growth-retarded children in Kingston, Jamaica, provides some of the best longitudinal data from developing countries of the benefits of early psychosocial intervention.<sup>5-7</sup> Between 1987 and 1989, growth-retarded children participated in an intervention study of nutritional supplementation and/or psychosocial stimulation. After 2 years, both interventions revealed independent benefits to the children's development.<sup>5</sup> Supplementation also benefited growth.<sup>8</sup> At 7 years, small benefits were found to cognition from each intervention but not to growth.<sup>9,10</sup> At ages 11 and 17 years, stimulation had sustained benefits to cognition, and to reading ability at age 17 only, whereas supplementation no longer had any benefit.<sup>6,11</sup> At 17 years, stimulation also had benefits for psychological functioning.<sup>7</sup> However, some children had not yet finished their education, so final attainment could not be examined.

The objectives of this study were to determine whether previous benefits

were sustained to adulthood (22 years old) and to examine possible effects on educational attainment, general knowledge, social and sexual relationships, social inhibition, and antisocial behavior.

## METHODS

### Initial Study

#### *Design and Sample*

The children were identified at age 9 to 24 months by house to house survey of poor neighborhoods in Kingston, Jamaica. All 129 growth-retarded children (length-for-age < -2 SD of the National Center for Health Statistics references) identified were enrolled in a 2 year study and assigned to 1 of 4 groups: control; supplementation; stimulation; or both interventions. The initial order of group assignment was determined randomly.

#### *Intervention*

All groups were visited weekly by a community health worker (CHW) for 2 years. For the control group, the visit was used to obtain information on illnesses only. Supplementation comprised 1 kg milk-based formula weekly, delivered during the visits to the supplementation and both groups.<sup>8</sup> The CHWs who visited the children assigned to stimulation were given 4 weeks' training in child development and the stimulation program. The objectives of the program were to increase the mother's ability to promote her child's development through play, to improve mother-child interaction, and to promote the self-esteem of both mother and child. The intervention was based on 1 used in previous studies in Jamaica in which additional details of the intervention can be found,<sup>12,13</sup> and it is described briefly here. We used a structured curriculum which included some Piagetian concepts for children under 24 months, and concepts such as shape, quantity, position, and color

for children older than 24 months, on the basis of the curriculum by Palmer,<sup>14</sup> using activities we designed. During the weekly 1-hour visit, the CHWs demonstrated play techniques and involved the mother in a play session with her child. Mothers were encouraged to continue play activities between the visits and to integrate them in their daily routines. They were encouraged to chat with their children and to label objects and actions. Emphasis was placed on the use of praise and positive reinforcement, and physical punishment was discouraged. The general approach to visits was inspired by Gray's program in Tennessee.<sup>15</sup> Toys made from commonly discarded household materials and simple picture books were left in the home and exchanged each week. A supervisor monitored the quality of the visits.

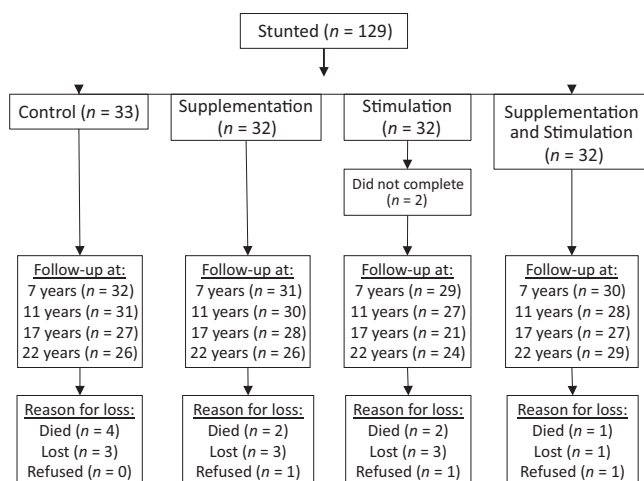
#### *Previous Follow-up*

The children's cognition and growth were reassessed at ages 7 to 8 years<sup>9</sup> and 11 years.<sup>11</sup> At 17 years, cognition, psychological functioning, social behavior, and school achievement were assessed.<sup>6</sup>

## Current Study

### *Participants at 22 Years Old*

Loss to follow-up in previous rounds was primarily because of emigration. In the current study we included participants who emigrated. There were 105 participants assessed (82.7% of 127 who completed the initial study); 91 of 95 who currently reside in Jamaica, 14 of 23 emigrants, and there have been 9 deaths. Ten participants were lost to follow-up (8 emigrants), and there were 3 refusals (1 emigrant). The stimulation groups tended to have more emigrants than the no-stimulation groups ( $\chi^2 = 3.02$ ,  $P = .082$ ) and a greater proportion of emigrants located were from stimulation



**FIGURE 1**  
Trial profile with reasons for loss to follow-up.

groups (11/15 compared with 3/8 in no stimulation groups). Sample follow-up by group is shown in Fig 1.

### Measurements

#### Cognition

IQ was assessed with the Wechsler Adult Intelligence Scale (WAIS).<sup>16</sup> There are no IQ tests standardized for Jamaican adults. We used the WAIS previously at age 17 when it was correlated with school achievement scores.<sup>6</sup> At this follow-up, WAIS IQ was significantly correlated with grades attained ( $r = 0.40$ ), scores in reading ( $r = 0.81$ ) and mathematics ( $r = 0.84$ ), general knowledge ( $r = 0.75$ ), and depression ( $r = -0.32$ ) (all  $P < .001$ ). This indicates that the WAIS scores are a valid measure of cognitive ability; however, we use them only for within population comparisons.

#### Educational Achievement

Reading and mathematics were measured with the Wide-Range Achievement Test, Expanded Form.<sup>17</sup> Information was obtained by questionnaire on highest grade level attained, secondary level examination passes, expulsion from school, and postsecondary school education or skills training.

#### General Knowledge

A test of practical general knowledge useful for daily living in Jamaica was designed. It was given only to participants who reside in Jamaica.

#### Mental Health

Participant reports of symptoms of depression were obtained with the Short Mood and Feelings Questionnaire, which we had used at 17 years old.<sup>18</sup> Anxiety was assessed with the State-Trait Anxiety Inventory,<sup>19</sup> and 3 subscales from the Inventory on Interpersonal Problems<sup>20</sup> were adapted and used to assess social inhibition, aggression, and assertiveness. Internal consistency (Cronbach's  $\alpha$ ) of the mental health scales was 0.83 for the depression scale and 0.82 for anxiety. However, the interpersonal scales had values  $\leq 0.5$  except for social inhibition, which was 0.65. Therefore, only the social inhibition scale was used in the analyses.

Test/retest and inter-observer reliability were determined with Intra-class correlation coefficients (ICCs) estimated using a two-way mixed analysis of variance model, treating the people factor as random and the measure effect as fixed, using a consistency definition in which the between-

measure variance is excluded from the denominator of the estimated ICCs.<sup>21</sup> ICC for test/retest reliability was determined for 17 nonstudy subjects for IQ, educational achievement, and the mental health questionnaires, and was determined to be 0.71 for the social inhibition scale, 0.77 for depression, and  $>0.8$  for all remaining measures. ICC for inter-observer reliability was high for all instruments ( $>0.9$ ).

#### Antisocial Behavior, Arrests, and Convictions

Information on involvement in fights, use of weapons, stealing, burglary, rape, and gang membership was obtained by interviewer-administered questionnaire. Participant reports of arrests and convictions also were collected; we did not attempt to verify these reports.

#### Other Behavior

Participants were asked to rate their relationships with their parents on 4 4-point scales and with partners on 2 4-point scales. Information was obtained on sexual relationships, number of children and age at birth of first child, alcohol and drug use, church attendance, and community involvement.

#### Anthropometry

Participants' height and weight were measured using standard procedures.

#### Housing

Homes were visited and data collected on crowding, toilet and water facilities, and number of household possessions from a list of 15 items. One regression-scored unrotated housing factor was calculated using principal components factor analysis.

#### Enrollment Measurements

Child's developmental quotient and height-for-age, housing, mothers' age, education, and verbal IQ (Peabody Picture Vocabulary Test<sup>22</sup>), and stimula-

tion in the home (Home Observation for Measurement of the Environment<sup>23</sup>) on enrollment were used to compare the initial characteristics of participants included in this follow-up and to compute weights to account for loss to the study (see “Statistical Analysis”).

### Procedure

Participants who reside in Jamaica were brought to our research unit for administration of IQ and educational tests, mental health questionnaires, and interview. Emigrants were tested and interviewed in their homes. Tests and interviews were conducted by 2 persons blind to the participants’ group assignments.

Ethical approval for the study was obtained from the ethics committee of the University of the West Indies, and participants gave written informed consent.

### Statistical Analysis

Group differences among tested participants in enrollment and follow-up characteristics were determined by analysis of variance and  $\chi^2$ . The distributions of continuous dependent variables were examined for normality using histograms, the Shapiro-Wilk test, and the Kolmogorov-Smirnov test.<sup>24,25</sup> Normality was rejected for mathematics, reading, and depression scores ( $P < .001$  in both tests). The Box-Cox method was used to select appropriate power transformations.<sup>26,27</sup> Mathematics and reading scores were log-transformed, and square root transformation was used for depression scores.

Factor analysis with varimax rotation was used to reduce the number of items related to violent behavior and identify underlying constructs. The minimum factor loading for items to be included on a factor was 0.4. Summary variables were created for each

of the factors, giving a value of 1 if the participant was involved in any of the items on the factor or 0 for no involvement.

Inverse probability weighted estimation was used to correct for possible bias because of loss to follow-up.<sup>28,29</sup> A logistic regression for the variable “assessed at follow-up” (yes = 1, no = 0) was estimated over enrollment characteristics (child age, developmental quotient, height-for-age, housing, mothers’ age, education and verbal IQ, and level of stimulation in the home), intervention group assignment, and emigrant status (resident: 0; emigrant, 1), and the probability of being assessed at follow-up was calculated using the estimated logistic regression. Inverse probability weights were computed as 1 divided by the estimated probability of being assessed at follow-up. These weights were used in all regressions of the impact of interventions.

Multiple linear regressions were estimated to determine the effects of interventions on IQ, educational achievement, general knowledge, grade level attained, and psychological functioning and count data regression (poisson) to estimate effects on the number of secondary examinations passed.<sup>30</sup> Logistic regressions were used for the violence summary variables. In all regressions, intervention groups (no stimulation: 0; stimulation, 1; no supplementation, 0; supplementation, 1) were entered as well as any enrollment characteristics that differed by group. Separate analyses were conducted for the sample who reside in Jamaica and for the total sample.

## RESULTS

### Participant Characteristics

Enrollment and current characteristics of the participants tested are shown in Table 1. Mother’s education on enrollment was significantly lower in the stimulated groups ( $P = .020$ ),

and housing was higher in the supplemented groups ( $P = .040$ ). No other significant differences in enrollment characteristics by intervention group were found. At follow-up there were no significant differences in age, height, or housing (Table 1), but there were significantly more emigrants from the stimulated groups than from the non-stimulated groups ( $P = .024$ ).

### IQ, Education, and Psychological Functioning

Scores for the total sample on IQ, educational tests, educational attainment, general knowledge, and psychological functioning are shown in Table 2 with the significance of unadjusted intervention effects.

Table 3 shows treatment effects using weighted multiple regression analyses. Stimulation had significant benefits to IQ and mathematics and reading scores among the participants who reside in Jamaica and the total sample including the emigrants. Stimulation benefitted general knowledge in the residents (emigrants not tested). Among the resident sample, stimulation increased the highest grade level attained and the number of secondary level examination passes, with similar nonsignificant trends for the total sample. Four resident participants passed advanced-level examinations, all had received stimulation (Fisher’s exact test,  $P = .061$ , total sample). Nine participants (17.3%) in the no-stimulation groups and 2 (3.8%) in the stimulation groups had been expelled from school (Fisher’s exact test,  $P = .028$ , total sample). There were no significant group differences in additional training after secondary school. Stimulation led to significant reductions in symptoms of depression and in social inhibition in residents and the total sample but was not associated with levels of anxiety. There were no significant effects of supplementation.

**TABLE 1** Characteristics of Participants (Residents and Emigrants) Tested at Age 22 Y on Enrollment and Follow-up

	Control ( <i>n</i> = 26)	Supplement ( <i>n</i> = 26)	Stimulation ( <i>n</i> = 24)	Both ( <i>n</i> = 29)	<i>P</i> , ANOVA <sup>a</sup>	
					Stimulation	Supplement
<b>Enrollment</b>						
Girls, <i>n</i> (%)	12 (46.2)	11 (42.3)	12 (50.0)	13 (44.8)	.76	.65
Height-for-age (z score)	−2.90 (0.59)	−2.84 (0.66)	−2.89 (0.45)	−3.09 (0.78)	.34	.60
Age, mo, mean (SD)	19.1 (4.8)	18.7 (3.8)	18.8 (4.6)	19.0 (3.8)	.99	.89
Developmental quotient, mean (SD)	95.7 (9.7)	98.5 (8.8)	101.0 (10.6)	97.9 (7.2)	.19	.93
Housing, <sup>b</sup> mean (SD)	7.8 (1.8)	7.3 (1.8)	7.6 (1.0)	6.8 (1.6)	.27	.040
HOME, mean (SD)	18.4 (4.9)	15.9 (4.3)	16.0 (4.3)	16.1 (3.9)	.21	.18
Mothers PPVT, mean (SD)	82.4 (18.9)	87.3 (18.8)	87.7 (20.9)	86.0 (22.4)	.62	.68
Mothers age 19 or younger, <i>n</i> (%)	10 (38.5)	3 (11.5)	6 (25.0)	7 (24.1)	.96	.10
Mothers' education: secondary exams, <sup>c</sup> <i>n</i> (%)	6 (23.1)	5 (19.2)	2 (8.3)	1 (3.4)	.020	.44
<b>Follow-up</b>						
Age, y, mean (SD)	22.7 (0.5)	22.7 (0.4)	22.8 (0.4)	22.7 (0.4)	.38	.82
Height, cm, mean (SD)	168.7 (9.5)	169.1 (9.2)	167.4 (9.9)	166.4 (7.9)	.26	.88
Housing, <sup>d</sup> mean (SD)	−0.12 (0.99)	−0.33 (1.07)	−0.04 (1.14)	0.26 (0.84)	.09	.84
Migrant, <i>n</i> (%)	2 (7.7)	1 (3.8)	5 (20.8)	6 (20.7)	.024	.85

ANOVA indicates analysis of variance; HOME, Home Observation for Measurement of the Environment; PPVT, Peabody Picture Vocabulary Test.

<sup>a</sup> ANOVA with stimulation and supplementation as factors or  $\chi^2$  for categorical variables.

<sup>b</sup> Sum of ratings of water, toilet, possessions, and crowding (reverse-coded) as used during the original study when information on only 4 possessions was collected.

<sup>c</sup> Mother passed grade 9 achievement test or "O"-level examinations.

<sup>d</sup> Score derived from factor analysis of water, toilet, possessions, and crowding.

**TABLE 2** Unadjusted IQ, Educational Tests, General Knowledge, and Psychological Measures at Age 22 Y

	Control ( <i>n</i> = 26)	Supplement ( <i>n</i> = 26)	Stimulation ( <i>n</i> = 24)	Both ( <i>n</i> = 29)	ANOVA <sup>a</sup>	
					<i>F</i>	<i>P</i>
<b>IQ (WAIS), mean (SD)</b>						
Full scale	70.5 (8.9)	73.4 (11.8)	77.6 (12.0)	75.7 (11.1)	4.76	.031
Performance	73.5 (8.8)	77.4 (12.1)	81.0 (12.4)	79.2 (11.1)	4.56	.035
Verbal	72.3 (10.3)	74.0 (10.6)	78.0 (11.8)	76.3 (10.4)	3.68	.058
<b>Educational achievement</b>						
Mathematics, mean (SD)	3.4 (1.8)	3.7 (2.2)	4.9 (3.1)	4.6 (3.1)	4.43	.038
Reading, mean (SD)	3.9 (2.4)	4.8 (3.0)	5.7 (3.4)	5.1 (2.6)	3.41	.068
Highest grade level, mean (SD)	10.5 (0.9)	10.3 (1.3)	10.9 (1.1)	10.6 (0.7)	2.34	.13
Secondary level examination passes, <i>n</i> (%)						
1–3	2 (7.7)	4 (15.4)	4 (16.7)	1 (3.4)	1.86	.39 <sup>b</sup>
4–8	2 (7.7)	3 (11.5)	6 (25.0)	4 (13.8)		
General knowledge, mean (SD)	14.9 (5.8)	14.7 (6.1)	17.0 (6.4)	17.8 (4.7)	4.62	.034
<b>Psychological functioning, mean (SD)</b>						
Anxiety	46.8 (7.3)	44.5 (10.6)	44.8 (7.6)	43.6 (6.3)	0.88	.35
Depression	8.5 (4.9)	7.7 (4.9)	6.5 (4.6)	6.1 (4.7)	3.78	.055
Social inhibition	6.2 (3.8)	6.1 (4.2)	5.1 (3.6)	4.9 (2.3)	2.59	.11

ANOVA indicates analysis of variance.

<sup>a</sup> ANOVA with stimulation and supplementation as factors. Values are presented for stimulation only as none of the analyses for supplementation approached significance (all  $P > .2$ ).

<sup>b</sup>  $\chi^2$  analysis.

## Behavior

Factor analysis of participants' reported involvement in violent behavior yielded 4 factors. The first factor comprised 6 variables related to more serious behavior (fights with weapons, hurt someone with a weapon, carried a gun in past month, threatened someone with a gun, shot someone with gun, gang member; eigen value: 3.03), the second factor comprised physical fights (involved in fight, started a fight;

eigen value: 1.99), and the third comprised use of weapons other than guns (eigen value: 1.44). The fourth factor comprised a single question concerning rape. Two participants in the no-stimulation groups and 2 in the stimulation groups admitted to rape, and this item was not included in additional analyses. Weighted logistic regression analyses of the violence outcomes (involvement in any of the activities on the factor, 1; no involve-

ment, 0) are shown in Table 4. For the total sample, the stimulated groups tended to be less likely to be involved in fights (odds ratio: 0.36 [95% confidence interval: 0.12–1.06]  $P = .061$ ) and were significantly less likely to be involved in more serious violent behavior (odds ratio: 0.33 [95% confidence interval: 0.11–0.93]  $P = .037$ ). Results for residents only were similar.

There were no significant differences among the groups in alcohol

**TABLE 3** Effect of Early Childhood Stimulation on IQ, Educational Achievement, General Knowledge, and Psychological Well-being at Age 22 Y

	Resident in Jamaica						Total Sample					
	Stimulation			Supplementation			Stimulation			Supplementation		
	$\beta$	95% CI	<i>P</i>	$\beta$	95% CI	<i>P</i>	$\beta$	95% CI	<i>P</i>	$\beta$	95% CI	<i>P</i>
<b>IQ</b>												
Fullscale	6.7	2.2–11.2	.004	1.6	–2.9–6.0	.48	6.3	2.2–10.4	.003	.4	–2.7–5.5	.49
Performance	5.6	0.9–10.3	.020	1.4	–3.2–6.0	.55	6.0	1.7–10.3	.007	1.7	–2.6–6.0	.44
Verbal	6.7	2.3–11.0	.003	1.5	–2.8–5.8	.50	5.6	1.6–9.6	.006	0.9	–3.1–4.9	.65
<b>Educational achievement</b>												
Maths (log)	0.28	0.06–0.49	.012	0.01	–0.20–0.22	.94	0.25	0.05–0.45	.014	–0.02	–0.22–0.17	.83
Reading (log)	0.27	0.07–0.47	.009	0.11	–0.09–0.30	.28	0.27	0.09–0.44	.004	0.08	–0.10–0.25	.40
Highest grade level	0.48	0.04–0.92	.033	–0.15	–0.59–0.28	.49	0.35	–0.06–0.76	.09	–0.17	–0.58–0.24	.41
No. secondary level examination passes <sup>a</sup>	1.03	0.17–1.89	.019	–0.26	–0.99–0.47	.49	0.82	–0.09–1.72	.08	–0.21	–1.02–0.59	.60
General knowledge	3.5	1.1–5.8	.005	0.24	–2.1–2.6	.84	—	—	—	—	—	—
<b>Psychological functioning</b>												
Anxiety	–2.2	–5.6–1.2	.20	–0.4	–3.7–2.9	.80	–1.4	–4.6–1.9	.40	–2.8	–6.0–0.5	.10
Depression (sqrt)	–0.42	–0.75–0.08	.016	–0.15	–0.48–0.18	.38	–0.35	–0.67–0.04	.030	–0.22	–0.54–0.09	.16
Social inhibition	–1.5	–3.0–0.06	.042	0.28	–1.2–1.7	.70	–1.4	–2.8–0.00	.050	–0.16	–1.5–1.2	.82

Weighted multiple regression analyses: Variables were entered in all regressions: stimulation; supplementation; housing; and maternal education on enrollment. CI indicates confidence interval.  $\beta$  is the regression coefficient.

<sup>a</sup> Count data regression (poisson).

**TABLE 4** Weighted Logistic Regression Analysis of Effect of Early Childhood Stimulation on Violent Behavior

	Residents Only, Odds Ratio (95% Confidence Interval)		Total Sample, Odds Ratio (95% Confidence Interval)	
	Stimulation	Supplementation	Stimulation	Supplementation
Involved in physical fight <sup>a</sup>	0.20 (0.05–0.78)	1.02 (0.30–3.44)	0.36 (0.12–1.06)	0.76 (0.29–2.03)
<i>P</i>	.021	.98	.061	.58
Involved in violent crime <sup>b</sup>	0.35 (0.11–1.06)	1.38 (0.46–4.16)	0.33 (0.11–0.93)	1.49 (0.51–4.33)
<i>P</i>	.063	.56	.037	.46
Weapon use <sup>c</sup>	0.66 (0.27–1.63)	1.31 (0.51–3.35)	0.59 (0.25–1.38)	1.38 (0.54–3.39)
<i>P</i>	.37	.57	.22	.48

Weighted logistic regression analyses: Variables entered were stimulation; supplementation housing; and maternal education on enrollment. The regression for violent crime is estimated on the subsample of mothers without secondary exams (91 of 105 for the entire sample and 79 of 91 for the resident sample) because none of the participants whose mother had secondary exams was involved in violent crime. Hence, the data is uninformative on how the interventions could have changed the probability of being involved in violent crime for these children.

<sup>a</sup> Involved in physical fight or started fight.

<sup>b</sup> Involved in any of the following: fight with weapon; hurt someone with weapon; carry gun in past month; threatened someone with gun; shot someone with gun; or gang member.

<sup>c</sup> Carried weapon in past month or ever threatened someone with a weapon.

consumption, cigarette smoking, and marijuana use. Burglary was reported by 1 participant in the no-stimulation groups and shoplifting by 2 in the stimulation groups. Detention by the police, being charged with a crime, or being convicted of a crime did not differ by intervention group. Overall, 20.9% of participants had been detained by the police, 12.4% charged with an offense, and 7.6% convicted; however, only 1 participant from the stimulation groups

was sentenced to prison, and the remaining convictions led to fines.

There were no differences among the groups in the quality of their relationships with their mothers, fathers, or partners, or in number of sexual partners, safe sex (condom use), or use of birth control. Forty-three participants had 1 or more children. The percentage of participants with children did not vary significantly among the groups. There were also no significant

differences in teenage births. Church attendance, participation in community groups, and the numbers who voted in the last national elections did not differ by group.

## DISCUSSION

This study provides the most comprehensive data available on the adult benefits of early psychosocial stimulation for disadvantaged children from a developing country. The findings reveal that ECD programs can reduce the large number of children who do not attain their developmental potential. Earlier benefits to IQ, reading ability, and depressive symptoms are sustained, and we demonstrate new benefits to attainment in mathematics, final school grades, national secondary examination passes, and to general knowledge likely to facilitate everyday functioning and reduced social inhibition. The reductions in violent behavior are important, given the substantial problems with societal conflicts in many developing countries. Although participants may under-report antisocial behavior, they were assured of confidentiality, and interviewers were unaware of the participants' group as-

signment. We have no reason to hypothesize that any under-reporting would differ by intervention group.

As at age 11 and 17 years,<sup>6,11</sup> there were no detectable benefits of supplementation. The supplement comprised approximately two-thirds of the children's daily energy requirement; however, the level of supplementation achieved was less because of substitution for the child's usual diet.<sup>8</sup> Supplementation produced modest increases in linear growth and head circumference;<sup>8</sup> however, these gains were not sustained at 7 years old.<sup>10</sup>

Brain function may be most sensitive to the effects of nutrition in the first 2 years and less from 2 to 4 years.<sup>31–33</sup> In the only other randomized trial of nutritional supplementation with long-term follow-up we are aware of, children supplemented from birth to 24 months old had significant benefits to adult cognition, and women had better educational achievement.<sup>35</sup> Men who had received supplement for the first 3 years of life had greater hourly wages.<sup>31</sup> However, no benefits were detected in those beginning supplementation after 24 months.

It is also possible that providing supplement to children who were already growth-retarded rather than preventive supplementation contributed to the lack of sustained benefits. Undernourished children in Colombia received a combination of supplementation and educational interventions from 42 months old for 1 to 4 9-month treatment periods. The interventions benefited cognitive ability up to 1 year after the end of intervention, but it was not possible to determine the impact of supplementation alone.<sup>34</sup> However, some children received supplementation and health care only during the first 3 treatment periods and had no concurrent cognitive benefit compared with an untreated group.<sup>35</sup>

Participants who received stimulation were less likely to have been expelled from school (usually a result of behavior problems). They reported less involvement in physical fights and were less likely to be involved in serious violent behavior such as gun use, fights with weapons, and gang membership. These findings reinforce the importance of beginning strategies to prevent aggressive behavior in early childhood.<sup>36,37</sup>

The benefits of stimulation to IQ were substantial, with an effect size of 0.6 SD, and benefits to educational outcomes were wide-ranging and should have implications for future earnings. In the United States, ECD interventions with long-term follow-up have usually involved intensive center-based interventions; however, few have revealed benefits to IQ,<sup>38</sup> whereas educational benefits occurred more often.<sup>38–40</sup> Studies of home-visiting only revealed no benefits to high school graduation,<sup>41</sup> or benefits to graduation and school dropout that were not significant after controlling for enrollment IQ.<sup>42</sup> There are few long-term evaluations of ECD interventions outside of the United States. In Turkey, 2 years of educational day care and/or mother training starting at ages 3 or 5 years increased college attendance only.<sup>43</sup>

In Jamaica, participants in the stimulation groups reported fewer depressive symptoms, as seen at 17 years old,<sup>7</sup> but there were no differences in level of anxiety. Benefits to depression have also been reported from ECD interventions in the United States;<sup>44,45</sup> however, other than our previous finding of reduced anxiety when the participants were aged 17 years, we are unaware of any reports of an impact on anxiety. Stimulation also reduced participants' social inhibition, which indicates difficulty in meeting and interacting with new persons. Less social

inhibition may benefit functioning in the workplace, in job interviews, and in other social relationships. Noncognitive skills have been demonstrated to affect wages, employment, and occupation choice.<sup>46</sup>

In contrast to the wide-ranging benefits in other areas, we did not find significant reductions in alcohol and drug use, risky sexual behavior, or teen pregnancy. Evidence from other studies for the impact of early childhood programs on these types of behaviors is mixed.<sup>38,40,41,45</sup>

Reduction in arrests and incarcerations have been reported from ECD interventions in the United States.<sup>40,45</sup> However, others found no differences,<sup>38</sup> or differences in girls only.<sup>41</sup> There were no differences in Jamaica to arrests or convictions, and later follow-up of the cohort will be important to determine if benefits extend to these areas.

The reduction in violent behavior and benefits to cognition, educational attainment, general knowledge, and psychological functioning came from a home-based intervention delivered by paraprofessionals. The Jamaican children had experienced chronic undernutrition severe enough to cause linear growth retardation and came from poor neighborhoods and were therefore very disadvantaged, and this may be 1 reason for the extensive benefits.<sup>4</sup> Characteristics of the program may also have contributed to the long-term benefits. We focused on working through the mothers and supporting them in improving their children's development. The visits were centered around play activities on the basis of a structured curriculum. We emphasized verbal interaction and praise and ensured that the level of the visit allowed both mother and child to experience success. The community health workers were women of similar background to the

mothers, which may have helped them to establish friendly, empathetic relationships with the mothers. In addition, the community health workers received regular supervision to maintain the quality of the program.

The benefits of early psychosocial intervention for adult educational attainment and behavior have important policy implications. The challenge now is to develop effective strategies for scal-

ing up of interventions to reach the millions of children at risk of poor development. This will require identification of opportunities within existing services for integrating child development activities.

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Noted by Patrick Huffer, MS-IV

## Early Childhood Stimulation Benefits Adult Competence and Reduces Violent Behavior

Susan P. Walker, Susan M. Chang, Marcos Vera-Hernández and Sally Grantham-McGregor

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