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Extending The Jamaican Early Childhood Development Intervention

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Introduction

It is now well established that exposure to poverty in early childhood affects children's cognitive, language, and socio-emotional development as well as their health and nutrition.[1-5] Furthermore, brain function and structure are also affected[6] and may mediate some of the effects of poverty on function.[7,8] Development in early childhood is particularly important as it provides the foundation of later development, determining to some extent health and well-being in adulthood. The gap in development between children from rich and poor families is probably greater in low- and middle- income countries (LMICs), where malnutrition and poverty are likely to be more severe. A recent Bangladeshi study[9] showed that the gap between children from families in the upper and lower wealth quintiles in cognition was apparent as early as age 7 months and increased up to age 63 months when it was 1.2 standard deviations in IQ (Figure 1).

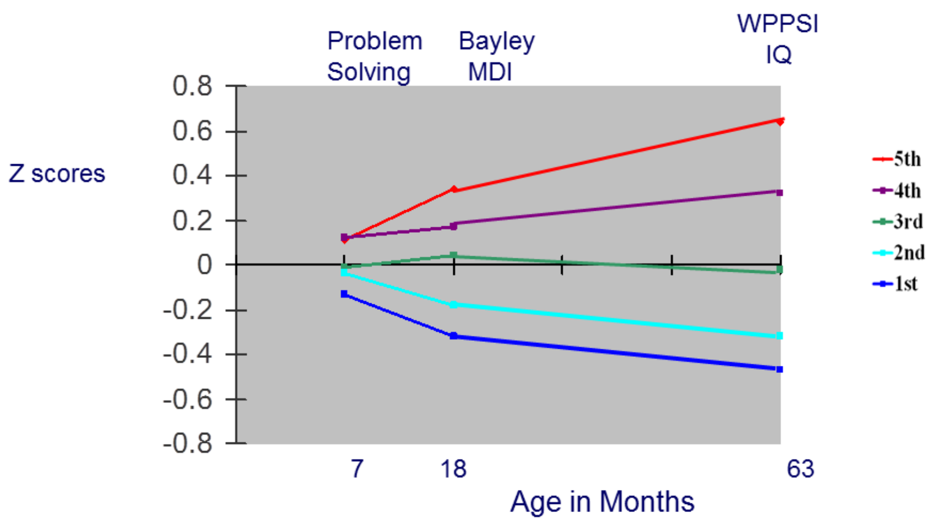

Figure 1. Mean Cognitive Development in Standard Scores by Wealth Quintiles at Birth in 1,579 children in Bangladesh[9]

In an attempt to remediate or prevent the effects of poverty, many different approaches to early childhood interventions have been tried.[10,11] Some of the first ones were in the US and tended to be high cost with professional teachers[12] and were often center-based programs. The most well-known one was the HighScope Perry Preschool Program, which comprised 2½ hours per day at a center with 1 highly trained teacher for every 5 or 6 children; the teacher also did weekly home visits.[13] There were relatively fewer interventions in LMICs, and the Jamaican intervention was one of the first. There have now been 12 published trials and 5 recently completed ones using the intervention in 5 different countries, and several had long term follow-ups. In this paper, we briefly review the published studies and present effect sizes, which are calculated by dividing the final difference between the intervened and control groups by the standard deviation of the controls. We also describe the development of the intervention. We then describe international spread and discuss what we have learned and what information is still needed.

The Jamaican Intervention and Evidence Base

We began developing a home visiting intervention in Jamaica in the early 1970s. A recent study had shown that the developmental level of poor children in Kingston declined from 1 to 3 years of age.[14] Informal observations indicated that the children had no books and very few toys and that mothers with low levels of education had little idea of how to promote their child's development. Another study of Kingston children found that 15% were underweight (< 80% expected for age and gender) at 12 months of age.[15]

We chose home visiting because centers were not readily available, and we thought it would be easier to make close relations with the mothers and be more likely to change their child-rearing practices in home visits. We thought that if we could change the mothers' practices, any benefits to the children were more likely to be sustainable. Other considerations were that individual play sessions with the children should facilitate tailoring the activities to the specific developmental level of the children. The intervention focused on supporting the mothers to become better teachers of their children and to interact with them in responsive and sensitive ways likely to promote their development. We were also inspired to use a home visiting model by the work of Susan Gray, whose home visiting program targeted extremely poor families in Tennessee[16] where the families appeared to be as poor as the Jamaican ones.

The Jamaican intervention comprised weekly home visits when the visitor demonstrated play activities to the mother using toys and books. We began developing the intervention using expensive inputs and then gradually reduced the costs to make it more feasible to go to scale. We examined the effect of frequency of visits to determine if weekly visits were necessary. Also we examined the intervention effect on different types of high-risk children, including severely malnourished, stunted, and low birth weight infants born at term, all of which conditions are prevalent in LMICs. In all the Jamaican studies, children's development was evaluated before and after the intervention with a modified version of the Griffiths Mental Development Scales,[17,18] which have been shown to be valid and reliable in Jamaica.[19] The first few studies were small and used matched controls; following this, we only used randomized controlled study designs (RCTs).

Study 1: Disadvantaged Children

In the first study, we matched 2 adjacent neighborhoods for standard of housing, and 21 children aged 34 to 40 months from each were enrolled. Children in 1 neighborhood were visited weekly for 8 months whereas children in the other were not visited (control); both groups received free medical care. The intervention was reasonably expensive in that a nurse or doctor conducted home visits and we used high-quality, purchased toys and books. We wanted to determine if it was possible to work with the mothers to improve their child's development in the best possible conditions. At that time, many professionals thought that uneducated mothers could not be used and that center-based care was more desirable. After 8 months, the children showed marked benefits to their developmental quotients (DQs) (effect size 1.08 standard score [SD]) compared with matched controls.[20]

Study 2: Severely Malnourished Children

In the second study, we intervened with children who were hospitalized with severe malnutrition (ISM). A recent Jamaican study had shown that children hospitalized for severe malnutrition had very low levels of IQ for several years after recovery.[21] Twenty-one children in the intervention group had daily play sessions in the hospital followed by weekly home visits for 2 years, then every 2 weeks for a third year. They were compared with 18 matched controls (CSM) who had been in the same hospital with severe malnutrition the previous year and with 15 adequately nourished children (AN) who were in the hospital at the same time with acute short-term illnesses.[22] To reduce costs, we used homemade toys made from waste materials, and either a trained nurse or a community health aide (CHA) (who had some secondary schooling and a short course in health care) did the home visits. After leaving the hospital, the children were followed for 14 years until they were 16 to 17 years old[19] (Figure 2). Both malnourished groups had similar and extremely low levels of development on enrollment and markedly lower than the comparison AN group. The CSM group showed no improvement in developmental levels compared with AN children in spite of nutritional rehabilitation. In contrast, the intervened malnourished children initially made remarkable improvements, and after 24 months of visiting their DQs were higher (effect size = 1.7 SD) than the CSM group, and they had caught up to the AN group, who came from better-off backgrounds. However, the ISM children's scores declined in the third year of visiting and continued declining until they levelled off around age 8 years. At the 14-year follow-up when they were 16 to 17 years old, they retained substantial IQ benefits (8.6 points, effect size 0.91 SD) compared to the CSM group and had slightly higher school achievement scores (p= 0.1). Their IQs were not significantly lower than the ANM group.

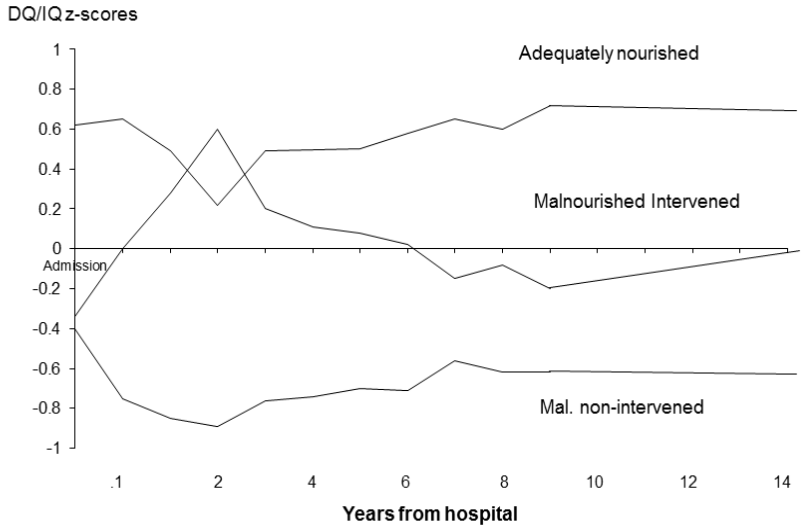

Figure 2. Mean DQs/IQs in Standard Scores Adjusted for Age for the 3 Groups on Enrollment and at Each Test Session for 14 Years After Leaving the Hospital[19]

Studies 3 and 4: Frequency of Visits

We then explored the effect of frequency of visits, and to further reduce costs we no longer used nurses to visit but used only CHAs .[23] Three poor neighborhoods matched for socioeconomic conditions were surveyed and children aged 6 to 30 months identified (Study 3). The neighborhoods were assigned to monthly home visiting (45 children) or visiting every 2 weeks (49 children) or no visits (controls, 45 children) for 2 years. The 2 weekly group showed moderate improvements to the Griffiths scores compared to controls whereas the monthly group had no significant benefit, although they had small benefits to vocabulary assessed on the Peabody Picture Vocabulary Test.[24] We were unsure whether the reduced visiting frequency or using only CHAs as visitors was responsible for the lower impact. We therefore ran a second study (Study 4) in the same neighborhoods using the same staff. All available children aged 16 to 30 months in the selected neighborhoods were individually randomized to control (n =29) or weekly (n = 29) visiting. After 1 year, the impact was similar to that of the first study[20] when a nurse or doctor did the visits (effect size 1.0 SD: 13 IQ points), suggesting that reduced visit frequency had been the reason for smaller impacts rather than the educational level of the visitors. Furthermore, finding the large impact following random assignment to treatment reassured us as to the validity of previous findings where groups were matched.

Study 5: Stunted Children

An estimated 156 million of children under 5 years in LMICs are stunted (height for age <-2SD of international standards),[25] and their development is usually poorer than that of non-stunted children.[26] We investigated whether nutritional supplementation and/or stimulation improved their development in another RCT.[27] One hundred and twenty-nine stunted children aged 9 to 24 months were randomized to 4 groups: nutritional supplementation (n = 32), home visiting (n = 30), both treatments (n = 32), or control (n = 33) for 2 years. A fifth group of non-stunted children (n = 32) from the same neighborhoods was also studied. Initially the stunted groups' development was behind the non-stunted group, and the control stunted group increased their deficit during the intervention. At the end of the intervention, stimulation and supplementation independently improved the children's DQs (effect size 0.88 SD and 0.59 SD respectively), and the combined treatments were additive (effect size 1.47SD), with the group receiving both treatments catching up to the non-stunted group.

The children have been followed to 22 years of age. The tests used at each follow-up to 22 years are given in the tables (Tables 2 to 6) in the appendix. The cognitive effects of stimulation declined and were smallest at 7 to 8 years,[28] when the mean IQ was not significantly different from the controls. However, the stimulated group improved by 11 to 12 years, when their IQs became significantly higher than the controls.[29] We detected no significant intervention effect on behavior or school achievement at 11 to 12 years.[30] The impacts continued to increase, and by 22 years the 2 groups with any stimulation showed wide-ranging benefits to IQ (6.7 points, p=0.004), school achievement and grade attainment, general knowledge and reduced depression, social inhibition and participation in severe violence, and a 25% increase in wages.[31,32] In contrast, we detected no effect of supplementation after age 7. The control stunted group remained significantly behind the comparison non-stunted group, and the small differences between the intervened stunted group and the non-stunted group were generally not significant. The DQs and IQs converted to standard scores are shown in Figure 3 with the stunted groups who received stimulation with or without supplementation combined.

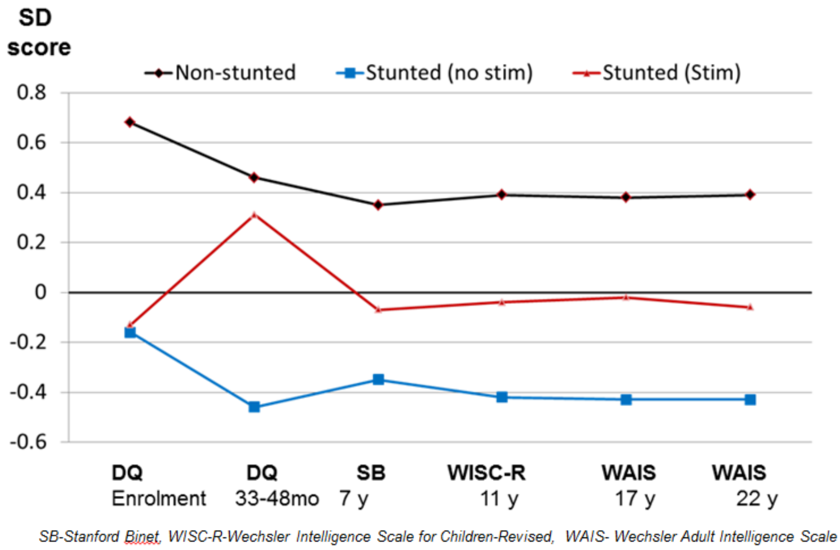

Figure 3. Long-term Benefits to DQ/IQ in Standard Scores (SDs) in Stunted, Stimulated Groups Combined Compared to Stunted Non-stimulated Groups and Non-stunted Group[31]

Study 6: Low birth weight term children

Subsequently we studied the effects of the home visiting intervention on 140 low birth weight children born at term (LBWT). We also compared them with 94 normal birth weight children matched for day and place of birth to 2 of every 3 LBWT infants. The LBWT infants were randomized to stimulation or control. We developed a new curriculum for stimulation from birth to 8 weeks and focused on maternal-child interaction, encouraging the mother to observe, respond, and vocalize to and show affection to the baby. The intervention comprised weekly home visits by CHAs for the first 8 weeks followed by an assessment of problem-solving at 7 months, when the intervened children showed improved problem-solving compared with controls (p=<0.05).[33] Following this, they began the usual weekly home visits from 7 to 24 months. At 24 months, the stimulated LBWT group had higher scores on the Hand and Eye and Performance subscales (effect size 0.38 and 0.42 respectively, p=0.05), but their DQs were not significantly different. These effects were less than in previous studies.[34] Possible reasons for smaller impacts could be that they had shorter visits lasting 30 minutes rather than 1 hour and that the children were generally younger than previous studies and were low birth weight. Follow-up at 6 years[35] showed moderate benefits to the WISC performance IQ (effect size 0.38SD), but the verbal and global IQ were not significantly affected. They also had reduced total behavior difficulties (effect size 0.40SD).

Study 7: Primary Health Care Study

In previous studies, we temporarily transferred CHAs from the government health service and hired them full time, whereas in this study we assessed whether it was feasible to use the existing primary health care staff during their routine work to deliver a home visiting intervention.[36] Eighteen nutrition clinics were randomly assigned to treatment or control, and 139 undernourished children aged 9 to 30 months were enrolled from these clinics. The CHAs in the intervention clinics each visited 3 to 5 children weekly. They succeeded in visiting the homes on average every 10 days, and the children showed significant benefits to every Griffiths subscale[17,18] except the gross motor scale. The effect size was impressive at 0.94 SDs on the Griffiths DQs. This large improvement may be partly due to the researchers who provided training and supervision. The next step would be for the clinic nurses to do the supervision. Unfortunately, there was no follow-up.

Curriculum

More detailed information on the curriculum is available elsewhere.[37] Briefly, the intervention was designed to be low cost and use paraprofessionals. The curriculum was structured and manualized with detailed guidelines for both materials and activities for every visit arranged in developmental order. The structure was necessary when using visitors with limited educational background. The children were placed on the curriculum at their developmental level and moved along week by week unless it was too easy or difficult when they were moved to their appropriate level. Every effort was made to keep the activities at the child's proximal zone of development.[38]

The curriculum for children under 18 months included Piagetian concepts as documented by Uzgiris and Hunt.[39] For older children, the curriculum included concept teaching based on Francis Palmer's list of concepts,[40] sorting and matching activities, and a series of puzzles and form boards. It also included general information about the world. Emphasis was placed on the mother playing, chatting, looking at books, singing and responding to the child, and using everyday child care activities and household work to add new words and games. We used homemade toys, which were left in the homes and exchanged for new ones at each visit. We had specific aims for the mothers including to improve their self-esteem and their child-rearing knowledge and practices. In preliminary piloting, we noted that the mothers used very little positive feedback or praise and that they rarely named concepts, objects, or activities. So we emphasized these points and aimed to improve the children's self-esteem as well as their cognitive, language, and socio-emotional development. We developed supportive, warm relations between the supervisor and CHAs and, in turn, between the CHAs and mothers. In the training, emphasis was placed on the quality of relations.

Spread to Other LMICs

Having shown that the intervention was effective in Jamaica, we investigated whether the intervention could be effective in other cultures, beginning in Bangladesh. The curriculum was adapted to Bangladesh by including their traditional games and songs and changing all pictures to reflect the children's environment. The International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) has now completed 5 studies, including 4 RCTs and 1 with matched controls. The Centre has also experimented with the delivery strategy. It used the Bayley Scales of Infant Development[41] to assess child development, and all showed some significant benefits to the Mental Development Index (MDI).

Bangladeshi Studies

Study 8. In the first study,[42] 20 villages were randomized to treatment or control group, and underweight children (weight-for-age <-2SD of international standards) enrolled in the nutrition centers were selected from each village. A total of 214 underweight children were enrolled (107 intervention and 107 control); 107 better nourished children, matched to alternate underweight children, were also studied for comparison. The intervention comprised weekly home visits and group meetings for 12 months. Local village women were trained to do home visits. There was a moderate effect on children's MDI (effect size 0.33), and their behavior ratings during the test also improved. These children are now being reassessed at age 17 years.

Study 9. Having shown that the intervention was effective in Bangladesh, we wanted to add stimulation to the care of severely malnourished children being treated at the icddr,b hospital.[43] Our aim was to encourage the routine addition of psychosocial stimulation to the treatment of malnourished children in the hospital. There was only one ward for the treatment of malnourished children, so it was considered unethical to have control and intervened children at the same time; we therefore used time-lagged matched controls. We observed the development of a control group of 43 severely malnourished children, aged 6 to 24 months, from admission to the hospital to 6 months after returning home for the first phase of the study. We then intervened with 54 severely malnourished children in the same hospital[43] matched for age and area of residence to the control group.

The intervention included 30 minutes of individual play and 30 minutes of mothers' group meetings every day for the 2 weeks while the children were in the hospital. This was followed by home visits or play sessions in the outpatient clinics every 2 weeks for 6 months. The children's development was extremely poor, and many children had MDI scores below 50. We therefore used raw scores, controlling for age when doing the analyses. The intervened children showed large improvements to their MDI scores compared with the control group (effect size 0.97SD) and less for their motor development (effect size 0.56SD). This large response has several possible explanations: it might be a reflection of the children's very poor initial level of development and nutritional status; the intense intervention for the 2 weeks in the hospital when the mothers lived in the hospital may also have helped. Another possibility is that the mothers were motivated by the very poor state of the child.

Study 10. In another RCT,[44] we compared 3 different treatments of 507 severely underweight children, aged 6 to 24 months, in the community. These children were less malnourished than those in the previous study and treated in the community rather than in the hospital according to the usual government health care procedure at that time, although the children were still severely underweight. The children were randomized to 5 groups: 1 received a protein calorie supplement for 3 months (Supp, n = 101), 1 participated in stimulation for 6 months (Stim, n = 102), and 1 received both treatments (Both, n = 103). There were 2 control groups who received no supplement or stimulation. One control group was given the routine treatment at the hospital outpatient clinic (HC) (n = 102), and 1 was treated at local community clinics (CC) (n = 99). All groups received multiple micronutrients and health care.

The stimulation varied from previous studies in that the mother and child met every 2 weeks with a play leader at the local health clinic for individual play sessions using the usual curriculum. This implementation schedule was an attempt to make the model more feasible to fit into the health services. However, we continued the stimulation program for 6 months because we had serious reservations about 3 months being sufficient to cause improvements. Stimulation alone or with supplementation improved MDI (effect size 0.37), which was encouraging because the inputs were less than before. In contrast, supplementation had no effect on development, and we hypothesize that the supplement was given for too short a time to affect development. The supplemented children showed a small weight improvement after 3 months when the supplement was stopped, but the weight improvement disappeared after 6 months. In the Jamaican study previously described with stunted children,[27] benefits to the children's development only occurred after 12 months of receiving supplement.

Study 11. Iron deficiency is another nutritional deficiency that is highly prevalent in Bangladesh, and there is debate as to whether it affects young children's development. We examined whether iron-deficient anemia (IDA) affected children's response to stimulation and how their developmental level compared with non-anemic, iron-sufficient (NA) children. Two parallel cluster randomized controlled trials were conducted[45] in 30 villages. The villages were randomized to weekly home visits or control. Two hundred and twenty-five iron-deficient anemic (IDA) children aged 6 to 24 months and 209 non-anemic (NA) children matched for age and village were enrolled from these villages. After 9 months of intervention, there was a moderate effect of stimulation on the NA group's MDI scores (effect size 0.38SD), but the effect on the IDA group was not significant. The interaction of anemic/non-anemic group X treatment approached significance (p=0.095). It is not clear why the iron-deficient group did not improve as much as the NA group. It may be that they needed more time to improve. On enrollment, the IDA group's development was not different from the NA children once socioeconomic differences were allowed for. They were all given iron treatment, and their iron status and anemia improved. In spite of improving iron status, at the final test the IDA group had lower motor scores than the NA group. The different response to stimulation and the deterioration in motor development during the study suggests that the development of children with IDA is different from that of NA children.

Study 12: Colombian Study

The Institute of Fiscal Studies, London (IFS), implemented an RCT "piggy backing" on a conditional cash transfer program.[46] We attempted to develop a model that could go to scale, and the sample was spread over 96 municipalities with 1,263 children. It had a 2 by 2 factorial design with weekly home visits, micronutrient supplement, both treatments and control. Cognition and language showed small improvements from stimulation (effect sizes: cognition 0.26 SD p 0.002; receptive language 0.22 SD, p = 0.032) whereas the micronutrients had no effect. These effects were smaller than previous studies, but the sample size was larger and the supervision was reduced from weekly contacts in the previous studies to 9 weekly; this probably explains the smaller effect sizes.

Study 13: Peruvian Program

The first program at scale was in Peru, where the intervention was adapted for a large national program of home visiting in 2012. Preliminary analyses of an evaluation by the Inter-American Development Bank have found benefits on the Bayley Scales[41] to cognition and language.[47]

A brief summary of the above studies has been compiled in Table 1 in the appendix.

Reach Up

In order to facilitate going to scale, an international group of researchers who had experience with the intervention and who were headed by the team from the University of the West Indies (Susan Walker, Christine Powell, and Susan Chang) developed a web package named Reach Up. Based on the Jamaican intervention, Reach Up includes a training manual with videos from 3 countries, a toy manual, a weekly and biweekly curriculum, a guide for supervisors, and a guide on how to adapt to different cultures and begin a program.

The Reach Up package has been adapted to several cultures and is presently being evaluated in new studies in China, Brazil, Guatemala, Bolivia, and Zimbabwe. The initial plan was to make the materials freely available; however, concern arose over maintaining the quality of the intervention, and it was decided to require implementing agencies to use a certified trainer who is experienced in the adaptation and training necessary for the intervention. A list of certified trainers who can provide training is being assembled, and future training will be organized by the University of the West Indies team.

Future Spread

The intervention is currently at scale in Peru, and 2 studies are approaching scale, 1 in Bangladesh and 1 in India. New studies in both India and Bangladesh include an arm with mother-and-child group meetings instead of home visits, and future studies are looking at different frequencies of group meetings and different group sizes. We continue to examine different ways of delivering the curriculum because countries have different conditions and requirements, and we also need to assess the cost-effectiveness of different strategies. There is a constant search for lower-cost models, but if we want to change the trajectory of children's future development, there is probably a limit to the reductions in inputs that are required. Some recent studies using a limited number of group meetings (e.g., Singla et al[48]) have had some success, but we are unaware of any long-term follow-up from group-alone interventions.

Discussion

We have reviewed a total of 13 studies that have used modifications of the Jamaican curriculum in 5 different LMICs. In addition, more studies have just finished and others are in progress, reaching a further 6 countries. In all completed studies, the intervened children have shown concurrent benefits to cognitive function and language or measures of mental development, which include both.

The success in producing benefits and spreading internationally is encouraging; however, there is no room for complacency. Only the Jamaican studies have had effect sizes of over 0.5 SDs. It is unclear whether the effects will be sustained when the initial benefits to mental development are small to moderate. The Jamaican studies were generally smaller, and the visitors were probably more rigorously supervised than in studies elsewhere; this may explain the different effects, and it highlights the challenges when going to scale. However, the impacts in other countries should improve as program managers become experienced with the intervention. For example, a just-completed Bangladeshi study integrating stimulation into the health services has found larger benefits in Bayley scores than reported in previous studies in that country (J. D. Hamadani, unpublished data, 2016). We hope the Reach Up package and training will help improve impacts.

Three Jamaican studies followed children to ages 6, 17, and 22 years and found cognitive benefits at the final test session in each.[28,29,31,49] The 2 studies that extended to 17 and 22 years were small, but both showed the well-recognized pattern of fade-off in cognitive impacts immediately after the intervention. However, in both cases the decline stopped around 8 years of age and benefits became substantial. These results illustrate the importance of long-term follow-ups. The sustained cognitive benefits in Jamaica contrast with findings from the HighScope study in the US,[50] which began at age 3 years and did not have persistent cognitive benefits, although there were other benefits in social behavior, educational attainment, and wages. In contrast, the Abecedarian intervention[51] began at age 4 months, and IQ benefits remained in adulthood. The Jamaican studies began at around 18 months, and it is possible that starting at 3 years of age is too old to get persistent cognitive benefits.

Unanswered Questions

Perhaps the most important unanswered questions about early childhood interventions are “when is the most effective age to begin?” and “how long does it need to last to ensure sustainable impacts?” Although the earlier the better is conventional wisdom, there is little evidence to support it (except for nutritional interventions), and if continued to school age, it is expensive. A study in South Africa[52] ran from late pregnancy to age 6 months, and at age 18 months, benefits were found to attachment but not to cognition. It is likely that the sensitive age varies by the type of function being measured and by curriculum.[53]

Considering duration of intervention, children do not necessarily continue to improve in cognition relative to controls even when the intervention continues. For example, in the Abecedarian study,[54] intervened children improved for 3 years, then stopped improving, although the intervention lasted 8 years, while in one Jamaican study,[19] the intervened children stopped improving after 2 years although home visiting continued. A very early study examined groups of children entering a center-based program approximately a year apart[55] beginning at age 42 months. Across all groups, benefits occurred only in the first intervention period and then leveled off. The size of the intervention effect in the first year of intervention got progressively smaller as the new groups got older and as children entering over 5 years made little improvement. We hypothesize that how long the intervened children continue to improve with intervention may vary by their initial age. The age of ending intervention may also be important. It is likely that children’s benefits are less likely to fade if they proceed to preschool or school. In Jamaica, most children went to preschools, which may have helped sustainability. There remains a need for studies to investigate the question of timing and duration, standardizing for other intervention characteristics.

Another question is "does the type of child and family affect the response to intervention?" The Jamaican curriculum was specifically designed for disadvantaged, high-risk children, and we have no data on its effectiveness with low-risk children. Many types of high-risk children from Jamaica and Bangladesh benefited from the interventions; these children included severely malnourished children, small birth weight term babies, stunted children, underweight children in the community, and simply disadvantaged children. Although it is assumed that the poorest benefit the most, there are few data on low-risk children. A recent report from 3 LMICs showed that children of families with low resources benefited more from intervention than those in families with high resources.[56] Similarly, studies in the US showed that children of parents with low resources or low educational levels benefited more from stimulation than those with better-educated or better-resourced mothers.[57,58]

Policy Implications

It is now well established that small, well-run child development interventions can have concurrent and sustained benefits. However, there is no guarantee that the same benefits will occur if the programs are taken to scale. Some of the many problems faced when going to scale have been discussed elsewhere,[37] and they make maintaining the quality of the intervention difficult. The successful delivery depends both on the quality of the implementation and the intervention. Some of the more important obstacles to good implementation include the difficulty of locating local champions and leaders, reduced frequency and duration of contacts with families, and reduced training and supervision of home visitors. Low salaries and high staff turnover are also problems. We think that the frequency and quality of supervision is particularly critical, especially when using paraprofessionals. Furthermore, the supervision needs to be supportive and not authoritative or judgmental, something which often occurs in hierarchical cultures.

Integration of child development activities into health services should be cost effective if it is possible to use the health staff and facilities. However, it is challenging when the service lacks capacity and when child development interventions may not be a priority for the health staff, who often see child development only as screening for disability. Other impediments to maintaining the intervention's fidelity include adding non-evidence-based materials and attempting to address too many needs other than child development. The real challenge now is to develop mechanisms to monitor and maintain the quality of the intervention and identify the most effective implementation models to go to scale. It is unlikely that the same model will be suitable for all situations; and effective approaches may vary by country.

Appendix

Table 1. Summary of Intervention Studies Based on the Jamaica Home Visiting Intervention

Study	Country	Year	Sample Characteristics	Intervention	Results
1	Jamaica	1975[20]	Children living in suburban communities of Kingston (n = 40; 20 intervention and 21 matched controls).	Mothers and children were visited: - 1hr/week - 29 visits - duration 8 months	DQs effect size 1.08 SDs
2	Jamaica	1980[22] 1983[59] 1987[60] 1994[19]	3 groups all in the hospital aged 6 to 24 months. Severely malnourished children n= 39 (18 controls; 21 intervened) and n=15 adequately nourished children hospitalized with other conditions.	Children had 1 hour daily play sessions while in the hospital then home visits for 1hr/week for 2 years and 1hr/biweekly for a third year.	After 24 months, intervened children had higher DQs (effect size 1.7 SD) than severely malnourished controls. By age 17 years, the intervened group IQ increased, effect size 0.91 SD compared to controls.

Study	Country	Year	Sample Characteristics	Intervention	Results
3 & 4	Jamaica	1989[23]	Inner-city survey Study 3 n = 139; 3 groups matched for SES and age: 45 monthly visits, 49 biweekly, and 45 control A. Study 4: n = 58 from same neighborhoods randomized to 29 intervention and 29 control B.	Home visits by a CHA: Study 3 1hr per month for 2 years OR 1hr biweekly for 2 years. Study 4 1hr/week for 1 year.	Study 3: Biweekly group's DQs increased 2.2 points, whereas control A group declined 4.9 points ($p<0.02$). The monthly group declined 5.7 points. Study 4: Weekly group's DQs increased by 8.9 points compared with control B (effect size 1.0 SD $p <0.001$).

Study	Country	Year	Sample Characteristics	Intervention	Results
5	Jamaica	1991[27]	House-to-house survey identified n = 129 stunted children (below -2SD of the NCHS references) randomized to 4 groups: 33 control, 32 supplemented, 32 stimulated, and 32 both supplemented and stimulated. Also n = 32 non-stunted matched to controls.	Mothers and children were visited by a CHA: 1hr/week for 2 years. Supplemented group received 1kg milk-based formula per week.	After 2 years, the DQ and all the subscales of mental development were significantly higher in the stimulated groups than controls ($p<0.01$). Stimulation: DQ effect size 0.88 SD, supplementation: 0.59 SD; Both group: DQ effect size 1.47 SD.

Study	Country	Year	Sample Characteristics	Intervention	Results
6	Jamaica	2003[33]	140 low birth weight term infants (LBWT) born in public hospital randomized to 70 intervention and 70 control with n = 94 normal birth weight infants.	Visited at home by a CHA: for 1hr per week for first 8 weeks after birth.	The intervened group had better scores on problem-solving test "cover" than the control ($p<0.05$) at 7 months.
		2004[34]		Visited at home by a CHA for 30 minutes per week for 17 months (from 7 to 24 months).	At 24 months, the intervened children had higher scores on the Performance and Hand and Eye subscales (effect size 0.4 and 0.3 SDs respectively) but not DQs.

Study	Country	Year	Sample Characteristics	Intervention	Results
7	Jamaica	2004[36]	Undernourished children from 18 urban nutrition clinics. Clinics randomized to intervention or control. (n = 139 children aged 9 to 30 months: 70 intervention and 69 control)	Visited at home by a CHA for 30 mins per week for 12 months.	The intervened children had higher DQs (effect size 0.88 SDs).

Study	Country	Year	Sample Characteristics	Intervention	Results
8	Bangladesh	2006[42]	214 undernourished children who attended 20 community nutrition centers. Centers randomized to intervention and control n = 107 children from each group and n = 107 better-nourished matched comparisons.	Mothers and children attended group meetings: For 1 hour per week for 10 months and 1 hour every 2 weeks for 2 months and home visits weekly for 12 months.	There was a benefit to children's Bayley Scales Mental Development Index (MDI) (effect size 0.33 SD).
9	Bangladesh	2009[43]	Severely malnourished children admitted to a Nutrition Rehabilitation Unit; controls admitted 1 year before (n = 97; 54 intervention and 43 control).	Daily 30-minute group and individual sessions for 2 weeks in the hospital. After leaving the hospital, 18 play sessions at home or at outpatient clinic for 6 months.	Children in the intervened group had significant benefits on mental score (effect size 1.0 SD, $p<0.001$) and motor score (effect size 0.50 SD, $p<0.02$).

Study	Country	Year	Sample Characteristics	Intervention	Results
10	Bangladesh	2012[44]	Children with severe malnutrition (n = 507) randomized to 102 stimulation only, 101 food supplementation only, 103 stimulation and food supplementation, 99 clinic controls, and 102 hospital outpatient controls.	Mother and child attended local health clinic for 1 hour play session biweekly for 6 months OR food supplement for 3 months OR both treatments.	Stimulation alone or with supplementation improved Bayley Scales MDI (effect size 0.37 SD, p=0.037) compared to control groups.

Study	Country	Year	Sample Characteristics	Intervention	Results
11	Bangladesh	2013[45]	30 villages randomized to intervened or control children with iron-deficiency anemia (IDA) (n = 225; 117 intervention and 108 control) matched to children with no iron deficiency or anemia in same village (n = 209; 106 intervention and 103 control).	Children with IDA received: 30mg per day of ferrous sulphate for 6 months given to IDA group. Mothers and children in intervention group received weekly home visits for 9 months.	Non-anemic intervened group improved more than the non-anemic controls in MDI (effect size 0.38 SD). The IDA intervened children did not improve significantly.

Study	Country	Year	Sample Characteristics	Intervention	Results
12	Colombia	2014[46]	1,263 children whose parents were part of a conditional cash transfer program randomized to 4 groups: 318 stimulation, 308 supplementation, 319 stimulation and supplementation, and 318 control.	Stimulation: weekly home visits by "mother leaders" for 18 months Supplementation: multiple micronutrient sachets every 2 weeks for 18 months.	Intervened children's cognition and language showed improvements (effect size 0.26SD and 0.22SD respectively); micronutrient supplementation had no effect.

Table 2. Long-term Effects of Psychosocial Stimulation: Follow-up of the Jamaica Study at Age 7 to 8 Years

Age	Name of Test*	Function	p-value
7-8 years Grantham-McGregor et al, 1997[28]	**General Cognitive Factor**		NS
	Wide Range Achievement Test[61]	Reading Spelling Arithmetic	
	Stanford Binet Test	Intelligence Quotient	
	Peabody Picture Vocabulary Test[24]	Language comprehension	
	Raven's Progressive Matrices[62]	Non-verbal reasoning	
	Verbal Analogies	Verbal analogies	
	French Learning Test[63]	Long-term memory	
	Digit Span Forwards	Auditory working memory	
	Perceptual-Motor Factor		<0.05
	Corsi Blocks[64]	Visual spatial working memory	
	The Lafayette Grooved Pegboard[65]	Fine motor speed	
	Long-term Semantic Memory Factor		NS
	Categorical Fluency[66]	Categorical fluency	
	Free Recall	Free recall	

*Test scores were factor analyzed and formed the 3 factors shown. The stimulated group did better than the control subjects in 13 of 15 tests p<0.05; however, no individual test was significantly different.

Table 3. Long-term Effects of Psychosocial Stimulation: Follow-up of the Jamaica Study at Age 11 to 12 Years

Age	Name of Test*	Function	p-value
11-12 years Walker et al, 2000[29]	The Wechsler Intelligence Scales (Revised)[67]	Full-scale IQ Verbal IQ Performance IQ	<0.05 <0.05 0.08
	Raven's Progressive Matrices[62]	Non-verbal reasoning	<0.05
	Peabody Picture Vocabulary (PPVT)[24]	Language comprehension	NS
	Verbal Analogies	Verbal analogies	NS
	Stanford Binet Subscale	Vocabulary	<0.05
	Digit Span Forwards	Auditory working memory	NS
	Digit Span Backwards	Auditory working memory	NS
	Corsi Blocks[64]	Visual-spatial memory	NS
	Search Test	Speed of visual information processing and sustained attention (Log)	NS
	Stroop Test (Modified)[68]	Ability to inhibit responses and the speed of processing (Log)	NS

Table 4. Long-term Effects of Psychosocial Stimulation: Follow-up of the Jamaica Study at Age 11 to 12 Years

Age	Name of Test*	Function	p-value
11-12 years Chang et al, 2002[30]	Wide Range Achievement Test[61]	Arithmetic Spelling Word reading abilities	<0.001 <0.01 <0.001
	Rutter Parent Scales for School Aged Children[69]	Conduct difficulties	<0.05
		Emotional difficulties	NS
		Hyperactivity/inattention	NS
		Prosocial behaviour	NS
	Rutter Teacher Scales for School Aged Children[70]	Conduct difficulties	NS
		Emotional difficulties	NS
		Hyperactivity/inattention	NS
		Prosocial behaviour	0.052
	Suffolk Reading Scales[71]	Reading comprehension	<0.01

Table 5. Long-term Effects of Psychosocial Stimulation: Follow-up of the Jamaica Study from Age 17 to 18 Years

Age	Name of Test*	Function	p-value
17-18 years Walker et al, 2005 & 2006[49,72]	The Weschler Adult Intelligence Scales (WAIS)[73]	Full-Scale IQ Verbal IQ Performance IQ	0.019 0.054 0.018
	Raven's Progressive Matrices[62]	Non-verbal reasoning	0.051
	Corsi Blocks[64]	Visual-spatial working memory	0.11
	WAIS: Digit Span Forwards	Auditory working memory	0.74
	Digit Span Backwards	Auditory working memory	0.56
	Verbal Analogies	Verbal analogies	0.028
	Peabody Picture Vocabulary Test (PPVT)[24]	Receptive language	0.031
	Group Reading Test 2R[74]	Sentence completion	0.007
		Context comprehension	0.001
	Wide Range Achievement Test[75]	Mathematics	0.18
	What I Think and Feel[76]	Anxiety	0.01
	How I Think About Myself[77]	Self-esteem	0.04
	Short Mood and Feeling[78]	Depressive symptoms	0.02
	Behavior and Activities Check List[79]	Anti-social behavior	0.53

Table 6. Long-term Effects of Psychosocial Stimulation: Follow-up of the Jamaica Study from Age 22 Years

Age	Name of Test*	Function	p-value
22 years Walker et al, 2011[31]	Weschler Adult Intelligence Scales (WAIS)[73]	Full-Scale IQ Verbal IQ Performance IQ	0.003 0.006 0.007
	Wide Range Achievement Test* (WRAT)[80]	Mathematics Reading	0.014 0.004
	General Knowledge (Jamaican Residents Only)	General knowledge	0.005
	Short Mood and Feelings Questionnaire*[78]	Symptoms of depression	0.03
	State-Trait Anxiety Inventory*[81]	Anxiety	NS
	Inventory on Interpersonal Problems*[82]	Social inhibition	0.05
22 years Gertler, 2014[32]	Average Lifetime Earning	All job types Full-time jobs Non-temporary jobs	<0.05 <0.05 <0.05

(*Analyses based on total sample = residents and emigrants)

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