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Global Health and Development in Early Childhood

Frances E. Aboud[1] and Aisha K. Yousafzai[2]

[1]Department of Psychology, McGill University, Montreal, H3A 1B1 Canada; email: frances.aboud@mcgill.ca

[2]Department of Paediatrics and Child Health, Aga Khan University, Karachi, 74800 Pakistan; email: aisha.yousafzai@aku.edu

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Keywords

developing countries, low- and middle-income countries, nutrition, psychosocial stimulation, meta-analysis and systematic review, behavior change, child development

Abstract

Health and nutritional risks co-occur in the lives of children under the age of 2 years who live in developing countries. We review evidence showing how these risks, in addition to inadequate psychosocial stimulation, prevent children from developing expected cognitive and language abilities. A systematic review and meta-analysis of 21 interventions aimed at enhancing stimulation and 18 interventions that provided better nutrition—all conducted since 2000—revealed that stimulation had a medium effect size of 0.42 and 0.47 on cognitive and language development, respectively, whereas nutrition by itself had a small effect size of 0.09. The implementation processes of these interventions are described and compared. A number of unresolved issues are outlined and discussed, including ways to maximize parental health behavior change, assess mediators that account for intervention effects, and expand the assessment of young children's brain functions that underlie language and cognition and are affected by nutrition and stimulation.

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INTRODUCTION

Most people in the world live in what are known as developing countries, that is, the 144 or so countries with gross national income per person of $11,905 or less a year (World Bank 2012). In fact, of the 7 billion people in the world, 80% live in developing countries, also known as low- and middle-income countries. Approximately 90% of the newborns delivered in any one year are born in developing countries [United Nations Children's Fund (UNICEF) 2013]. What are the prospects for these newborns as they reach adulthood and become full-fledged members of society? Nineteen out of 20 children now survive to their fifth birthday (You et al. 2012), and their mental development has been the subject of research and programs by national and international organizations. Mental development is the term used by multidisciplinary experts to refer to what psychologists call growth in cognitive, language, social, and emotional capabilities. Here we focus on cognitive and language capabilities, about which most research is available. It is generally acknowledged that physical health and nutrition in the first 24 months of life are critical and that this window may also be optimal for mental development. Consequently, we focus our review on this period of a child's life.

Although contemporaneous influences are important throughout life, the experiences of a child in the first 24 months can have a profound effect on future development and place a limit on future growth. For example, many children are delivered at home by an unskilled birth attendant and so experience complications leading to birth injuries and asphyxia. If levels of iodine in the early months and prenatally are severely deficient, mental development is irreversibly impeded, regardless of whether iodine is added to the diet during the school years (Bougma et al. 2013). Short stature or stunting is largely determined in developing countries by diet, not genes; stunting is a noticeable problem in many countries by 24 months of age and is generally cumulative (Martorell et al. 1994). Poor beginnings can deal children extra burdens that will challenge them throughout life.

The purpose of this review is to examine the extent to which early health, nutrition, and psychosocial stimulation affect cognitive and language development. Evidence from nonexperimental studies suggests that all three do affect development, but ultimately conclusions must be based on intervention studies. We focus on children less than 24 months of age living in developing

countries. Although many cultural differences exist among developing countries, there are also many similarities in the problems experienced by young children and in the ecological variables that contribute to these problems. The similarities become evident when one integrates global research documenting the prevalence of and contributors to health and development problems. The similarities also provide optimism that people can learn from solutions evaluated in one country when designing programs in another. Goals for children's health and development articulated by the international community are laid out in the eight Millennium Development Goals (United Nations 2013; **www.un.org/millenniumgoals/pdf/report-2013/mdg-report-2013-english.pdf**), which apply to all countries. Ways of measuring children's health and nutritional growth are universally accepted and reported in statistical tables of annual documents such as *The State of the World's Children* (UNICEF 2012, 2013). Mental development indicators are still under study and are rarely used in international surveys. However, psychometrically sound measures such as the Bayley Scales of Infant and Toddler Development (Bayley 2006) are widely used and validated in the research covered here.

Millennium Development Goals: eight goals related to health and education endorsed by the United Nations. A new set of goals is to be established in 2015

Consequently, the first part of the article describes the poor beginnings experienced by young children in the first 24 months of life that confer serious vulnerability and affect their mental development. The second part presents a systematic review of research evaluating interventions to promote children's mental development in the early years, with a view to highlighting two successful and well-researched interventions: nutrition and psychosocial stimulation. Finally, in the third part we examine two challenges that researchers are currently tackling, namely behavioral and neurological ways to measure mental development and techniques to stimulate behavior change.

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POOR BEGINNINGS

Four types of events capture experiences of young children in the first 24 months that, if the children survive, will have consequences for their mental development. These events have been integrated into the Millennium Development Goals and have been the subject of several *Lancet* series on global health. They include:

1. delivery by an unskilled attendant in the mother's home,
2. infections such as malaria and diarrhea,
3. inadequate nutrition, and
4. inadequate psychosocial stimulation.

The first three have always been at the top of the agenda because they were clear causes of child mortality. Now that most children survive to their fifth birthday, these same events along with the fourth conspire to reduce their capacity for cognitive and language development. In fact, children rarely experience only one of these events, as they tend to co-occur. The list could be expanded to include maternal depression (Fisher et al. 2012) and environmental toxins such as arsenic. Many of these events begin during the prenatal period (the phrase "the first 1,000 days" refers to the period from the start of a woman's pregnancy through her child's second birthday), although our evidence focuses on the postnatal period. For our list of four early high-risk events, we review evidence from developing countries concerning why the events are prevalent and how they impact mental development.

Delivery at Home

Children who are delivered at home by an unskilled birth attendant are at high risk of dying, as are their mothers. Half of the approximately 3 million newborn deaths (within the first month after

delivery) occurred at home, not in a clinic or hospital (Lawn et al. 2005, UNICEF 2013). Home delivery is common in Africa and South Asia. In fact, in the 50 or so least-developed countries, more than half of mothers delivered at home with the help of an unskilled attendant (Darmstadt et al. 2009, UNICEF 2013). For example, 90% of mothers in Ethiopia did so, 68% in Bangladesh, 51% in Tanzania, and 48% in India. This is due to a number of factors related to the quality and accessibility of facilities and skilled birth attendants and to the prevailing social norms about delivery and newborn care (Bang et al. 2005). Because most informed women have expressed the preference to deliver at a facility with a skilled attendant, two strategies to facilitate this have been to give vouchers directly to pregnant women to cover the expenses of a safe delivery at a nearby facility (e.g., Nguyen et al. 2012) and to arrange women's support groups in the community (Prost et al. 2013). It is still too early to see how well these strategies are working.

Home deliveries with an unskilled attendant are found to increase the likelihood that the infant will struggle to overcome initial setbacks due to infection and asphyxia. Delivering in the traditional way may mean that the newborn is left uncovered while the mother is attended to, given special foods rather than the beneficial antibodies of breast milk for the first day, and exposed to sources of contamination such as unclean hands and razors used to cut the umbilical cord, leading to severe infection (e.g., Bang et al. 2005). It also means that there is no assistance for prolonged labor, which is more likely to occur if the mother is short or young and may lead to newborn asphyxia. On average, 6% to 10% of newborns in developing countries fail to start or sustain breathing (23% in a Zambian hospital; Halloran et al. 2009), and a resuscitation procedure is used to facilitate breathing. In developing countries, this procedure is uncommon in rural areas and absent in home deliveries. Of those who survive asphyxia, one-third will have neurological problems such as epilepsy, cerebral palsy, and impaired mental development (Haider & Bhutta 2006). In summary, asphyxia, infection, tetanus from contaminated razors, hypothermia, and lack of breast milk mean that a newborn's nutritional stores and oxygen are directed to survival rather than brain development, with long-term consequences for mental development.

Infection and Illness

Over the course of their first 24 months, children experience multiple episodes of infection, some of which leave them weak and malnourished and others of which directly affect their brain. Here we describe the common infections due to geohelminths (worms) and rotavirus as well as the more serious cerebral malaria.

Whereas the immunized diseases are transmitted mainly from person to person, the diarrhea that results from worms, viruses, and bacteria comes from fecal-oral transmission. When family members do not use a latrine, the infant may be crawling on contaminated ground. Feces also make their way into sources of drinking water. Consequently, diarrhea becomes most prevalent between 6 and 24 months of age, when children have on average four to five episodes a year (Kosek et al. 2003). One of the geohelminths, hookworm, is responsible for half the anemia found in children, and diarrhea is a common cause of malnutrition. Particularly concerning is the under-researched disease called tropical or environmental enteropathy, which results from constantly ingested fecal bacteria and leads to chronic changes in the villi of the small intestines (Humphrey 2009, McKay et al. 2010, Weisz et al. 2012). The effect of enteropathy is to increase absorption of bacterial products such as endotoxins into the system and to allow for leakage of nutrients such as proteins; accompanying symptoms of diarrhea are not necessarily present. Consequently, children experience recurrent infections, with associated loss of appetite and diversion of nutrients to fight infections and inflammation, resulting in inactivity and growth faltering. Although worms and diarrhea themselves do not appear directly to reduce mental development, they may reduce

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important determinants such as growth and activity (Fischer Walker et al. 2012, Taylor-Robinson et al. 2007).

Given the obvious environmental causes of infection, the most commonly implemented solutions are construction and use of latrines, improved drinking water, promotion of hand washing with soap, and deworming of children starting at 12 months of age (Dangour et al. 2013, Ejemot et al. 2008, Fewtrell et al. 2005). There is a gaping urban-rural divide in developing countries, particularly with respect to latrines. Whereas 68% of urban dwellers in developing countries have a latrine, only 40% of rural people have one (UNICEF 2012). Although the provision of improved water sources is the one Millennium Development Goal that has reached its target, and deworming will become a regular feature of preschools in the near future, latrine use and hand washing are notoriously difficult to change. Like other health behaviors studied worldwide, interventions to increase latrine use and hand washing have met with success mainly in controlled experimental settings and have been less successful when implemented at the community level (Luby et al. 2008).

One infection with serious consequences for mental development is cerebral malaria. There are 104 malaria-endemic countries in the world, mostly in Africa. Among the four parasites carried from one person's blood to another's by the Anopheles mosquito, *Plasmodium falciparum* is associated with cerebral malaria leading to high fever, coma, and organ failure. Use of bed nets, intermittent preventive treatment, and vaccines are the currently studied preventive interventions (e.g., Cissé et al. 2006). Malaria is a serious cause of death and disability among children. The implications of cerebral malaria for mental development have only recently been studied, mainly in urban settings where children can be treated and tested. In one study, approximately 10% of survivors had severe neurological deficits, and the majority had moderate problems that were detected only with psychological testing when the children were older (Bangirana et al. 2006). These impairments included visual processing, auditory processing, memory, and attention problems. Language problems were also found, but with similar frequency to a control group of children who experienced seizures without fever (probably epilepsy). Because impairments vary, with some children showing visual and others auditory problems, many researchers report the number of subtests on which cerebral malaria survivors show deficits compared to controls. For example, a prospective study with children 5 to 9 years of age in Kampala, Uganda, found that on several tests of attention, working memory, and learning, 36.4% of children showed deficits on at least one measure at hospital discharge, and 21.4% maintained deficits at six-month and two-year follow-ups compared to 5.7% of healthy controls (Boivin et al. 2007, John et al. 2008). Deficits in attention and memory were most common and were related to the number of seizures and duration of coma. Consequently, the evidence is strong that a large proportion of children with cerebral malaria and its associated brain complications experience long-term cognitive problems.

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Malnutrition

The relation between nutrition and mental development has received extensive support from cross-sectional studies showing a strong correlation between height and mental development (Barros et al. 2010, Hadley et al. 2008, Olney et al. 2009, Servili et al. 2010) and from several longitudinal studies (see Grantham-McGregor et al. 2007). More specific nutrients, such as iron, iodine, zinc, and fatty acids, have also been studied for their effects on cognitive and language development.

Where international norms are available as a standard, one important nutrition indicator is length or height for age; moderate-to-severe stunting is operationalized as more than 2.00 standard deviations below the median for a child's sex and age. Stunting increases rapidly after 6 months of age; by 24 months of age, 50% of children in developing countries are stunted (also known as linear growth retardation; Victora et al. 2010). By 60 months of age, 40% of children are moderately to

severely stunted in Africa and 47% in South Asia (Black et al. 2013, UNICEF 2013). Despite the common belief that certain ethnic and national groups are genetically short, there is no evidence for this in children under 5 years of age in the multinational study that created norms provided by the World Health Organization and used by health professionals and researchers worldwide (Milman et al. 2005). Practices known to support healthy rates of growth include exclusive breastfeeding from birth to six months and provision of sufficient energy, protein, and fats thereafter. The latter is captured by the term dietary diversity and measured as the number of different food categories, such as grains, eggs, and fruit, in a child's daily diet (Jones et al. 2014). The minimum adequate diversity is considered to be four or more food categories daily, which usually means that the child has at least one animal-source food (Daelmans et al. 2009). Improving dietary diversity with animal-source foods is therefore a critical message in nutrition education interventions. In eight studies, nutrition education alone for mothers of children ages 6 to 24 months, usually about foods to feed and number of meals, led to gains in length with an effect size of $d = 0.21$ (Dewey & Adu-Afarwuah 2008, Imdad et al. 2011). However, nutrition education alone is unlikely to be very effective in areas where food is inaccessible to the poor.

Multiple micronutrients: vitamins and minerals (e.g., iodine, iron, zinc, and fatty acids) that are necessary in small amounts for health, growth, and mental development

Home Observation for Measurement of the Environment (HOME) Inventory: a 45-item observation and interview assessment of opportunities for child stimulation in the home

In addition to deficiencies in calories and proteins, children often lack multiple micronutrients, such as iron and iodine, that are considered crucial to mental development. In Africa and South Asia, 20% of children under age 5 years and 20% of pregnant women are anemic (Black et al. 2013). In Africa, 40% of children have iodine deficiency; in Asia, the prevalence is 31.6% (Black et al. 2013). The provision of food to young children for 6 months or less, often fortified with extra proteins and micronutrients, led to greater gains in length with an effect size of $d = 0.41$ for the six studies conducted in food-insecure sites in Africa and South Asia (Imdad et al. 2011). However, the nutritional and mental consequences of providing children with iodine and iron are more mixed (Bougma et al. 2013, Pasricha et al. 2013). We therefore conducted a systematic review, described below, to determine whether this inconsistency in mental development outcomes (cognition and language) is common across current studies.

One important nutrient, namely fatty acids, has been studied in relation to mental development but mainly in developed countries and so is not included in our systematic review. Long-chain polyunsaturated fatty acids are present in the brain (e.g., myelin sheath) as well as in breast milk and so were considered a promising candidate for enhancing mental development. A number of trials, conducted mainly in developed countries where it is possible to provide infants with formula milk with varying amounts of fatty acids, have found no effects on Bayley mental or motor scores (Beyerlein et al. 2010, Qawasmi et al. 2012, Smithers et al. 2008). Similar tests of fatty acids found in fish and fish oil have shown no advantage to Bangladeshi children whose mothers received fish oil during pregnancy (Tofail et al. 2006). Consequently, despite their widespread presence in the brain, these fatty acids do not appear to have any effect on mental or motor development in children under 24 months of age. However, follow-up research on some of these children continues as they age (Colombo et al. 2013).

Psychosocial Stimulation

Because country-level indicators for psychosocial stimulation do not exist, poverty was used as a proxy to identify the approximate number of children worldwide performing well below expected levels on tests of cognitive and language development (200 million or 39%; Grantham-McGregor et al. 2007). A more specific measure of psychosocial stimulation is the Home Observation for Measurement of the Environment (HOME Inventory; Bradley & Caldwell 1984, Bradley & Corwyn 2005). The infant and toddler version for children under 24 months includes 45 items that are assessed through observation of mother-child interaction and play materials along with

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interview questions about exposure to places, people, and conversation. Mothers with higher HOME scores in one Bangladeshi sample were more responsive and stimulating when conversing with their children about pictures (Aboud 2007), thus providing some validation of the measure. Scores are also highly correlated with children's mental development. The HOME Inventory may reasonably serve as a blueprint for stimulation interventions and be used as a manipulation check on whether the intervention has led to changes in parenting practices.

Human Development Index (HDI): encompasses life expectancy, education, and gross domestic product; the index ranges from 0.00 to 0.99

A brief version of the inventory, the Family Care Indicators, has now been validated in Africa and South Asia (Hamadani et al. 2010, Kariger et al. 2012) and used to evaluate responsive and stimulating caregiving in 28 developing countries (Bornstein & Putnick 2012). Mothers (caregivers) were asked what they did with their children under age 5 years in the past three days. Items largely focus on the variety of play materials available for the child (e.g., things for making music, things for pretending, things for drawing) and play activities (e.g., reading or looking at pictures, telling stories, singing songs). Only 25% of mothers said they had read to their children in the past three days, 25% had sung songs, and 35% had told stories. Scores did not vary by the child's gender but were lower in families with more children. More stimulating and supportive caregiving was found in countries with a higher Human Development Index (HDI). This index ranges from 0.00 to 0.99 and consists of three components that reveal the level of human resources: life expectancy, education, and gross domestic product (United Nations Dev. Program 2013). Across all 28 developing countries surveyed, the average number of caregiving practices out of six performed in the past three days with a child under age 5 years was 3.03. Many parents from medium-low HDI countries in Africa and South Asia practiced only one or two play activities. Interventions to improve mental development therefore focus on promoting stimulating and responsive caregiving (Engle et al. 2011). A systematic review of evaluations published since 2000 was conducted to determine how effective the interventions were at improving children's cognitive and language development. The generally positive findings are described in the following section.

SYSTEMATIC REVIEW AND META-ANALYSIS OF NUTRITION AND STIMULATION INTERVENTIONS

A search conducted on three databases for nutrition or stimulation interventions with children ages 24 months and younger from developing countries yielded 1,750 unique articles published between 2000 and 2013. Guidelines produced by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses group were used to identify, screen, and describe all relevant studies (Mohrer et al. 2009) and then to calculate statistics for the meta-analysis (Lipsey & Wilson 2001). With inclusion criteria that limited articles to those with children who were 0 to 24 months old at the time of the intervention and at follow-up within a year and who were not premature or did not have a serious illness (e.g., very-low birth weight, autism, cancer), and using a mental development outcome measure of cognition and/or language, we identified 21 articles with a stimulation intervention and 18 with a nutrition intervention (several had both). (Information on the search strategy, the outcomes, and the implementation process is available. Follow the **Supplemental Material link** in the online version of this article or at **http://www.annualreviews.org/**.)

Supplemental Material

Most of the designs were cluster or individual randomized-controlled trials using a standardized test of mental development such as the Bayley or Griffiths scales. The quality of studies was strong in other respects as well: In most cases, research assistants were blind to condition, groups were fairly comparable at baseline, and statistical adjustments were made for covariates. Attrition was under 20% in 15 of the 21 stimulation studies (71%) but in only 10 of the 18 nutrition studies (56%). Attrition was particularly high when parents were required to bring their child to the clinic for the intervention. Only 9 of the 21 stimulation studies and 11 of the 18 nutrition studies

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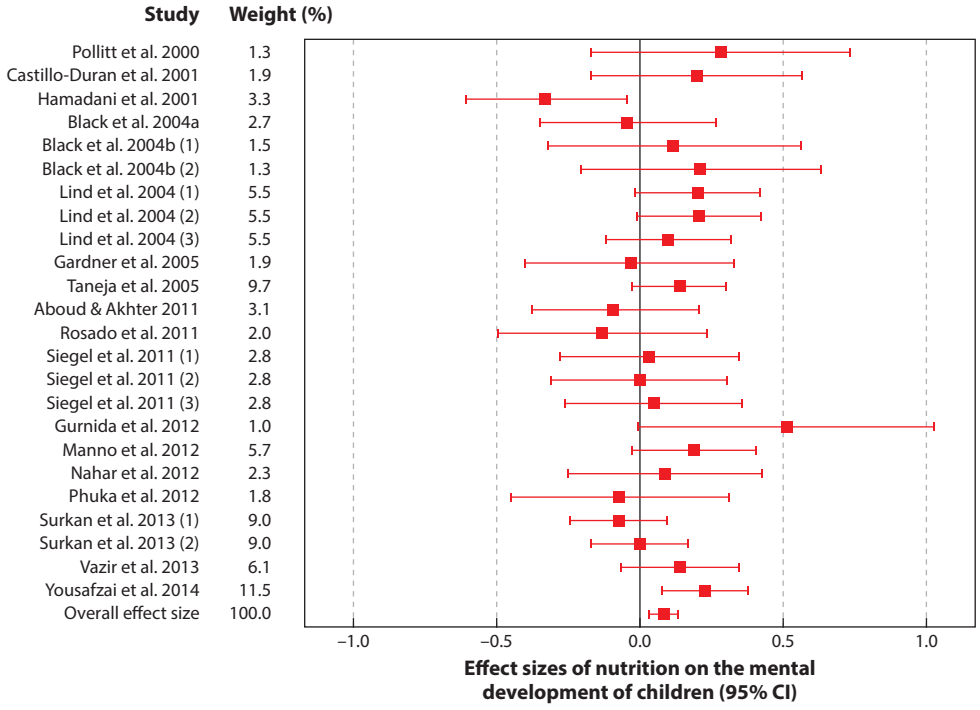

Figure 1

Forest plot for effect sizes (standard mean difference represented as a red square and 95% confidence interval represented as red lines) of nutrition on the mental development of children. Overall effect size was 0.086 (95% CI 0.034, 0.137). The studies were homogeneous [homogeneity statistic Q (coefficient of homogeneity) = 28.34, df (degrees of freedom) = 23, $p > 0.05$]. The fixed effects model was therefore more appropriate.

analyzed group sample sizes greater than 85, which would have been necessary to find a medium effect size on the Bayley scales of $d = 0.50$, or half a standard deviation difference between the groups. Consequently, half of the studies might have been underpowered.

Nutrition interventions yielded very small effects of $d = 0.086$ (95% CI 0.036, 0.137), whereas stimulation interventions were moderately effective, with a weighted mean effect size for cognitive outcomes of $d = 0.420$ (95% CI 0.36, 0.48) and for language outcomes of $d = 0.468$ (95% CI 0.37, 0.56) (see **Figures 1**, **2**, and **3** for forest plots). A detailed examination of how the interventions were implemented is provided below and offers insights on why some interventions were more effective than others. However, at a glance, major differences between stimulation and nutrition interventions are worth noting. These include resources of countries where interventions take place, labor-intensive contact, and evidence that the intervention improves an essential mediator, namely stimulation and/or nutritional status. Although all studies included poor, malnourished samples, nearly 30% of stimulation interventions were conducted in medium-high HDI countries (HDI > 0.77), where government resources and education levels are higher. Seventy-one percent of the 21 stimulation studies were conducted in medium-low HDI countries (HDI < 0.711), and 15 or 83% of the 18 nutrition studies were conducted in medium-low HDI countries. Another important difference is that stimulation interventions were labor intensive, with only six providing less than 10 hours contact time; most provided less than 50 hours, but four interventions with high-risk children provided between 60 and 120 hours. In contrast, nutrition interventions required

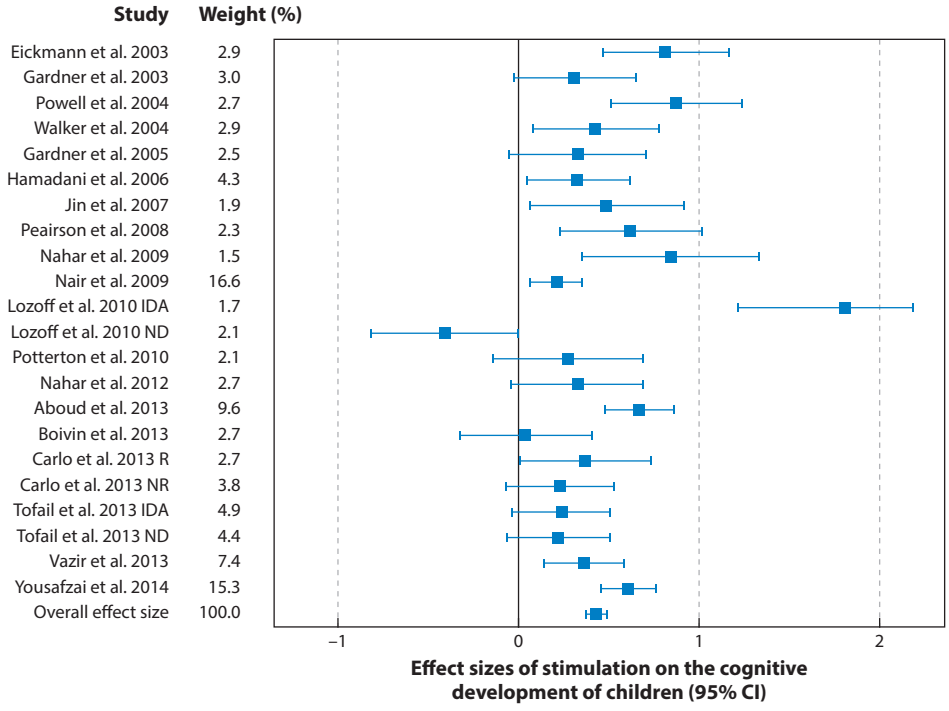

Figure 2

Forest plot for effect sizes (standard mean difference represented as a blue square and 95% confidence interval represented as blue lines) of stimulation on the cognitive development of children. Overall effect size was 0.420 (95% CI 0.36, 0.48). The studies were heterogeneous (homogeneity statistic $Q = 112.81$, $df = 21$, $p < 0.01$). The random effects model was therefore more appropriate. Abbreviations: IDA, iron-deficiency anemia; ND, nondeficient; NR, not resuscitated; R, resuscitated.

only that the supplement be delivered to parents, who in turn gave their child a daily serving of the syrup, powder, tablet, or fortified porridge with single or multiple micronutrients. Labor-intensive contact has implications for the cost-effectiveness of the intervention. Finally, postintervention assessment of stimulation (in 9 of 21 studies) produced significantly higher HOME Inventory scores for the intervention compared to control families. In a sense, this is a check on the mediator, namely whether the caregiver became more verbally responsive to the child and provided play materials. In contrast, nutrition indicators such as iron status or linear growth were rarely better for intervention children despite six months of nutritional supplements. Some of the issues raised by nutrition interventions are discussed first.

Micronutrient and Macronutrient Interventions

The nutrition interventions generally sought to examine the effects of zinc, iron, gangliosides, or multiple micronutrients, whereas control children received a partial set of nutrients or, less often, a placebo. Despite variation among nutrition interventions in the specific nutrients given, the meta-analysis showing small effect sizes yielded good homogeneity among outcomes (see **Figure 1**). Questions are still to be resolved concerning whether macronutrients (carbohydrates, protein, and fats) are required along with micronutrients, how many and which micronutrients

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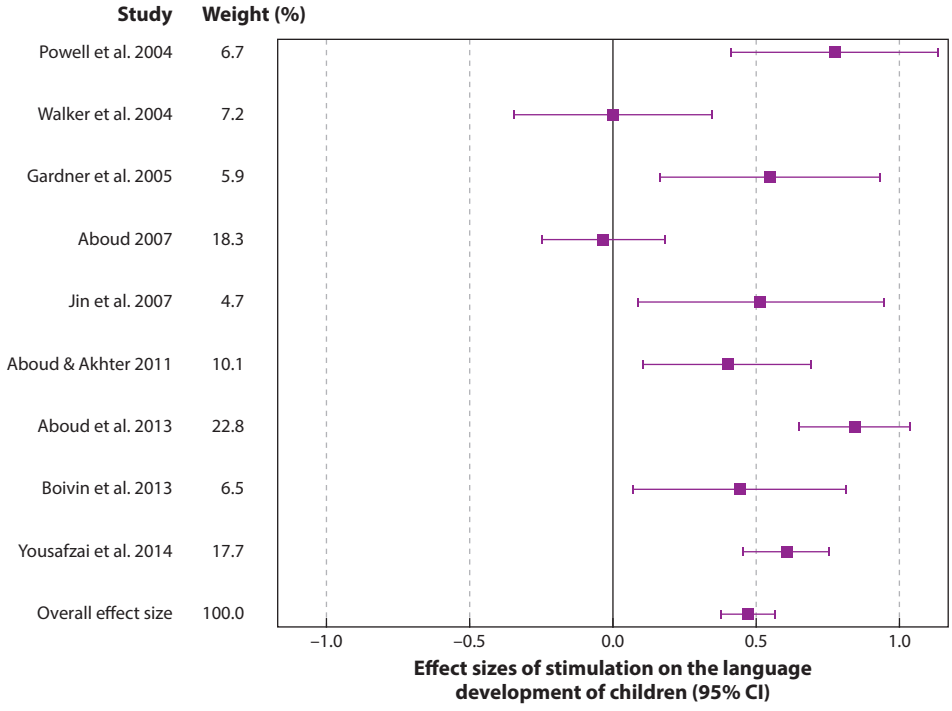

Figure 3

Forest plot for effect sizes (standard mean difference represented as a purple square and 95% confidence interval represented as purple lines) of stimulation on the language development of children. Overall effect size was 0.468 (95% CI 0.37, 0.56). The studies were heterogeneous (homogeneity statistic $Q = 46.66$, $df = 8$, $p < 0.05$). The random effects model was therefore more appropriate.

are to be combined, and whether only deficient children should be included, among other issues. Concerning macro- and micronutrients, Pollitt et al. (2000) for example gave all children eight micronutrients (vitamins and minerals), but only intervention children received high-energy milk. By comparison, Phuka et al. (2012) gave all children 17 micronutrients, but only intervention children received extra macronutrients such as carbohydrates, protein, and fat. In contrast, Manno et al. (2012) gave all children carbohydrate- and protein-enriched porridge, and only intervention children received an extra 18 vitamins and minerals. Finally, the porridge given by Rosado et al. (2011) consisted of energy, mainly in the form of carbohydrates, for control children but was fortified with protein, three minerals, and six vitamins for intervention children. Effect sizes were small, regardless. In medium-low HDI countries where most samples are malnourished, it may now be deemed unethical to have a placebo control. Consequently, researchers tend to compare a control group of children receiving some nutrients with an intervention group receiving one or more extra macro- or micronutrients. Although it is generally agreed that energy, protein, and fats are necessary, the rationale for studying single and multiple micronutrients is that they are found in specific sites of the brain: Iron is found in the hippocampal-frontal and striatal-frontal areas, zinc is found in the hippocampus and cerebellum, and long-chain fatty acids are found in the eye and the cortex (Georgieff 2007). However, this micronutrient strategy has not yet yielded strong effects on mental development. The addition of macronutrients such as energy and fats may be

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INFANT BRAIN DEVELOPMENT REQUIRES ENERGY

The brain of a newborn is actively processing stimulation even when attention is not fixated on anything specific. Speech of family members, songs, household sounds, faces, and other stimulation from the ambient environment are thus processed by the brain. Raichle (2010) and others examined regional brain blood flow and oxygen consumption and estimated that 20% or more of the body's entire glucose energy is used by the infant's brain when in this resting state. It is proposed that brain development in the form of synapse proliferation (perhaps overproduction) takes place within the first 3 months in the auditory cortex (superior temporal fold) and within the first 15 months in the frontal cortex (Casey et al. 2000). Researchers note striking increases of 149% in gray matter volume and 240% in the cerebellum during the first year, with lower increases in the second year (Knickmeyer et al. 2008). These increases parallel rapid development in cognitive, language, and motor abilities during infancy. Development requires energy. Thus, inadequate levels of energy would reduce the amount of brain activity and development even in the early months.

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more effective with children who are moderately to severely stunted, as in the Pollitt et al. (2000) and Gurnida et al. (2012) studies (see sidebar on Infant Brain Development).

The few studies that included nutrition education, with or without nutrient fortification, had varying outcomes (e.g., Vazir et al. 2013, Yousafzai et al. 2014). Nutrition education, delivered to the child's caregiver, operates much like the stimulation interventions and is labor intensive. Information is transmitted about the quantity and quality of foods to be fed to the child starting at 6 months of age, along with recipes and possibly cooking demonstrations (e.g., Vazir et al. 2013). It might also include hygiene instructions on hand washing and disposing of leftover food if refrigeration is not available. These interventions tend to be uniform because they are based on guidelines for child feeding (World Health Organ. 2003), yet they are tailored to the eating habits of the specific sample. It is generally acknowledged that nutrition education by itself is not sufficient to halt stunting in places with high malnutrition where poor families cannot easily access food. Consequently, nutrition education by itself is unlikely to affect cognitive and language development in such contexts. Yet, such education is important to add for sustainability; we turn to this topic in the discussion below on behavior change.

Another unanswered question is what mediates the effect of nutrition on cognitive and language development. Only a few studies found better ganglioside, iron, or zinc status after the intervention (e.g., Gurnida et al. 2012, Manno et al. 2012, Taneja et al. 2005), but there was no consistency in their relation to mental development. Linear growth is still the strongest correlate of mental development, so it is important to evaluate the effect of a nutrition intervention on a child's height. Systematic reviews have consistently shown that the effect sizes of various types of nutrition interventions on linear growth gains were lowest for micronutrient fortification (~0.12); effect sizes were better for energy alone (~0.25) and the provision of food with extra proteins and nutrients (~0.28) (see Bhutta et al. 2013, Dewey & Adu-Afarwuah 2008). Effect sizes for nutrition education, particularly education emphasizing dietary diversity and animal-source foods, were 0.20. All this said, it is not clear why linear growth is related to mental development.

Three potential mediators of nutrition on mental development have been proposed. First, some have suggested that motor development mediates the effects of better nutrition on mental development (Brown & Pollitt 1996, Prado & Dewey 2014). This explanation rests on the notion that better nutrition results in the child walking at an earlier age, and walking allows the child to explore and independently access stimulation (Dewey et al. 2001). Currently, little evidence exists for a positive relation between gross motor and mental development (Hamadani et al. 2013).

A second proposed mediator is elicited stimulation from others: Better nutrition leads to more linear growth, and a taller child looks older and so elicits more sophisticated stimulation from the mother. There is some evidence for each of these hypothesized relations but as yet no integrated analysis across studies. A third explanation is brain structure and function, a potential mediator that has begun to gain empirical support (discussed more fully below).

How Stimulation Interventions Work

Stimulation interventions were effective overall in producing cognitive and language development with a medium effect size (mean effect size for cognitive outcomes was $d = 0.420$; for language outcomes, $d = 0.468$). These interventions are based on the well-established finding that children need fine motor play activities and materials, along with adult conversation, in order to develop cognitive and language skills in the first few years (Tamis-LeMonda et al. 2001). The implementation of stimulation programs requires a manualized curriculum, a delivery format, and trained personnel, usually paraprofessionals who require supervision. Fidelity to the intended program, reported by only 5 of the 21 studies, is a major shortcoming.

Three delivery formats were common: home visits, group sessions, and clinic appointments. Home visits were used by nine studies in which a trained paraprofessional visited homes weekly or monthly to talk to and play directly with the child while the mother watched. Often play materials or picture books were left in the home to be replaced at the next session. The curriculum specified age-appropriate activities to conduct with the child at each session. In the second model, group sessions allowed a village peer educator to address small groups of mothers who might be asked to bring their children to the session. The manual of activities might include demonstrations of playing/talking activities to do with the child followed by having mothers practice and be coached. The children might range in age, so the focus would be on showing the mother what to provide her child. The third model used well- or sick-baby clinic visits as an opportunity to inquire into what the mother knew about stimulating her child with toys and talk and to counsel her on improved practices; this was usually done by a professional.

There are advantages to all three models. The benefit of home visiting is that a paraprofessional interacts with the child, thus ensuring that high-quality stimulation is given directly to the child. Group and clinic contacts rely on indirectly affecting the child by changing the mother's behavior. Of the 21 stimulation studies, 9 used home visits (5 in high HDI and 4 in medium-low HDI countries); 8 used group sessions, usually with some home visits (1 in high HDI and 7 in medium-low HDI countries); and 4 used clinic appointments (all in medium-low HDI countries). When two outliers (one high, one low) were removed from the home visiting studies, the weighted mean of 10 effect sizes was $d = 0.324$ (95% CI 0.23, 0.42), but heterogeneity remained significant. Group sessions with some home visits produced a weighted mean of seven effect sizes of $d = 0.592$ (95% CI 0.50, 0.68) after removing one outlier; the effect sizes were homogeneous. The effect size for clinic visits is similar to home visits, but because only four studies have been conducted, it is too early to draw conclusions.

For a variety of reasons, group sessions along with some home visits to overcome family-related challenges is the most promising model for future stimulation programs: It is less labor intensive than relying solely on home visits, requires fewer contact hours, encourages peer support, and potentially modifies group norms for child rearing. The group model has one serious limitation, namely that actual changes to the parents' behavior are found to be small although significantly greater than changes in the control group. Too few longitudinal studies exist to confirm that parents are able to sustain the new practices and adapt them as the child ages. Parent behavior change

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is challenging and is addressed more extensively in the next section. However, stimulation interventions, regardless of their delivery strategy, overall have been successful in improving mental development. This may be partly attributed to their effect on improving parental stimulation practices, which in addition to linear growth is one of the strongest correlates of mental development.

Event-related brain potential (ERP): electrical brain activity from a site-specific cluster of nerves in response to speech

UNRESOLVED ISSUES

Behavioral and Neurological Measures of Mental Development

Questions have been raised about the sensitivity of measures used to assess cognitive and language development. Typically the Bayley and Griffiths scales are used; currently they both have subscales to assess cognitive, language, fine motor, and gross motor skills. They have been translated into different languages, and items, especially those on the language development subscale, are modified for the sample while maintaining the appropriate level of difficulty. Most researchers conduct some analyses to support the validity of the scores. Yet most acknowledge that the standardized scores, normed for North American or European samples, are not normed for the sample being studied. One way of deriving international norms would be to follow the strategy used to create international norms for weight and height, namely to have a multicountry sample of nourished and stimulated children. In the meantime, researchers examining the benefits of nutrition and stimulation compare either raw or standardized scores with the understanding that the difference between the two groups, rather than the absolute score, identifies an effective program. Systematic reviews have pointed to the overall effectiveness of stimulation programs evaluated with the Bayley and Griffiths measures; nutrition programs were found to be less effective.

In the hope of finding more sensitive measures, psychologists studying the benefits of nutrition have turned to a battery of tests assessing narrow-band processes such as attention, memory, and speed of processing (Hughes & Bryan 2003, Wainwright & Colombo 2006). The rationale is that specific macro- or micronutrients may affect specific structures or functions of the brain; if any one of these functions is delayed or undeveloped, then more general cognitive/language skills will be affected. So far, this strategy has not provided definitive answers to the question of what measure is most suited to a specific nutrient.

Another approach is to assess structures and functions of the developing brain (Prado & Dewey 2014). Noninvasive procedures for studying the activity of known language sites in the brain are easily applied to infants (for procedures, see Thomas 2003). One of these procedures requires that the infant be fitted with a cap with nodes that are placed over critical regions of the skull to pick up underlying brain activity. Earphones transmit language sounds, syllables, words, and sentences directly to the child without requiring his/her attention. The electrical activity picked up by each node is plotted as an average waveform (using electroencephalogram) called an event-related brain potential (ERP). The waveform is time locked to the event, in this case the speech form. The waveform thus reveals the site of the brain where speech is processed, the latency or time between the sound and processing it, and the amplitude of the waveform. Evidence from this research has shown that a mature, proficient brain responds to language in a gradually more focused area in the left superior temporal lobe (Wernicke's area) and the left inferior frontal area (Broca's area) (Montr. Neurol. Inst. 2013). Furthermore, evidence exists for the effects of language stimulation indicating greater proficiency (focal left hemisphere activation, lower amplitude, and shorter latency) in processing syllables at 6 to 10 months of age, word meaning at 12 to 20 months, and sentence grammar at 24 to 36 months of age (Friederici 2009, Mills et al. 2004, Sheehan & Mills 2008). The effects of stimulation on neurological development have been confirmed with

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studies of children who are deaf from birth and eventually receive a cochlear implant that allows them to hear. They acquire native-like proficiency in language only if they receive the implant before 24 months of age. Those who are deprived of language input for more than five years remain severely limited in their perception of speech sounds and vocabulary (Harrison et al. 2005). The implication of this research is that synapses for language acquisition are available by 6 months of age but are pruned if not maintained by language stimulation. This research has been conducted only in developed countries but is feasible in developing countries as well.

Brain development as measured with ERPs is also sensitive to nutritional status. One study conducted in India with iron-deficient children ages 6 to 24 months found that the latency for brain activation to visual input was delayed in deficient compared with nondeficient children (Monga et al. 2010), confirming similar findings from North America with iron-deficient children's processing of auditory stimuli (Lozoff & Georgieff 2006). Analogous research conducted with iron-deficient children shows different ERPs in cortical areas of attention and recognition to the face of the child's mother versus a stranger (Burden et al. 2007). Shorter latencies in left temporal and frontal sites in response to language sounds were also found for breast-fed children at 6 months of age compared to those given formula or soy-based (vegetable) milk (Pivik et al. 2011); the implication is that fatty acids from breast milk are involved in maintaining the myelin sheath, which allows for rapid neural transmission (Innis et al. 2001). This research strategy for linking nutrients with clear neurological indicators of language or visual processing might be conveniently extended to malnourished children in developing countries. Moreover, ERPs might be more sensitive to the timely acquisition of three milestones of language development (syllables, meanings, and grammar) and so distinguish children receiving a nutrition intervention from controls.

Behavior Change Mechanisms

As with many programs attempting to change health behaviors, the interventions reviewed here showed mixed success in parent behavior change. Reviews have called for more attention to theories of behavior change in order to build on past successes and failures (Glanz & Bishop 2010). None of the interventions reviewed actually tested a theory of behavior change. Rather, the focus was on finding a model that worked. The authors of the present review therefore examined techniques of behavior change, a level of analysis that is somewhat lower than theories but that captures mechanisms by which behaviors change. Certain techniques, such as providing a demonstration of the behavior followed by mothers practicing it and receiving feedback, are associated with Bandura's (1977) social learning theory. Other techniques such as providing small media in the form of a take-home poster are associated with communication theory (Finnegan & Viswanath 2008), whereas providing books and toys is a form of social marketing (Storey et al. 2008); both also serve as cues to action, a key construct of the health belief model (Champion & Skinner 2008). Consequently, we organized the techniques into the categories used by Briscoe & Aboud (2012) for child survival interventions in low- and middle-income settings.

Table 1 outlines the techniques of behavior change used in the 21 stimulation interventions, which relied on behavior change more than nutrition interventions did. A short description of how the techniques were implemented reveals why some were more effective than others. Effectiveness can be indicated by the effect size of the child outcome or the parental behavior change. Too few studies included a direct measure of behavior change in the form of higher HOME Inventory scores for the intervention families compared with the control families. Thus the effect size of the child development outcome was correlated with the presence or absence of each technique. Effectiveness was found not to correlate with contact hours, but it did with the country's HDI

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Table 1 Techniques of behavior change implemented in psychosocial stimulation interventions

References (listed chronologically)	Country HDI	Effect size (Cohen's d)[a]	Delivery strategy	Expected frequency (if known) and duration of contacts	Evidence for behavior change[b]	Techniques of behavior change					
						Information	Performance	Problem solving	Social support	Materials[c]	Media[d]
Eickmann et al. (2003)	Brazil, 0.730	0.81	Home and groups	14 over 6 months	—	+	+			+	
Gardner et al. (2003)	Jamaica, 0.730	Cover test, 0.31 Support, 0.06	Home visits	Weekly over 2 months	—	+	+			+	
Powell et al. (2004)	Jamaica, 0.730	Cognitive, 0.87 Language, 0.77	Home visits	Weekly over 12 months	INT 31.4 > CTRL 24.5	+	+	+		+	
Walker et al. (2004)	Jamaica, 0.730	Cognitive, 0.42 Language, 0.00	Home visits	Weekly over 19 months	INT 34.9 > CTRL 32.2, $p < 0.05$	+	+			+	
Gardner et al. (2005)	Jamaica, 0.730	Cognitive, 0.32 Language, 0.55	Home visits	Weekly over 6 months	—		+	+		+	
Hamadani et al. (2006)	Bangladesh, 0.515	0.33	Home and groups	124 over 12 months	—	+	+			+	
Aboud (2007)	Bangladesh, 0.515	Language, −0.04	Groups	Weekly for 10 months	INT 29.97 > CTRL 28.2, $p = 0.002$	+					
Jin et al. (2007)	China, 0.699	Cognitive, 0.48 Language, 0.51	Clinic visits	2 over 6 months	—	+	+	+			+
Peairson et al. (2008)	Paraguay, 0.669	0.62	Home and groups	Monthly over 24 months	INT 25.8 > CTRL 20.7, $p < 0.001$	+	+				
Nahar et al. (2009)	Bangladesh, 0.515	0.84	Home and groups	20+ over 6 months	—	+	+			+	
Nair et al. (2009)	India, 0.554	0.21	Clinic visits	Approximately monthly over 12 months	—		+				
Lozoff et al. (2010)	Chile, 0.819	IDA, 1.80 Non-IDA, −0.41	Home visits	Weekly over 12 months	—	+	+	+			+
Potterton et al. (2010)	South Africa, 0.629	0.27	Clinic visits	4 over 12 months	—	+				+	

(*Continued*)

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Table 1 (*Continued*)

References (listed chronologically)	Country HDI	Effect size (Cohen's *d*)[a]	Delivery strategy	Expected frequency (if known) and duration of contacts	Evidence for behavior change[b]	Techniques of behavior change					
						Information	Performance	Problem solving	Social support	Materials[c]	Media[d]
Aboud & Akhter (2011)	Bangladesh, 0.515	Language, 0.39	Group	Weekly over 5 weeks plus booster session	INT 29.5 > CTRL 27.6, $p < 0.007$	+	+	+			+
Nahar et al. (2012)	Bangladesh, 0.515	0.32	Clinic visits	9–12 over 6 months	—	+	+			+	
Aboud et al. (2013)	Bangladesh, 0.515	Cognitive, 0.67 R language, 0.85 E language, 0.97	Home and groups	15–19 over 10 months	INT 35.0 > CTRL 31.5, $p < 0.001$	+	+				+
Boivin et al. (2013)	Uganda, 0.456	R language, 0.44 E language, 0.39	Home visits	Fortnightly over 12 months	INT 22.0 > CTRL 17.5, $p < 0.0001$	+	+				
Carlo et al. (2013)	India, 0.554 Pakistan, 0.515 Zambia, 0.448	Resuscitate, 0.37 Normal, 0.23	Home visits	Fortnightly over 36 months	—	+	+				+
Tofail et al. (2013)	Bangladesh, 0.515	IDA, 0.23 Non-IDA, 0.22	Home visits	Weekly over 9 months	Play: INT > CTRL, $p < 0.001$	+	+			+	
Vazir et al. (2013)	India, 0.554	0.36	Home visits	30 over 11 months	—	+	+			+	
Yousafzai et al. (2014)	Pakistan, 0.515	Cognitive, 0.60 Language, 0.70	Home and groups	Monthly over 33 months	INT 32.5 > CTRL 27.7, $p < 0.0001$	+	+	+	+	+	

[a]Effect size is shown for overall mental development outcome unless otherwise stated.
[b]Evidence refers to HOME Inventory scores after intervention.
[c]Materials were toys and books left with the child for a week or two.
[d]Media refers to interpersonal media such as leaflets with prompts and cues for behavior change.
Abbreviations: CTRL, control; E, expressive; HDI, Human Development Index; IDA, iron-deficiency anemia; INT, intervention; R, receptive.
Notes: — indicates data not available, + indicates technique was used, blank cell indicates technique was not used.

($r = 0.50$, $p < 0.05$), so HDI was controlled in our correlations. The analysis provides the first attempt at identifying critical qualities of an effective stimulation intervention.

The technique most strongly correlated with mental development gains was the use of small media ($r = 0.51$, $p < 0.05$). Media most often took the form of small posters, cards, or brochures illustrating the stimulation practices and given to parents to keep at home. They were used by 6 of the 21 programs, mainly ones that did not provide play materials. They served as a means of instruction, particularly for less-educated mothers who benefited from the illustrations of materials and play activities. They also served as a reminder in the home setting for mothers who frequently forgot to provide opportunities for play and conversation or thought they had to buy toys at the store.

Performance and problem solving were the second- and third-strongest correlates (both $r = 0.34$, $p < 0.12$). Performance was used by 19 interventions and included demonstrations of the practice, having mothers engage in the practice with their child, and giving feedback. Of those interventions that included performance-related activities, eight appeared to have the trainer demonstrate how to talk and play with the child during home visits (i.e., Gardner et al. 2003, 2005; Hamadani et al. 2006; Nahar et al. 2009, 2012; Powell et al. 2004; Tofail et al. 2013; Walker et al. 2004). Others explicitly had mothers practice the activity with her child, such as playing a game with materials or talking about pictures, while the peer educator coached and gave feedback (e.g., Aboud & Akhter 2011, Aboud et al. 2013, Boivin et al. 2013, Carlo et al. 2013, Jin et al. 2007, Yousafzai et al. 2014).

Problem-solving techniques (e.g., discussion about how to overcome barriers to change or common parenting challenges) were rarely used. Solutions to overcoming personal and family barriers were more often identified during individual home or clinic visits (e.g., Jin et al. 2007, Lozoff et al. 2010, Yousafzai et al. 2014) and included, for example, addressing the mother's depression or need for instrumental and emotional support from the family. Group sessions addressed common barriers during a question-and-answer discussion (Aboud & Akhter 2011). Common barriers to enacting new practices included simply not remembering, not finding time to provide stimulation, not having play materials readily available, or not knowing how to talk with a child who does not yet speak (Affleck & Pelto 2012).

Social support—described explicitly as motivating peers, family members or authority figures to encourage parents—was too infrequent to assess its value. Only Yousafzai and colleagues (2014) described paying home visits with family members to demonstrate how to support and encourage the young mother. Group sessions with peers may have provided a convenient setting for peer support, but none of the interventions explicitly promoted it. Likewise, verbally communicating information or instructions was widespread and so was too frequent to assess its value. Unexpectedly, the provision of materials to parents, used by 12 interventions, had a small negative relation to the effectiveness of the intervention ($r = -0.23$, ns). Materials included low-cost play items and picture books, sometimes on loan until the next session. The purpose was twofold: to provide stimulation for the child and to demonstrate to the parent the value of such materials in the hope that the parent would replicate them. The negative effect may have been the result of parents relying on these materials rather than collecting materials already in the home.

Interestingly, interventions that used more techniques were more effective at improving children's mental development than those that used only one or two ($r = 0.44$, $p < 0.05$). Several used only one technique, namely communicating information and verbal instructions about what caregivers should do and why (Aboud 2007, Potterton et al. 2010). The inclusion of information alone assumes that parents' lack of knowledge about child development and nutrition is the main obstacle to providing stimulation. However, the force of habit and the pressure of social norms are known to be important barriers to change (Affleck & Pelto 2012, Verplanken & Orbell 2003). The

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use of more techniques to stimulate multiple modalities of change, such as knowledge, behavior, social input, and memory, may help consolidate learning and performance.

In summary, several conclusions can be drawn about the techniques that are most successful in leading to parental behavior change and improvements in children's mental development. One conclusion is that the use of multiple techniques is better than relying on one or two methods, such as verbal instruction. Second, small media, performance, and problem-solving techniques led to better outcomes than the provision of materials. Too little is known about social support to draw conclusions on its impact. Generalizing from stimulation-promotion studies to nutrition or hand-washing interventions might require a leap of imagination. Yet commonalities such as the targeted behaviors being preventive and requiring daily enactment suggest that the six techniques may be relevant. In fact, the findings from psychosocial stimulation interventions in developing countries show interesting similarities with other preventive health interventions in developing countries (Briscoe & Aboud 2012) and developed countries (Abraham & Michie 2008, Glanz & Bishop 2010). One commonality is that programs require a broad theoretical framework, such as the social ecological model (Glanz & Bishop 2010), with inputs at the individual, family, and community levels in order to make significant, sustained changes. For example, performance and problem-solving techniques may change the individual caregiver's behavior, but changes often dissipate if family and neighbors disapprove. Activation of social support at the family level, along with information and instruction directed to the community, might augment and sustain the change in practice. Another similarity across behavior change efforts is that preventive health practices are changed among possibly 50% of the participants, who constitute what Rogers (2002) calls innovators and early adopters. The other half, known as late adopters and laggards, wait to see a critical mass performing the new practice and need extra help overcoming obstacles. The 50% change rate fits data from studies reviewed here; for example, in one study the number of parents providing a new toy in the past month rose from below 10% to 50%, telling a story in the past week rose from 20% to 58%, and providing four or more food categories increased from 5% to 57% (Aboud et al. 2013).

Unique challenges to changing behaviors of parents in developing countries arise mainly from the number of interrelated behaviors that require change and the capacity of families to change. Because children face multiple risks, researchers have moved away from the "silo" approach of focusing on one problem and toward aiming for change in at least three areas: stimulation (play and talk), feeding (quantity and quality), and hygiene (hand washing). Delivering newborns in a health facility, using bed nets in malarial regions, and seeking treatment for sick children are three additional messages advocated by health organizations. Mothers who are already overloaded with work and are not highly educated may reach their limit with four to five practices. So the "seven plus or minus two" rule of psychology must be applied here by packaging practices into chunks and aligning them with a daily routine. Given low levels of education, high levels of maternal depression, and lack of easy access to toys, food, and soap, parents require more than a cognitive-based program to effect change. These challenges explain why multiple techniques for behavior change yield better outcomes.

CONCLUSION

This review brings together international research that bridges health, neuroscience, behavior change, nutrition, and child development in order to explain the cognitive and language development of young children. Using basic science findings from these disciplines that demonstrate the serious consequences of birth asphyxia, infection, malnutrition, and inadequate stimulation, multidisciplinary teams have developed and evaluated interventions to reduce their impact. It is

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clear from the meta-analysis that interventions aimed at enhancing stimulation in the home have been successful. Several different models, including group sessions, home visits, and clinic visits, have been tested and found to be effective. Nutrition interventions since the year 2000 have been less effective, but it may be important to integrate macronutrients, micronutrients, and nutrition education. The hypothesized mediators linking nutrition interventions to mental development need to be clarified and tested; at this point it is not clear whether brain function, height, gross motor development, or environmental stimulation are influenced by nutrition and in turn improve mental development. Most researchers agree that because risks to mental development co-occur in developing countries, practices related to health, nutrition, and stimulation need attention. The focus now is on how to promote and maintain behavior change. Critical features of successful interventions have been identified and include multiple techniques of behavior change such as small media use, skill-building activities, and problem solving methods. How to bring about change in a manner that is cost-effective and compatible with families' goals and abilities is one ongoing challenge. So too is the way to create readiness at the community level to support these changes. Changing norms and support from the community and health system will lessen the burden on families to make changes on their own. This in turn can facilitate the integration of interventions concerned with health, growth, and development that promise synergistic benefits.

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SUMMARY POINTS

1. Four common events that occur in the first 24 months of children's lives have important consequences for their mental development, namely delivery by an unskilled attendant, infection such as malaria, inadequate nutrition, and inadequate stimulation.
2. Interventions that provide or promote psychosocial stimulation have a medium effect on children's cognitive and language development. Interventions that provide or promote nutrition have a very small effect on children's cognitive and language development.
3. Initial findings regarding brain function show neural sensitivity (e.g., quick activation with low amplitudes in focal hemispheric sites) to nutrition and stimulation inputs, and assessments of brain functioning, will increasingly be used along with behavioral measures to assess development.
4. So far, stimulation interventions have been moderately successful at identifying parental practice mediators of interventions; less is known about mediators in nutrition studies where a number of interesting psychosocial mediators are still untested.
5. Interventions that include multiple techniques of behavior change, especially those related to performance, problem solving, and the provision of small media, are effective in changing parents' stimulation behavior.

FUTURE ISSUES

1. Research, programs, and families will benefit more when psychologists collaborate closely with health and nutrition experts to address malnutrition, infection, and inadequate stimulation.
2. Advances in neuroscience will improve our understanding of the critical links among nutrition, stimulation, and mental development.

3. The question of which techniques promote behavior change in this context is critical for our understanding of how to motivate and sustain stimulation and nutrition practices in the family and the community.
4. A metric by which we can assess the quality of an intervention or program needs to be validated against the effectiveness of the program. This requires more careful assessment of the implementation process, including how new practices are passed from researcher to delivery personnel to community caregivers.
5. Steps required to scale up successful interventions at a national level are being considered using a variety of creative models. These models will need to be evaluated and improved over time.

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DISCLOSURE STATEMENT

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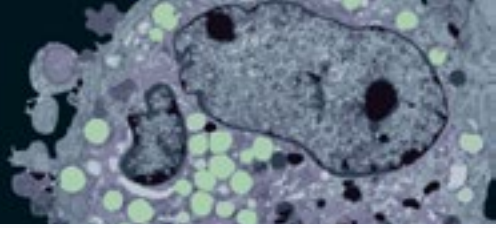

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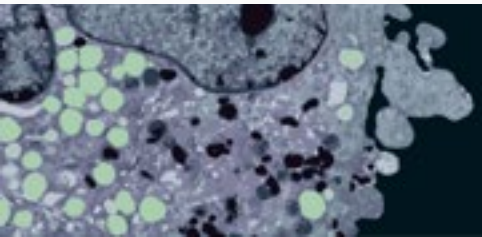

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