

## Child development in developing countries 3

# Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world

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This paper is the third in the Child Development Series. The first paper showed that more than 200 million children under 5 years of age in developing countries do not reach their developmental potential. The second paper identified four well-documented risks: stunting, iodine deficiency, iron deficiency anaemia, and inadequate cognitive stimulation, plus four potential risks based on epidemiological evidence: maternal depression, violence exposure, environmental contamination, and malaria. This paper assesses strategies to promote child development and to prevent or ameliorate the loss of developmental potential. The most effective early child development programmes provide direct learning experiences to children and families, are targeted toward younger and disadvantaged children, are of longer duration, high quality, and high intensity, and are integrated with family support, health, nutrition, or educational systems and services. Despite convincing evidence, programme coverage is low. To achieve the Millennium Development Goals of reducing poverty and ensuring primary school completion for both girls and boys, governments and civil society should consider expanding high quality, cost-effective early child development programmes.

### Introduction

This is the third paper in a series that addresses the lost developmental, educational, and economic potential of more than 200 million children under the age of 5 years in developing countries.<sup>1</sup> The second paper identified risks with the strongest evidence base and highest prevalence as stunting, iodine and iron deficiencies, and inadequate cognitive and social-emotional stimulation.<sup>2</sup> Less well-documented, but with consistent epidemiological evidence, are risks related to social conditions (maternal depression and violence), environmental factors (lead and arsenic), and some infectious diseases (malaria and HIV). Risk factors often co-occur and interfere with children's development, thereby contributing to a trajectory that includes poor health, lack of readiness for school, poor academic performance, inadequate preparation for economic opportunities, and perpetuation of the inter-generational cycle of poverty.

This paper examines the effectiveness of intervention programmes in developing countries. Based on the recommendations from earlier papers in this series,<sup>1,2</sup> we assess programmes that promote child development through preventing or ameliorating the effects of stunting, iodine deficiency, iron deficiency anaemia, and inadequate stimulation. We also identify examples of interventions to reduce the effects of social, environmental, and infectious risks. We include only evaluations that report cognitive or social-emotional outcomes.

Child development refers to the ordered emergence of interdependent skills of sensori-motor, cognitive-language, and social-emotional functioning (figure 1). Early child development programmes<sup>3</sup> are designed to improve the survival, growth, and development of young children, prevent the occurrence of risks, and ameliorate the negative effects of risks. Most are directed toward

disadvantaged children. Some programmes work directly with children through improved services such as growth monitoring, early child-care centres, or improved hygiene or health services; others work with parents to improve their parenting skills and resources, through home visits, group sessions, or communication for behaviour change.

### Developing country interest in early child development programmes

Awareness of child development is increasing in developing countries. The health sector has advocated for early child development programmes for children with low birth-weight,<sup>4</sup> developmental delays,<sup>5</sup> and from low-income disadvantaged environments.<sup>6-8</sup> Child development information is often incorporated into growth monitoring charts. Government-supported preschool programmes for children are increasing; in the past 15 years, at least 13 developing countries have instituted compulsory preschool or pre-primary programmes.<sup>9</sup> By 2005, the World Bank had financed loans to 52 developing countries for child development programmes, for a total of US\$1680 million, at least

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This is the third in a *Series* of three articles about child development in developing countries

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### Search strategy

Databases searched were MEDLINE (PubMed), Embase, Psych Info, the Cochrane Review, the Educational Resources Information Center (ERIC), the World Health Organization, the World Bank and the International Bureau of Education for UNESCO (United Nations Educational, Scientific and Cultural Organization), SIGLE (grey literature from Europe), LILACS (Latin American and Caribbean Health Services), and UNICEF. The UNICEF and World Bank databases were searched and queries were sent to international organisations that may have had access to unpublished evaluations, including Plan International, Save the Children, Christian Children's Fund, Aga Khan Foundation, Bernard Van Leer Foundation, Consultative Group for Early Child Care and Development, and regional early child development networks.

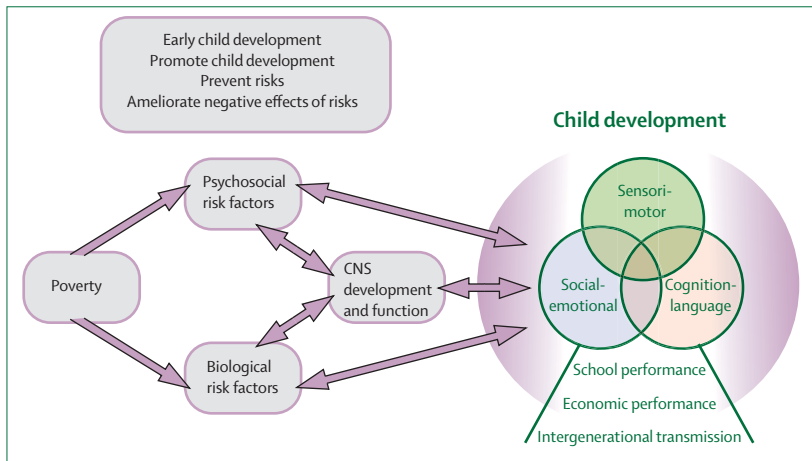


Figure 1: Conceptual model of how interventions can affect early child development

30 developing countries had policies on early child development,<sup>10</sup> and UNICEF was assisting governments in supporting parenting programmes in 60 countries.<sup>10</sup> Despite this interest, there have been few systematic evaluations of early child development programmes in developing countries.

### Early child development programmes Improving food intake and reducing stunting

Both efficacy trials and programme evaluations have shown that improving the diets of pregnant women, infants, and toddlers can prevent stunting<sup>11,12</sup> and result in better motor and mental development.<sup>2,13,14</sup> Food supplementation during the first 2–3 years of life improves cognition at 3 years of age and beyond.<sup>13,15</sup> One trial showed an improvement in motor development with exclusive breastfeeding.<sup>16</sup> The longest follow-up duration is from Guatemala, where supplementation before age 3 years showed beneficial effects on schooling, reading, and intelligence tests during adulthood (25–42 years).<sup>17</sup>

Conditional cash transfers provide funds dependant on behaviour, such as participation in nutrition monitoring and supplementation programmes.<sup>18</sup> Evidence from a conditional cash transfer programme in Mexico for more than 20 million people showed that transfers to women plus direct nutritional supplements for young children and nutrition education<sup>19</sup> were associated with children's improved growth and motor development.<sup>18,20</sup> Conversely, analysis of such a transfer programme in Brazil noted that recipient children grew slower than non-recipients, perhaps because families feared that benefits would be discontinued if their child grew well.<sup>21</sup>

### Reducing iodine and iron deficiencies

Assessments of efficacy trials and programmes of iodine interventions provide conclusive evidence of a significant effect on cognition and behaviour.<sup>2</sup> Salt iodisation remains the most cost-effective way of delivering iodine and of substantially improving cognition. At least 30

developing countries have reached the 2005 goal of sustainable elimination of iodine deficiency through universal salt iodisation:<sup>10</sup> 69% of households consume iodised salt, with rates of 86% in Latin America, 85% in east Asia, but only 47% in central Europe and central Asia.<sup>10</sup>

Iron deficiency anaemia impedes child development.<sup>2</sup> Detrimental effects in infants and toddlers might not be readily reversed by iron therapy, suggesting the need for a preventive approach.<sup>22</sup> Iron supplementation to prevent anaemia in young children has positive effects on motor, social-emotional, and language development.<sup>2</sup> Innovations for iron supplementation include: microencapsulated ferrous fumarate plus ascorbic acid supplied as sprinkles added to complementary foods;<sup>23</sup> growing plant varieties with higher iron content;<sup>24</sup> removing phytates from plants that inhibit iron absorption; soaking maize flour in excess water with phytase and decanting the water before cooking the flour;<sup>25</sup> and new iron fortification methods that eliminate aftertaste, reduce risk of excess intake, and maintain bioavailability.<sup>26,27</sup> These approaches are promising for the reduction of iron deficiency and anaemia in young children.<sup>26,27</sup> A 6-month trial in South Africa assessed the effect of iron and other micronutrient-fortified maize porridge on infant development and reported better motor development in the fortified porridge group than the non-fortified group.<sup>28</sup>

Concerns have been raised about giving iron supplements to iron replete infants, eg, decreased linear growth<sup>29,30</sup> or increased hospitalisations and death in a malarial region.<sup>31</sup> These issues should be studied further and need to be considered in public health programming.

### Stimulation combined with nutrition and health programmes

Stimulation occurs through responsive and increasingly complex developmentally appropriate interactions (matched to the child's emerging abilities) between caregivers and children that enhance child development.<sup>32,33</sup> Both cognitive and social-emotional skills provide the basis for later academic and employment success.<sup>1,34,35</sup>

Inadequate stimulation and interactions can affect child development through disrupting basic neural circuitry. Neural disruptions are measured through stress hormones,<sup>36</sup> brain images,<sup>37</sup> and event-related potentials.<sup>38</sup> Early stimulation may enhance neurocognitive processing and brain functioning, particularly for premature infants.<sup>39</sup> The effects of early stimulation are also evident in the dramatic improvements in child development in undernourished, institution-raised children adopted into middle-class homes. A study of Korean girls adopted into middle-class families illustrates the synergistic effects of malnutrition and environmental deprivation on children's intelligence.<sup>40,41</sup> IQ scores of children adopted after 2 years of age and with a history of malnutrition scored worse than equally malnourished children adopted at less than age 2 years (figure 2), but both were close to average.

Similar age-related findings have been reported in institutionalised Romanian children adopted into middle-class homes.<sup>42</sup>

In developed countries, long-term benefits from high-quality early intervention programmes for disadvantaged children include higher verbal and mathematics achievement, greater success at school (ie, less grade repetition, higher graduation rates), higher employment and earnings, better health outcomes, less welfare dependency, and lower crime rates than similar non-participants.<sup>43-48</sup> For children younger than 3 years, combining family and centre-based components is more effective than either alone.<sup>49,50</sup> Cost-benefit ratios for seven programmes in developed countries ranged from 1.8 to 17.0.<sup>45</sup> Programmes for disadvantaged children during early childhood have a better rate of return than programmes introduced later in life.<sup>34</sup>

Myers<sup>51</sup> reviewed the effects of nutrition and child development programmes on school progress (repetition, promotion, and dropout) in developing countries before

1990. Three of the four nutrition programmes, and six of the nine programmes with schooling data, showed significant effects of early intervention, particularly for the most disadvantaged. The absence of effect in four studies was attributed to automatic promotion, poor quality of the schools, and methodologically weak evaluation.

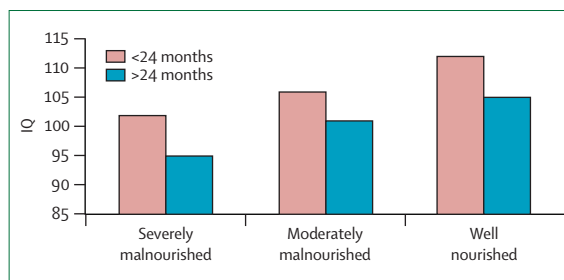


Figure 2: IQ scores among female Korean orphans varying by history of malnutrition and age of adoption

Data taken from references 40 and 41.

	Sample size*	Intervention	Age	Outcome measure	Significant effects	Effect size of cognitive measure	Scale†
<b>Centre-based</b>							
Guinea <sup>52</sup>	877	Informal community-based early learning centres	2-6 years	Cognitive development (Simplified Boehm Basic Concept Test) at 5 years	Cognitive development controlling for socioeconomic status p<0.05	0.33 0.66 socioeconomic status controlled	2
Cape Verde <sup>52</sup>	803	Formal preschool	3-6 years	Cognitive development (Simplified Boehm Basic Concept Test) at 5 years	Cognitive development with socioeconomic status controlled p<0.05	0.29 0.48 socioeconomic status controlled	3
Bangladesh <sup>53</sup>	208	Preschool run by NGO, feeding	4.5-6.5 years	(1) Cognitive development from WPPSI-III (2) Local school readiness assessment test (3) Play observation scale	(1) Treatment>control p<0.05 (2) Treatment>control p<0.05 (3) Treatment>control p<0.05	(1) 0.20-0.23 (2) 1.40 (3) 0.19-0.72	1
Burma <sup>54</sup>	(1) 1880 (2) 268	Community-based early child development centre and community support	3-5 years	(1) Primary school pass rate (2) Academic achievement tests (language, mathematics, thinking skills)	(1) Treatment=85%, control=72% (2) Treatment=86%, control=69% in language and mathematics; treatment=82%, control=73% in thinking skills	Not available	2
Nepal <sup>55</sup>	935	Community-based early child development centre (education and health)	3-6 years	(1) Primary school pass rate (2) Repetition rate for grade 1 (3) Yearly dropout rate after 4 years	(1) Grade 1: treatment>control by 32% Grade 2: treatment>control by 38% (2) 5.5% (1/15 of national norm) (3) 1.2% (1/10 of national norm)	Not available	2
Vietnam <sup>56</sup>	313	Centre and home (education, parenting, nutrition)	0-3 years for nutrition; 4-5 years for education	Raven's Colored Progressive Matrices at 6.5-8.5-year-old	Early child development+nutrition > than nutrition only on Raven's Colored Progressive Matrices. Greatest effect in malnourished children	Roughly 0.25 based on estimated SD	1
Colombia <sup>57,58</sup>	333 children all underweight 170 at follow up (all but higher socio-economic status group underweight initially)	Day care centre-based feeding and stimulation; 5 groups: food alone, and food+different periods of stimulation, and high socioeconomic status group	42 months up to 75 months (varying amounts)	Stanford-Binet IQ test	Greatest effect for children enrolled for the maximum time (4 years) and beginning earliest (age 4 years). Supplementation without stimulation had no effect on psychological development. Duration benefited performance.	Not available	1
Argentina <sup>55</sup>	More than 125 000 children	Increase in preschool places	3-5 years	Third grade mathematics and Spanish achievements	1 year of pre-primary increased mean third grade test score by 8% of mean or by 23% of SD. Child attention, effort, class participation, and discipline were also significantly higher in experimental group	0.23	3

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**Parenting and parent-child interaction**

Jamaica <sup>60</sup>	163	Home-visits by roving caregivers (health, nutrition, parenting, income-generating)	3–36 months	Griffiths Mental Developmental Scales Parent knowledge and practice	Treatment>control in Griffiths Score. Knowledge greater, practice was not	0.5 socioeconomic status controlled	1
Jamaica <sup>59</sup>	130	Home-visits by health aides (parenting)	9–30 months	(1) Griffiths Mental Developmental Scales, (2) Mothers' knowledge and practices of childrearing	Mothers showed improved knowledge and practices of childrearing. Children scored higher in the treatment group	(1) 0.8 socioeconomic status controlled	1
Colombia <sup>61,62</sup>	433 families	Nutritional supplement programme, a stimulation programme (home visit), or both A=Control A1=Stimulation B=Food 6 months to 3 years C=Food third trimester to 6 months D=Food third trimester to 3 years D1=Food+stimulation (Food: 623 cal+20g protein per child, 856 cal+38.4g protein per woman)	Prenatal to 3 years, follow up at 6 years	Griffiths Mental Developmental Scales at 4, 6, 12, 18, 24, 36 months Locomotor, personal-social, speech and language, eye-hand coordination, Einstein scale applied through 18 months	Food greater than control on all subscales and total; D (food prenatal to 3 years) greater than control (food third trimester to 6 months); treatment effects generally greater for girls Food and stimulation each affected different aspects of performance. Food affected motor development. Stimulation affected language, but no additive effects of food and stimulation on development. Stimulation plus supplementation had larger effect on growth than supplementation alone at 3 and 6 years.	Not available	1
Bolivia <sup>63</sup>	454	Adult literacy programmes and home visits (parenting, health, nutrition) in matched groups with and without intervention	24 months; some older	Psychosocial development (summary score of fine motor, gross motor, hearing, and language, personal and social assessment)	Preschool scored significantly better than parenting programme and control group; Children in parenting group scored higher than controls, controlling for age (p<0.07) on cognitive test	Not available	2
Turkey <sup>64</sup>	217	3 (centre) x 2 (mother training) design; Centre=educational, custodial, or none. Mother training=received or not received	3–5 years	10 year follow-up: (1) School attainment (percentage of children still in school) (2) Turkish school achievement test (3) WISC-R vocabulary test	(1) Mother training=86% of children still in school; non-mother training=67% still in school; no significant effect of centre attendance on percentage still in school. (2) Mother training =8.56; non-mother training=7.89; no significant effect of centre; but there was an interaction of parent training and child preschool attendance on test score. (3) Significant effect for both mother training and centre on tests.	(2) 0.45	1
Bangladesh <sup>65</sup>	170 Treatment 159 Control	Parent groups that meet weekly for 1 year; mean attendance was 16 sessions (range 0–42; assessment 2 months after end of programme)	2 years or 3 years	(1) Maternal knowledge (2) Home Scale and subscales (3) Receptive vocabulary (4) Weight/height (5) Five preventative health behaviours (6) Mother-child picture talk	(1) Treatment>control (2) Treatment>control, also for stimulation scale (3) Not significant (4) Control >treatment (5) Treatment>control (6) Not significant for stimulating talk	(1) 0.31 mother knowledge (2) 0.034 on HOME scale	2

\*Sample size for the evaluation, not for the whole programme. †Scale: 1=coverage fewer than ten villages. 2=coverage of ten or more villages, or a district but not national programme; 3=national-level government programmes. WPPSI=Wechsler Preschool and Primary Scale of Intelligence. HOME=Home Observation for the Measurement of the Environment (Scale).

**Table 1: Child-care centre programmes and parent-child interventions for child development in developing countries**

We reviewed programmes implemented in developing countries since 1990 using six criteria: (a) randomised controlled trial or matched comparison group; (b) intervention before age 6 years; (c) effectiveness or programme evaluations (not efficacy trials); (d) child development assessed; (e) targeted disadvantaged children; and (f) developing country. 35 studies from developing countries were identified, of which 20 met the criteria (tables 1 and 2 and search strategy).<sup>1</sup> The programmes fell into three groups: centre-based early learning (N=8); parenting or parent-child (N=6); and

comprehensive (N=6), including health and nutrition interventions.

#### Centre-based programmes

All eight evaluations recorded a substantial effect on children's cognitive development. Preschools were provided in Guinea and Cape Verde,<sup>52</sup> Bangladesh,<sup>53</sup> Burma,<sup>54</sup> Nepal,<sup>55</sup> Vietnam,<sup>56</sup> and Colombia,<sup>57</sup> and pre-primary schools were expanded in Argentina.<sup>35</sup> Most reported gains in non-cognitive skills such as sociability, self-confidence, willingness to talk to adults, and motivation. Longitudinal studies

Country	Sample size <sup>*</sup>	Intervention	Age	Outcome measure	Significant effects	Effect size of cognitive measure	Scale <sup>†</sup>
India <sup>59</sup>	3724	Integrated childcare centre; preschool education, support for pregnant and lactating mothers, growth monitoring, feeding, assistance for child immunisation and some emergency health	3–6 years	Motor and mental development using WHO Milestones assessment	Integrated Child Development Services significantly better than controls; stronger effect for younger; both nourished and undernourished performed better than matched controls	Not available	3
Peru <sup>72</sup>	304	Preschool and non-formal preschool, community nutrition programmes	3–5 years	Grades (A–C) in mathematics and language (Spanish) as assessed by the first grade teacher.	Both students in formal and non-formal preschool performed better than no pre-school	Not available	3
Bolivia <sup>13</sup>	1198	Child care centres in home for stimulation; feeding health and nutrition monitoring, education of mother	6–72 months	Gross and fine motor skills, language and auditory skills, and psychosocial skills	Effects stronger at younger age (2–3 years) with longer duration (>17 months)	0.4–1.5 depending on test	2
Uganda <sup>73</sup>	2010	Communication on early child development, health and nutrition, child health days, village grants on nutrition or early child development centres	0–6 years	(1) Ugandan version of the British Abilities Scale (2) Parenting practices (3) Nutritional status	(1) No significant difference (2) Significant difference in parent attitudes and behaviour towards early child development (3) Significant difference for younger than 1 year		2
Philippines <sup>74,75</sup>	6693	Family day-care programmes, home visits on parenting and nutrition, improved health and nutrition services, feeding	0–4 years	Early child development checklist of gross and fine motor skills, receptive and expressive language, social-emotional skills, cognitive skills, and self-help skills and development index	For Developmental Index, all differences significant ( $p < 0.05$ ) for children with duration of exposure >17 months, and for all children aged 2–3 years at enrolment for all durations. Strongest effect for language	Ranged from 0.5–1.8 for specific scales, ages, and durations	2
Bangladesh <sup>76</sup>	300 children with growth faltering	Stimulation in therapeutic feeding centre, home visits, and group meetings (treatment=centres with child development interventions, control 1=nutrition centres without child development programmes, control 2=well-nourished)	6–24 months	Bayley Scales of Infant Development	Treatment>control 1 for mental development, not motor; control 2>control 1 in mental and motor development. No effect of stimulation intervention on nutritional status	0.37	1

<sup>\*</sup>Sample size for the assessment, not for the whole programme. <sup>†</sup>Scale: 1=coverage fewer than ten villages; 2=coverage of ten or more villages, or a district but not national programme; 3=national-level government programmes.

**Table 2: Comprehensive programmes for child development in developing countries**

(Nepal,<sup>55</sup> Argentina,<sup>35</sup> Burma,<sup>54</sup> and Colombia<sup>58</sup>) recorded improvements in the number of children entering school, age of entry, retention, and performance.

#### Parenting and parent-child programmes

Four parenting programmes used home visiting, and all reported positive effects on child development.<sup>59–65</sup> In Jamaica, parenting practices improved when children and parents were actively involved in a home-visiting programme, but not when the parent component was limited to information sharing.<sup>60</sup> In Bolivia, information and skill building about health, hygiene, nutrition, and development, linked with a literacy programme for indigenous women and home visits, resulted in higher test scores for participants' children than those of matched non-participants.<sup>63</sup>

Two programmes used group sessions with mothers. In Turkey, where mothers practised skills to play with their children, there were short-term and long-term

effects on child development.<sup>64</sup> In Bangladesh, mothers' knowledge of child development and child rearing increased after information-based sessions, but there was no effect on child development,<sup>65</sup> perhaps because there were no practise or skill-based activities with families.

#### Comprehensive programmes

Six programme evaluations met the criteria for this group (table 2) and show the changes in programme models from 1975 to the late 1990s. The Integrated Child Development Services (ICDS) in India began in 1975, and provided counselling to pregnant and lactating women about nutrition, growth monitoring for children 0–5 years, and feeding and preschool centres for children 3–6 years old. The programme has been implemented at low cost, and currently serves more than 30 million children.<sup>66</sup>

In 1992, the National Institute of Public Cooperation and Child Development in India compared around

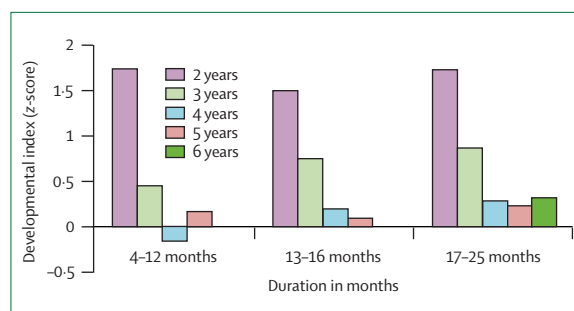


14000 ICDS children with 2000 control children from non-participating communities that had similar services, and reported less likelihood of ICDS children being severely malnourished and greater likelihood of attending school.<sup>67,68</sup> In three of the wealthier states, participating 3–5-year-old children scored higher on measures of child development than matched non-participants from neighbouring towns, with greater effects for younger and for malnourished children in two of the three states.<sup>69</sup> These assessments indicate that the ICDS can be effective, but a World Bank evaluation in 2002 indicated that the ICDS had “only modest positive effects”,<sup>70</sup> probably because of low funding, work overload of community workers, and insufficient training.<sup>71</sup>

In the early 1980s, Peru developed a community preschool and feeding programme for disadvantaged children. An evaluation in 1999 showed that first graders who had attended the programme did not differ on indices of school performance from those in formal preschools, but both groups had higher scores than children who did not attend the programme, controlling for socioeconomic variables.<sup>72</sup>

Three projects, supported by the World Bank, in Bolivia, Uganda, and the Philippines illustrate various models for early child development. In the early 1990s, the PIDI (Proyecto Integral de Desarrollo Infantil) programme in Bolivia trained low-income urban women to run child-care centres in their homes for malnourished children 6–72 months, and funded them to upgrade their homes, provide food for the centres, and run health and nutrition monitoring and educational activities.<sup>14</sup> Non-participants were compared with children who had at least 6 months of exposure. There were benefits in growth in children younger than 36 months and benefits in cognitive and psychosocial development, irrespective of age. The estimated cost was US\$43 per month per child, 40% of which was for food.

The Uganda Nutrition and Early Child Development Project began in the late 1990s.<sup>73</sup> Communities within



**Figure 3: Effects of the Philippine Early Child Development Programme on standardised Developmental Index score as a function of child's age at enrolment and duration**

Developmental index varies by child's age at programme enrolment and duration of time in programme, favouring younger children with longer duration. All differences are significant ( $p < 0.05$ ) for 17–25 months duration and for 2-year-olds and 3-year-olds for all durations compared with non-programme children. Adapted from data available in Armezin.<sup>74</sup>

25 districts were divided into intervention and control. Intervention communities received radio and newspaper messages on child stimulation, positive parenting, health, hygiene, and nutrition. Child health days every 6 months for the whole community provided growth monitoring and promotion, immunisation, deworming, and health care. Each intervention community could receive community grants for nutrition or early child development, and most chose nutrition. After 2 years, there were substantial improvements in breastfeeding practices, growth rates in the youngest children, and parental attitudes and behaviour supporting early child development, but there were few effects on cognitive development of children aged 3.5–6 years, possibly because of the low intensity of the intervention.

In the late 1990s, the Philippines increased training and supplies to existing services for children aged 0–5 years using an integrated, multi-sectoral approach for delivering a combination of services,<sup>74,75</sup> and added community child development workers responsible for parenting education on health, nutrition, and child development. The evaluation showed that programme communities had more feeding programmes, parent education, and home-based child care programmes than control communities, adjusting for child age and programme duration.<sup>74,75</sup> Children who had been exposed for more than 18 months showed a benefit in cognitive development, with effect sizes up to 1.8 SD in language development for 2–3 year-old children (figure 3). There was no effect on haemoglobin, despite an iron supplementation programme, nor on stunting, but participating children older than 4 years were heavier than non-participants.

#### Panel 1: Characteristics of successful early child development interventions

- Integration of health, nutrition, education, social, and economic development, and collaboration between governmental agencies and civil society.
- A focus on disadvantaged children.
- Sufficient intensity and duration and include direct contact with children beginning early in life.
- Parents and families as partners with teachers or caregivers in supporting children's development.\*
- Provide opportunities for children to initiate and instigate their own learning and exploration of their surroundings with age-appropriate activities.
- Blend traditional child-rearing practices and cultural beliefs with evidence-based approaches.\*
- Provide early child development staff with systematic in-service training, supportive and continuous supervision, observational methods to monitor children's development, practice, and good theoretical and learning-material support.\*

\*Adapted from Jaramillo and Mingat.<sup>111</sup>

A component of psychosocial stimulation was added to the Bangladesh Integrated Nutrition Project, a national nutrition programme for malnourished children. A 12-month randomised controlled trial of home-visiting and mothers' group sessions in community centres reported substantial benefits to the children's cognitive development and behaviour (fear, timidity), but no effect on growth.<sup>76</sup>

In summary, five of six early child development programmes showed beneficial effects. The recent programme models have been integrated into existing community-based systems and include families more effectively than earlier models. However, as the Uganda results indicate, low-intensity programmes that do not direct services toward children might have limited effect on child development outcomes.

#### Factors consistently associated with programme effectiveness

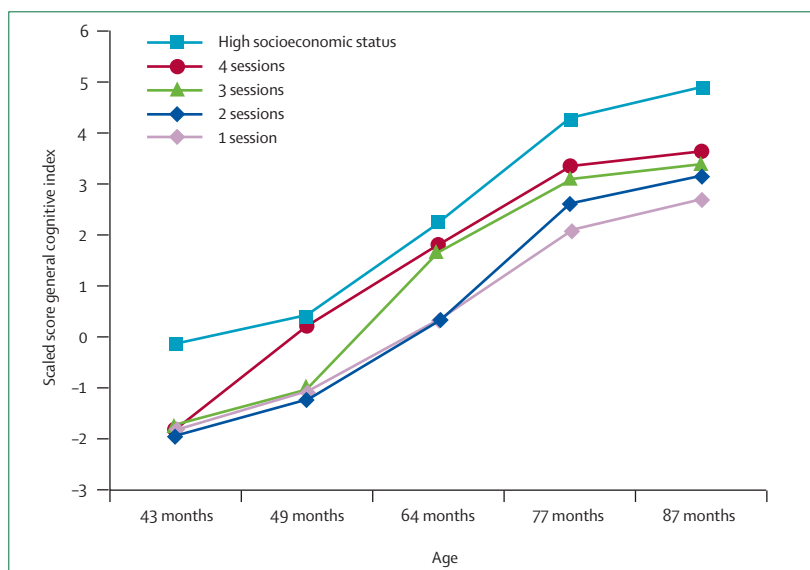
Numerous factors are associated with success of interventional programmes (panel 1). Providing services directly to children is more effective than only providing information to parents; demonstrations and opportunities for skill building and practice with parents increased effectiveness.<sup>60,64,65</sup> Disadvantaged children, including children who are stunted, benefit more than advantaged children.<sup>13,44-48,54,55,56,77</sup> Younger children (2–3 years) benefit more than older children (5–6 years), even after adjusting for duration.<sup>14,57,74</sup> Longer exposure results in more consistent and larger effect on child development.<sup>3,75</sup> For example, disadvantaged preschoolers in Cali, Colombia, with 4 years of intervention achieved test scores that were similar to a middle-class sample, whereas children with less intervention lagged behind (figure 4).<sup>57,58</sup>

Evaluations from Guinea, Cape Verde, and Bangladesh recorded associations between multiple measures of preschool quality and children's cognitive performance.<sup>52,53</sup> The International Association for the Evaluation of Educational Achievement (IEA)'s assessment of pre-primary programmes involving 1500 children from ten countries (three developing countries) identified programme quality (eg, more child-initiated activities and small-group rather than large-group activities) as a critical contributor to cognitive development.<sup>78</sup> Dimensions of quality that are important for child development are programme structure (children to staff ratio, group size, staff training, and physical environment), and processes (warmth and responsiveness of the caregiver, emotional tone of the setting, and variety of activities).<sup>79,80</sup>

Programmes that have assessed intensity report a linear relation between frequency of home visits and improvements in child development.<sup>81</sup> Beneficial effects of combined programmes have been found on efficiency of delivery, cost savings, and effect.<sup>61,62,82,83</sup> Most evaluations did not have the design or sample size to isolate the effects of individual components or to test for synergistic effects.<sup>84</sup>

#### Monitoring child development

Currently, there are no globally accepted indicators for child development. Indicators would improve countries' abilities to set targets, allocate resources, monitor progress, and ensure accountability, but a simple measure is hard to construct. Child development is often measured through individual assessments of developmental changes in multiple domains (eg, cognitive, language,



**Figure 4:** Change in general cognitive index of disadvantaged children in Cali, Colombia, by age of child and number of preschool 9-month sessions, compared with children of high socioeconomic status who received no interventions

Adapted with permission from: McKay H, Sinisterra L, McKay A, Gomez H, Lloreda P. Improving cognitive ability in chronically deprived children. *Science* 1978; **200**: 270–78.

	Total gross enrolment ratio				Repetition rate, grade 1	Dropout rate, all grades
	1990	1998	2001	2002/3	2001/2	2001/2
Arab States	10.8	13.5	19.6	17.7	3.7%	7.2%
Central and eastern Europe	74.0	50.6	60.2	74.3	1.1%	2.3%
Central Asia	37.9	15.2	22.3	28.8	0.1%	3.5%
East Asia and the Pacific	32.1	50.6	54.5	56.2	0.6%	n/a
Latin America and the Caribbean	43.6	57.0	67.3	60.9	8.1%	20.5%
North America and western Europe	68.9	86.3	87.0	86.8	0.8%	n/a
South and west Asia	n/a	19.5	26.4	32.2	5.9%	35.1%
Sub-Saharan Africa	n/a	5.0	5.8	5.6	16.8%	40.5%
Countries in transition	72.4	23.3	30.5	34.6	0.2%	1.8%
Developed countries	72.5	76.1	81.9	81.1	1.0%	2.3%
Developing countries	n/a	31.9	35.0	34.3	7.8%	25.5%
World	n/a	43.7	48.6	48.6	4.0%	15.1%

UNESCO, EFA Global Monitoring Report 2005<sup>9</sup> and EFA Global Monitoring Report 2006.<sup>131</sup> Attendance in preschool and pre-primary education has generally increased since 1990, apart from the former Soviet Republics, where preschool education was widely available in 1990. With the collapse of the USSR, many countries dropped their state-supported early child development programmes. However, in the past few years, there has been a resurgence of early child development programmes, almost to their former level. Although preschool enrolment is low overall in sub-Saharan Africa, the rate is over 25% in 14 of the 33 countries with data, such as Kenya (48%), Ghana (47%), and Namibia (28%).

**Table 3:** Gross enrolment ratios for preschool and pre-primary education and repetition and dropout

social-emotional). Concerns of culture specificity in content and administration have also slowed the development of global indicators.<sup>85</sup>

### Social, environmental, and infectious risks

#### Social risks

There have been few evaluations of social protection interventions designed to mitigate the effects of social risks (eg, maternal depression, exposure to domestic and community violence, and stigma and loss due to HIV/AIDS) on children from developing countries. Women in developing countries have high rates of stress and depressive symptoms,<sup>86,87</sup> often associated with poverty, lack of support, and negative life events. Children of depressed mothers are at risk for poor development, in part mediated through inconsistent and unresponsive parenting.<sup>88,89</sup> Reductions in maternal depressive symptoms with moderate to large effect sizes were shown in four psychosocial interventions,<sup>90–93</sup> but no substantial effect was seen on child competence in the one study that looked at these effects.<sup>91</sup> In Jamaica, mothers' depression scores declined after participating in a parenting intervention, similar to evidence from developed countries showing that teaching mothers practical caregiving skills has beneficial effects for both mothers and children.<sup>94–96</sup>

Violence toward young children often occurs through excessive corporal punishment, child abuse and neglect, and exposure to violence.<sup>97</sup> Responses include law reform on standards of care and mechanisms for surveillance and improving parenting practices. In some countries, supportive and therapeutic services (including therapeutic day-care) for young children who have witnessed or experienced violence have been established.<sup>98</sup> Although there is evidence that home

visiting can be an effective strategy for preventing child abuse,<sup>99</sup> results are not consistent.<sup>100</sup> There are few programmes directed toward young children in developing countries, and no evaluations were located.

Parental loss is often associated with violence or disease-related mortality, including the HIV/AIDS pandemic. In 2004, there were 43.4 million orphans (age 0–17 years) in sub-Saharan Africa, of which 28% were due to HIV/AIDS.<sup>101</sup> A breakdown of these data by age showed that 7 million orphans (16%) were younger than 6 years and 23 million (52%) were younger than 12 years.<sup>102</sup> Interventions for younger children affected by AIDS, such as home visiting, support for families, ensuring access to care, and community-based child care are limited in scale and have not been rigorously assessed.<sup>102</sup>

#### Environmental risks

The evidence that environmental toxins such as lead and arsenic can compromise child development<sup>103,104</sup> is a major reason for reducing exposure. Chelation, even oral chelation<sup>105</sup> or the removal of lead from children's blood and bone stores, although successfully reducing body burden, has not resulted in improvements in children's developmental functioning. Mitigation programmes (including provisions of deep water-wells and education) successfully reduce arsenic concentrations in exposed individuals, but there are no findings on whether they result in improvements in child development. Systematically preventing exposure is probably a more effective and efficient strategy than treatment, but the challenge is the extensiveness of environmental toxin exposure.

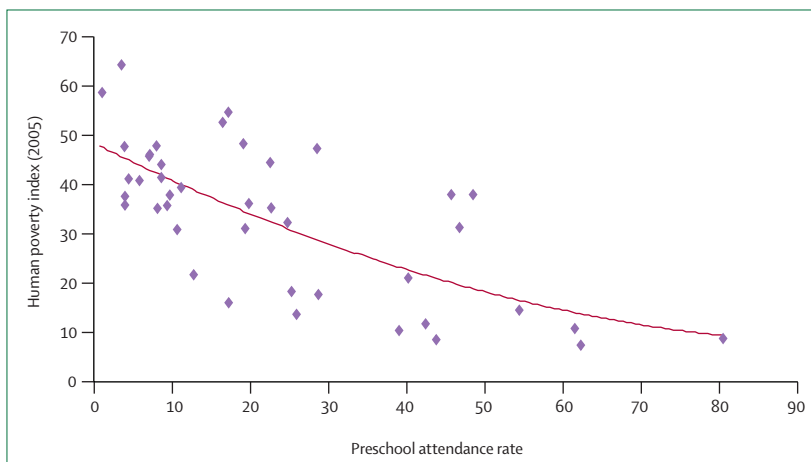
#### Infectious risks

Severe malaria and HIV/AIDS have been associated with poor child development.<sup>2</sup> Effective malaria prevention and control include insecticide treated bednets and artemisinin-based combination therapies.<sup>10</sup> Until recently, coverage of treated bednets for children under 5 years of age was estimated at less than 5%,<sup>106</sup> but countries are now rapidly scaling up coverage, with around 50 million nets expected to be delivered in 2006 and some countries expected to exceed the Abuja targets in 2006. Although the effect on children's development has not been sufficiently studied,<sup>107</sup> benefits to later cognitive abilities following chemoprophylaxis before the age of 6 years have been reported.<sup>108</sup>

Mother-to-child transmission of HIV can be prevented, but in 2005, only 9% of pregnant women in low-income and middle-income countries received services to prevent transmission to their newborn babies, and only 9.2% of HIV-positive pregnant women received prophylactic antiretrovirals.<sup>109</sup>

### Future directions and crucial issues

In the final section we discuss priorities for improving the development of the 200 million children younger than 5 years at risk for cognitive and social-emotional deficits.



**Figure 5: Preschool attendance by human poverty index for 40 developing countries**

Data for preschool attendance from the Global Monitoring Report.<sup>9</sup> Poverty levels (human poverty index) are from UNDP's Human Development Report. Human poverty index is a composite index measuring deprivations in the three basic dimensions captured in the human development index: a long and healthy life, knowledge, and a decent standard of living. UNDP, Human Development Report 2005, New York 2005. <http://hdr.undp.org/reports/global/2005/>.



### Investing in early child development programmes

Despite the substantial evidence that comprehensive early development programmes are effective in increasing children's chances of success, government investment is low. Preschool or kindergarten enrolment, the only early development programme that is monitored worldwide, was 35% in developing countries in 2001.<sup>9</sup> The rate has increased during the past 15 years in east and west Asia and the Pacific,<sup>9</sup> although the regions with the highest need (assessed by grade 1 repetition and dropout) have shown slower progress (table 3). Programme coverage is negatively associated with countries' general poverty index (figure 5), leaving the poorest countries with almost no investment in early child development. However, some countries, such as India, have invested in programmes, despite poverty. If the current rate of progress continues, the disparity between rich and poor countries in preschool attendance (figure 6) will increase.<sup>10</sup> Jaramillo and Mingat<sup>11</sup> estimate that in Africa, an increase in the preschool gross enrolment rate to 40% during the next decade could reduce repetition rates and increase the proportion of grade 1 students who reach grade 5 from 65% to 78%.

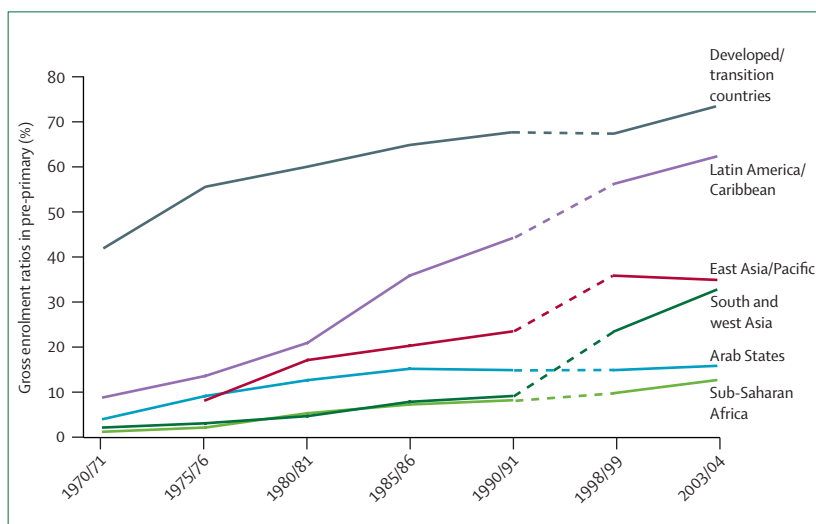
Investments are low for multiple reasons. For example, governments are organised sectorally and no one sector is responsible for early child development. The problem is not visible, and governments might be unaware of the cost to individual and society of not investing in early child development programmes (panel 2).<sup>112,113</sup>

There are human rights and economic reasons to invest in child development programmes (panel 3). The Convention for the Rights of the Child established the principle that children have the right to survive and to develop, and governments are responsible for supporting families in their childrearing.

Evidence indicates that early development programmes are beneficial for their costs. There are many considerations when estimating reliable benefit-to-cost ratios, including: measuring all benefits and costs in monetary terms, such as the value of increased academic performance; assessing diverse resource costs; and balancing between immediate gains versus long-term benefits.<sup>114</sup> Recent estimates of benefit-to-cost ratios for interventions for early child development yield ratios substantially above 1 in developing countries,<sup>115</sup> and in developed countries.<sup>34</sup> In PIDI (Bolivia), the benefit of a 5% increase in cognitive scores and a 2% increase in height translated into a benefit of between \$1.8 and \$3.66 per dollar of project cost.<sup>14</sup>

### Reducing disparities

Achievement differences in children from different socio-economic groups widen over time.<sup>34</sup> Early interventions can reduce disparities. If enrolment in high-quality programmes were increased to 100% for low-income children in the USA, disparities in readiness for school would be reduced up to 24% between black and white children and up to 36% between Hispanic and white children.<sup>116</sup> In Cali, Colombia<sup>37</sup> there was a difference of



**Figure 6: Change in preschool gross enrolment ratios from 1970 to 2003-04 by region**

Data for east Asia and the Pacific are for developing countries only; Australia, Japan, and New Zealand are included under developed countries. The broken line signifies a break in the data series due to a new classification.

Reproduced with permission from EFA Global Monitoring Report Team. EFA Global Monitoring Report 2007. Strong foundations: early childhood care and education. Paris: UNESCO, 2006.<sup>110</sup>

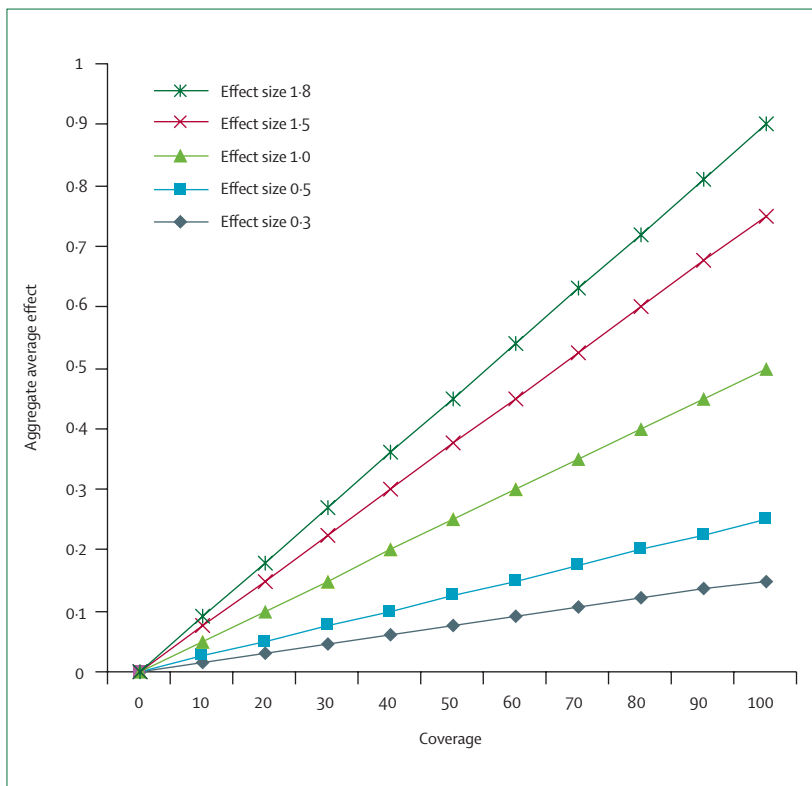
### Panel 2: Reasons that governments do not invest in early child development interventions

- Children's loss of developmental potential, and the cost of loss of developmental potential, both for individual children and poverty alleviation, are not recognised.
- There are no globally accepted indicators for child development to monitor progress or ensure accountability.
- Governments respond to short-term effects and find difficulty in justifying the long-term investment in human development.
- There are multiple organisational stakeholders for young children, so the responsibility for early child development is not assumed by any entity.
- There is not a single strategy for promoting early child development.

Some items were modified from Heaver<sup>112</sup> and the World Bank.<sup>130</sup>

### Panel 3: Why governments should invest in interventions for early child development

- It is the most cost-effective period in the child's life to invest.
- Events in the early years of a child's life influence the child's productivity and learning ability throughout the life course, and are effective strategies for reducing poverty among disadvantaged populations.
- Programmes increase the efficiency and effectiveness of school expenditures by reducing drop-out and repetition.
- Increased schooling for girls has a long-term effect on their children's survival, growth and development.
- Interventions are more sustainable because parents and families carry these changes over to subsequent children.
- There is a strong evidence base on effective interventions for early child development.
- The Convention on the Rights of the Child ensures every child the right to development as well as survival, and requires governments to support families in childrearing.



**Figure 7:** Estimated changes in number of years of school passed as a function of aggregate effect size and coverage of early child development programmes

Effect sizes are based on the range of estimates in tables 1 and 2. Benefits are the increases in schooling attainment for individuals based on estimates of the relation between preschool cognitive tests and completed schooling attainment using longitudinal data that started in pre-school ages and continued through young adulthood in Brazil<sup>117</sup> (age 18 years for 152 males) and Guatemala<sup>13,118</sup> (ages 25–42 years for 1471 females and males), controlling for maternal schooling, parental family income (Brazil), or socioeconomic status (Guatemala), and birth year and sex for Guatemala. Aggregate average benefit is the product of the range of individual benefits times the programme coverage. If coverage was not expanded randomly and the hardest cases were left for last, the lines probably would be less steep as coverage became very high.

#### Panel 4: Policy and programme recommendations

- Implement early child development interventions in infancy through families and caregivers, and add group learning experiences from 3 to 6 years, particularly for disadvantaged children as a poverty reduction strategy.
- Ensure that development programmes combine health and nutrition services with early learning, rely on families as partners, and have adequate quality, intensity, and duration to affect children's development cost effectively.
- Incorporate early child development into existing services and systems to increase programme coverage.
- Monitor the effectiveness of programmes with outcome measures of child development.
- Increase advocacy on the importance of early child development and the consequences of the loss of developmental potential to individuals and to society.
- Include programmes in policies and financial allocations at national, local, or international levels.
- Create coordinating mechanisms for ministries that share the responsibility for early childhood development.
- Ensure that all children are adequately nourished, including micronutrients, such as iodine and iron.

1.5 SD between middle-income and low-income 4-year-olds before intervention. The gap was reduced by 60% with 4 years of preschool (figure 4).

To estimate the effects of early child development on schooling and adult earnings among disadvantaged groups in developing countries, we used longitudinal data beginning before age 5 from 152 Brazilian males, 18 years of age,<sup>117</sup> and 1471 Guatemalan adults, age 25–42 years.<sup>13,118</sup> Both data sets included standardised assessments of preschool development and schooling attainment, as well as controls for maternal schooling and parental income or socioeconomic status, and birth year and sex for Guatemala. We used effect sizes from the review of programmes (tables 1 and 2), ranging from 0.3 to 1.8, to obtain the individual benefits on increased schooling attainment, and we varied the assumed programme coverage rates from 0% to 100% to obtain aggregate average benefits. Analyses across the two data sets found that with 90% coverage, an increase of 1 SD in pre-school cognitive skills is associated with an aggregate benefit of around two-thirds to more than one grade of additional schooling (figure 7 has the derivation of estimated benefits). Estimates for Guatemala that control for random measurement error find effects over five times as large. The estimates from Brazil and Guatemala (not controlling for measurement error) and estimates from developing countries of the economic returns of schooling suggest that preschool participation contributes to increases of around 5–10% in lifetime labour income.<sup>119</sup>

#### Integration of early child development programmes into other systems

Policy decisions on programmes often span multiple ministries (eg, health, education, welfare) and need coordination across sectors.<sup>120</sup> The health system is often the only infrastructure that reaches children younger than 3 years and therefore can initiate programmes to promote early development and prevent risks. Health visits or growth monitoring sessions<sup>120</sup> have added recommendations for child development.<sup>121</sup> The Care for Development Intervention, a module of WHO's Integrated Management of Childhood Illness, is based on interactive learning and includes strategies for improving psychosocial care and responsive feeding. Two pilot studies showed the feasibility of delivering the intervention in resource-poor settings,<sup>122,123</sup> and a controlled evaluation trial in Turkey showed that the Care for Development Intervention had a positive effect on parenting behaviours.<sup>124</sup> In the Congo, surveyed parents reported that they would like more information about their children's development in their health visits,<sup>125</sup> and in the USA, incorporating developmental counselling into primary care has improved quality of care and parenting practices.<sup>126</sup> These innovations are promising but their effect on child development has not yet been assessed.

**Panel 5: Research recommendations**

- Identify the characteristics of child development programmes that are effective and can be expanded and implemented through existing health, nutrition, education, and social protection services.
- Examine the role of early child development programmes in mitigating the effects of multiple disadvantages, including poverty.
- Research parenting interventions to identify the most effective and scaleable strategies.
- Assess possible synergies among programme components to guide implementation recommendations.
- Define a core set of globally accepted measurements and indicators for child development that can be adapted across countries for monitoring, planning, and assessment.
- Improve and assess strategies to increase effectiveness of outreach to disadvantaged children, including orphans.
- Strengthen the evidence base for the effects of maternal depression, exposure to violence, parental loss, toxins, malaria and other infectious diseases on child development and identify effective interventions to reduce their risks and adverse consequences.
- Create and test a method for estimating the costs of different models of early child development programmes.

The educational system can promote child development by supporting comprehensive programmes for early child development. If the programmes are of high quality, have family involvement, and when needed, provide health care and food supplementation or micronutrients, evidence suggests that disparities among the most disadvantaged children can be reduced before school entry. Linking early development programmes administered through the health system with programmes in the educational system increases the likelihood of building intervention follow-up for children at risk.

Early child development programmes can be coordinated across ministries, non-governmental organisations (NGOs), and civil society. In Turkey, parenting messages are provided by the health care system, the Ministry of Agriculture, the Ministry of Labor, and even the Military.<sup>127</sup> In Cuba, the Educate your Child programme covers 98% of young children. National, district, and local committees support community volunteers' (primarily health workers) work with families through home visiting and informal early learning centres to improve survival, growth and development.<sup>128</sup>

To increase coverage of early child development programmes and improve their quality and effectiveness

we need better advocacy strategies, coordination mechanisms, and improved policy (panel 4). Research is needed on approaches to delivering feasible effective child development programmes at scale and on the effects of synergies on child outcomes (panel 5). Effect and cost-effectiveness evaluations of these efforts are a priority for guiding future policies and programmes.

**Conclusion**

Effective interventions are available to reduce the developmental loss currently estimated to affect more than 200 million children under 5 years of age in developing countries, by promoting child development and preventing or ameliorating developmental loss. The most effective interventions are comprehensive programmes for younger and disadvantaged children and families that are of adequate duration, intensity, quality, and are integrated with health and nutrition services. Providing services directly to children and including an active parenting and skill-building component is a more effective strategy than providing information alone.

The papers in this series show that early interventions promote child development and prevent or ameliorate developmental loss. Despite the strength of the findings and the evidence for the effectiveness of investing in child development early in life, the response, particularly in the poorest countries, has been slow. Children's rights are threatened by the failure of countries to develop their human capital, resulting from the lack of attention to early development. Interventions to promote early child development are cost-effective investments to ensure that children are prepared for educational and economic opportunities, thereby reducing disparities and achieving the Millennium Development Goals of reducing poverty and hunger and ensuring primary school completion for girls and boys. Countries can make a commitment to the future by investing in early child development programmes that reach all young, disadvantaged children through comprehensive child development programmes of quality and by developing the financing and policy mechanisms for sustainability.

**Contributors**

P L Engle and M M Black are the lead authors and are responsible for the overall manuscript. The other authors (J R Behrman, M Cabral de Mello, P J Gertler, L Kapiriri, R Martorell, and M E Young) contributed to various sections of the manuscript. All authors, including the members of the International Child Development Steering Group, revised and edited the entire manuscript.

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**Conflict of interest statement**

We declare that we have no conflict of interest.

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#### References

- 1 Grantham-McGregor S, Cheung Y, Cueto S, Glewwe P, Richter L, Strupp B. Developmental potential in the first 5 years for children in developing countries. *Lancet* 2007; **369**: 60–70
- 2 Walker S, Wachs T, Meeks Gardner J, et al. Child development: risk factors for adverse outcomes in developing countries. *Lancet* 2007; **369**: 145–57
- 3 Engle PL, Bentley M, Pelto G. The role of care in nutrition programmes: current research and a research agenda. *Proc Nutr Soc* 2000; **59**: 25–35.
- 4 Malekpour M. Low birth-weight infants and the importance of early intervention: enhancing mother-infant interactions. A literature review. *Br J Dev Disab* 2004; **50**: 78–88.
- 5 Kohli T. Impact of home-centre based training programme in reducing developmental deficiencies of disadvantaged children. *Indian J Disab Rehab* 1990; **4**: 65–74.
- 6 Nair MK, Radhakrishnan SR. Early childhood development in deprived urban settlements. *Indian Pediatr* 2004; **41**: 227–37.
- 7 Phatak P. Early stimulation of infants with risks for development. *Psychol Studies* 2000; **45**: 83–86.
- 8 Panthuraamphorn C, Dookchitra D, Sanmaneechai M. Environmental influences on human brain growth and development. *J Prenat Perinat Psychol Health* 1998; **12**: 163–74.
- 9 Global Monitoring Report Team. *EFA Global monitoring report 2005 Education for all: the Quality Imperative*. Paris, France: UNESCO, 2004.
- 10 UNICEF. 2005 Global thematic report: integrated early child development. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2006).
- 11 Gillespie S, Allen L. What works and what really works? A review of the efficacy and effectiveness of nutrition interventions. *Public Health Nutrition* 2002; **5**: 513–14.
- 12 Schroeder D, Martorell R, Rivera J, Ruel M, Habicht J. Age differences in the impact of nutritional supplementation on growth. *J Nutr* 1995; **125** (4 suppl): 1051S–59S.
- 13 Pollitt E, Gorman KS, Engle PL, Martorell R, Rivera J. Early supplementary feeding and cognition: effects over two decades. *Monogr Soc Res Child Dev* 1993; **58**: 1–99.
- 14 Behrman J, Cheng Y, Todd P. Evaluating preschool programs when length of exposure to the program varies: A nonparametric approach. *Rev Econ Stats* 2004; **86**: 108–32.
- 15 Li H, Barnhart HX, Stein AD, Martorell R. Effects of early childhood supplementation on the educational achievement of women. *Pediatr* 2003; **112**: 1156–62.
- 16 Dewey K, Cohen R, Berown K, Rivera L. Effects of exclusive breastfeeding for four versus six months on maternal nutritional status and infant motor development: results of two randomized trials in Honduras. *J Nutr* 2001; **131**: 262–67.
- 17 Maluccio J, Hoddinott J, Behrman J, Martorell R, Quisumbing A, Stein A. The impact of an experimental nutritional intervention in childhood on education among Guatemalan adults. Food and Nutrition Division Discussion Paper 207, June, 2006, International Food Policy Research Institute, Washington DC. <http://www.ifpri.org/divs/fcnd/dp/papers/fcndp207.pdf> (accessed Jan 8, 2007).
- 18 Gertler P, Fernald L. The medium term impact of Oportunidades on child growth and development in rural areas of Mexico. Cuernavaca, Mexico: Instituto Nacional de Salud Publica, 2004.
- 19 Behrman JR, Hoddinott J. Programme evaluation with unobserved heterogeneity and selective implementation: The Mexican PROGRESA impact on child nutrition. *Oxf Bull Econ Stats* 2005; **67**: 547–69.
- 20 Hoddinott J, Skoufias E. The impact of PROGRESA on food consumption. *Econ Devel Cult Change* 2004; **53**: 37–61.
- 21 Morris SS, Olinto P, Flores R, Nilson EA, Figueiro AC. Conditional cash transfers are associated with a small reduction in the rate of weight gain of preschool children in northeast Brazil. *J Nutr* 2004; **134**: 2336–41.
- 22 Lozoff B, Jimenez E, Hagen J, Mollen E, Wolf AW. Poorer behavioral and developmental outcome more than 10 years after treatment for iron deficiency in infancy. *Pediatr* 2000; **105**: E51.
- 23 Zlotkin S, Arthur P, Antwi K, Yeung G. Treatment of anemia with microencapsulated ferrous fumarate plus ascorbic acid supplied as sprinkles to complementary (weaning) foods. *Am J Clin Nutr* 2002; **76**: 691–93.
- 24 Haas J, Beard J, Murray-Kolb L, del Mundo A, Felix A, Gregorio G. Iron-biofortified rice improves the iron stores of nonanemic Filipino women. *J Nutr* 2005; **135**: 2823–30.
- 25 Manary MJ, Krebs NF, Gibson RS, Broadhead RL, Hambidge KM. Community-based dietary phytate reduction and its effect on iron status in Malawian children. *Ann Trop Paediatr* 2002; **22**: 133–36.
- 26 Mehansho H. Iron fortification technology development: new approaches. *J Nutr* 2006; **136**: 1059–63.
- 27 Zlotkin SH, Christofides AL, Hyder SM, Schauer CS, Tondeur MC, Sharieff W. Controlling iron deficiency anemia through the use of home-fortified complementary foods. *Indian J Pediatr* 2004; **71**: 1015–19.
- 28 Faber M, Kvalsvig JD, Lombard CJ, Benade AJ. Effect of a fortified maize-meal porridge on anemia, micronutrient status, and motor development of infants. *Am J Clin Nutr* 2005; **82**: 1032–39.
- 29 Dewey KG, Domellof M, Cohen RJ, Landa RL, Hernell O, Lonnerdal B. Iron supplementation affects growth and morbidity of breast-fed infants: results of a randomized trial in Sweden and Honduras. *J Nutr* 2002; **132**: 3249–55.
- 30 Majumdar I, Paul P, Talib V, Ranga S. The effect of iron therapy on the growth of iron-replete and iron-deplete children. *J Trop Pediatr* 2003; **49**: 84–88.
- 31 Sazawal S, Black RE, Ramsan M, et al. Effects of routine prophylactic supplementation with iron and folic acid on admission to hospital and mortality in preschool children in a high malaria transmission setting: community-based, randomised, placebo-controlled trial. *Lancet* 2006; **367**: 133–43.
- 32 Young M. *From early child development to human development*. World Bank Publications, 2002.
- 33 Landry SH, Smith KE, Swank PR. Responsive parenting: Establishing early foundations for social, communication, and independent problem-solving skills. *Developmental Psychology* 2006; **42**: 627–42.
- 34 Heckman JJ. Skill formation and the economics of investing in disadvantaged children. *Science* 2006; **312**: 1900–02.
- 35 Berlinski S, Galiani S, Gertler P. *The effect of pre-primary education on primary school performance*. London, Buenos Aires, Washington DC: University College London, Institute for Fiscal Studies, Universidad de San Andres and World Bank, 2006.
- 36 Gunnar MR, Morison SJ, Chisholm K, Schuder M. Salivary cortisol levels in children adopted from Romanian orphanages. *Dev Psychopathol* 2001; **13**: 611–28.
- 37 Noble KG, Tottenham N, Casey BJ. Neuroscience perspectives on disparities in school readiness and cognitive achievement. *Future Child* 2005; **15**: 71–89.
- 38 Parker S, Nelson C. An event-related potential study of the impact of institutional rearing on face recognition. *Dev Psychopathol* 2005; **17**: 621–39.
- 39 Als H, Duffy FH, McAnulty GB, et al. Early experience alters brain function and structure. *Pediatr* 2004; **113**: 846–57.
- 40 Winick M, Meyer K, Harris R. Malnutrition and environmental enrichment by early adoption. *Science* 1975; **190**: 1173–75.
- 41 Lien N, Meyer K, Winick M. Early malnutrition and “late” adoption: a study of their effects on the development of Korean orphans adopted into American families. *Am J Clin Nutr* 1977; **30**: 1734–39.
- 42 Rutter M, O’Connor TG. Are there biological programming effects for psychological development? Findings from a study of Romanian adoptees. *Dev Psychol* 2004; **40**: 81–94.
- 43 Currie J. Early childhood intervention programs: what do we know? *J Econ Perspec* 2001; **15**: 213–38.
- 44 Currie J, Thomas D. Early test scores, socioeconomic status, school quality and future outcomes. *Res Labor Econ* 2001; **20**: 103–32.
- 45 Karoly L, Kilburn M, Canon. *Early childhood interventions*. Santa Monica, CA: Rand Corporation, 2005.
- 46 Karoly L, Greenwood P, Everingham S, et al. Investing in our children: what we know and don’t know about the costs and benefits of early childhood interventions. Santa Monica, CA: Rand Corporation, 1998.
- 47 McCormick MC, Brooks-Gunn J, Buka SL, et al. Early intervention in low birth weight premature infants: results at 18 years of age for the infant health and development program. *Pediatr* 2006; **117**: 771–80.



- 48 Mustard J. The early years study: reversing the brain drain. Toronto: Canada Ontario Children's Secretariat 1999. 1–107.
- 49 Love JM, Kisker EE, Ross C, et al. The effectiveness of early head start for 3-year-old children and their parents: lessons for policy and programs. *Dev Psychol* 2005; **41**: 885–901.
- 50 Sweet MA, Appelbaum MI. Is home visiting an effective strategy? A meta-analytic review of home visiting programs for families with young children. *Child Dev* 2004; **75**: 1435–56.
- 51 Myers R. The twelve who survive. Routledge: London and New York, 1992.
- 52 Jaramillo A, Tietjen K. Early childhood development in Africa: Can we do more or less? A look at the impact and implications of preschools in Cape Verde and Guinea. Washington, DC: World Bank, 2002.
- 53 Aboud FE. Evaluation of an early childhood preschool programme in rural Bangladesh. *Early Childhood Res Q* 2006; **21**: 46–60.
- 54 Save the Children. Early childhood care and development: a positive impact, Myanmar. Save the Children Myanmar Field Office, 2004. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 55 Save the Children. What's the difference? The impact of early childhood development programmes. A study from Nepal of the effects for children, their families and communities. Kathmandu, Nepal, 2003. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 56 Watanabe K, Flores R, Fujiwara J, Tran LTH. Early childhood development interventions and cognitive development of young children in rural Vietnam. *J Nutr* 2005; **135**: 1918–25.
- 57 McKay H, Sinisterra L, McKay A, Gomez H, Lloreda P. Improving cognitive ability in chronically deprived children. *Science* 1978; **200**: 270–78.
- 58 Pollitt E, Escamilla R. Developmental timing as moderator in the rehabilitation of malnourished children: The Cali Study. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 59 Powell C, Baker-Henningham H, Walker S, Gernay J, Grantham-McGregor S. Feasibility of integrating early stimulation into primary care for undernourished Jamaican children: cluster randomised controlled trial. *BMJ* 2004; **329**: 89.
- 60 Powell C. An evaluation of the roving caregivers programme of the rural family support organization, May Pen. Clarendon, Jamaica. UNICEF, 2004. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 61 Waber DP, Vuori-Christiansen L, Ortiz N, et al. Nutritional supplementation, maternal education, and cognitive development of infants at risk of malnutrition. *Am J Clin Nutr* 1981; **34** (suppl 4): 807–13.
- 62 Super CM, Herrera MG, Mora JO. Long-term effects of food supplementation and psychosocial intervention on the physical growth of Colombian infants at risk of malnutrition. *Child Dev* 1990; **61**: 29–49.
- 63 Morenza L, Arrazola O, Seleme I, Martinez F. Evaluacion Proyecto Kallpa Wawa. Santa Cruz, Bolivia, 2005: 1–130.
- 64 Kagitcibasi C, Sunar D, Bekman S. Long-term effects of early intervention: Turkish low-income mothers and children. *J Appl Dev Psychol* 2001; **22**: 333–61.
- 65 Aboud F. Evaluation of a parenting programme in rural Bangladesh. *J Health Popul Nutr* (in press).
- 66 Rao N. Children's rights to survival, development, and early education in India: the critical role of the integrated child development services programme. *Int J Early Childhood* 2005; **37**: 15–31.
- 67 Rao N, Sharma A. Early childhood services in India: Challenges and prospects for their development. In: Chan LKS, Mellor E, eds. International developments in early childhood services New York: Peter Lang, 2002: 97–117.
- 68 NIPCCD. National evaluation of ICDS. New Delhi 1992.
- 69 Vazir S, Kashinath K. Influence of the ICDS on psychosocial development of rural children in Southern India. *J Indian Acad Appl Psychol* 1999; **25**: 11–24.
- 70 World Bank. India: challenges of development. Overview of sectoral assistance evaluations. Washington DC, 2002.
- 71 Rao N, Sharma A. The impact of the integrated child development services program on the development of young children in India, 2004. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 72 Cueto S, Diaz J. Impacto de la educacion inicial en el rendimiento en primer grado de primaria en escuelas publicas urbanas de Lima. *Revista de Psicologia* 1999; **17**: 74–91.
- 73 Alderman H, Engle P. The synergy of nutrition and ECD interventions in Africa. Africa: World Bank (in press).
- 74 Armecin G, Behrman J, Duazo P, et al. Early childhood development through integrated programmes: evidence from the Philippines. Cebu City, New York, Philadelphia and Washington: Universities of Pennsylvania, and San Carlos, Population Council and World Bank, 2006.
- 75 Ghuman S, Behrman J, Gultiano S, King E. Children's nutrition, school quality, and primary school enrollment in the Philippines. Popul Council. New York, NY 2006. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 76 Hamadani J, Huda S, Khatun F, Grantham-McGregor S. Psychosocial stimulation improves the development of undernourished children in rural Bangladesh. *J Nutr* 2006; **136**: 2645–52.
- 77 Brooks-Gunn J, Fuligni A, Berlin L. Early child development in the 21st century: profiles of current research initiatives. In: College T, ed. New York: Columbia University, 2003. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 78 Montie JE, Xang Z, Schweinhart LJ. Preschool experience in 10 countries: cognitive and language performance at age 7. *Early Child Res Q* 2006; **21**: 313–31.
- 79 Network NECCR. Early child care and children's development prior to school entry: results from the NICHD study of early child care. *Am Ed Res J* 2002; **39**: 133–64.
- 80 Marshall N. The quality of early child care and children's development. *Curr Dir Psych Sci* 2004; **13**: 165–68.
- 81 Powell C, Grantham-McGregor S. Home visiting of varying frequency and child development *Pediatr* 1989; **84**: 157–64.
- 82 Grantham-McGregor S. Linear growth retardation and cognition. *Lancet* 2002; **359**: 542.
- 83 Grantham-McGregor SM, Powell CA, Walker SP, Himes JH. Nutritional supplementation, psychosocial stimulation, and mental development of stunted children: the Jamaican Study. *Lancet* 1991; **338**: 1–5.
- 84 Peltó G, Dickin K, Engle P. A critical link: interventions for physical growth and psychological development. Geneva: Dept of Child and Adolescent Health and Development, WHO, 1999.
- 85 Engle PL. Early child development: Should we have global indicators? In: Kolsteren P, Hoeree T, Perez-Cueto A, eds. Promoting growth and development of under fives. Proceedings of the International Colloquium. ITG Press, Antwerp, 2001: 23–39.
- 86 Rahman A, Iqbal Z, Harrington R. Life events, social support and depression in childbirth: perspectives from a rural community in the developing world. *Psychol Med* 2003; **33**: 1161–67.
- 87 Wolf A, De Andraca I, Lozoff B. Maternal depression in three Latin American samples. *Soc Psych Psychiatr Epidemiol* 2002; **37**: 169–76.
- 88 Cooper P, Tomlinson M, Swartz L, Woolgar M, Murray L. Post-Partum depression and the mother-infant relationship in a South African peri-urban settlement. *Br J Psychiatry* 1999: 554–58.
- 89 Murray L, Cooper PJ. Effects of postnatal depression on infant development. *Arch Dis Child* 1997; **77**: 99–101.
- 90 Araya R, Rojas G, Fritsch R, Gaete J, Rojas M, Simon G. Treating depression in primary care in low-income women in Santiago, Chile: a randomised controlled trial. *Lancet* 2003; **361**: 995–1000.
- 91 Baker-Henningham H, Powell C, Walker S, Grantham-McGregor S. The effect of early stimulation on maternal depression: a cluster randomised controlled trial. *Arch Dis Child* 2005; **90**: 1230–34.
- 92 Bolton P, Bass J, Neugebauer R, et al. Group interpersonal psychotherapy for depression in rural Uganda: a randomized controlled trial. *JAMA* 2003; **289**: 3117–24.
- 93 Chen C, Tseng Y, Chou F, Wang S. Effects of support group intervention in postnatally distressed women. A controlled study in Taiwan. *J Psychosom Res* 2000; **49**: 395–99.
- 94 Armstrong KL, Fraser JA, Dadds MR, Morris J. A randomized, controlled trial of nurse home visiting to vulnerable families with newborns. *J Pediatr Child Health* 1999; **35**: 237–44.
- 95 Armstrong KL, Fraser JA, Dadds MR, Morris J. Promoting secure attachment, maternal mood and child health in a vulnerable population: a randomized controlled trial. *J Pediatr Child Health* 2000; **36**: 555–62.



- 96 Hiscock H, Wake M. Randomised controlled trial of behavioural infant sleep intervention to improve infant sleep and maternal mood. *BMJ* 2002; **324**: 1062–65.
- 97 UNICEF. Children and violence. UNICEF: International child development centre. Florence, Italy: Innocenti Digest 1997, No 2.
- 98 Bross D, Miyoshi T, Miyoshi P, Krugman R. World perspectives on child abuse: The fourth international resource book. Oxford, UK: Elsevier Science, 2000.
- 99 Olds D, Henderson CR Jr, Cole R, et al. Long-term effects of nurse home visitation on children's criminal and antisocial behavior: 15-year follow-up of a randomized controlled trial. *JAMA* 1998; **280**: 1238–44.
- 100 MacMillan HL, Thomas BH, Jamieson E, et al. Effectiveness of home visitation by public-health nurses in prevention of the recurrence of child physical abuse and neglect: a randomised controlled trial. *Lancet* 2005; **365**: 1786–93.
- 101 UNICEF, UNAIDS, USAID. Children on the brink. Washington DC: USAID 2004.
- 102 Engle PL, Dunkelberg E. ECD and HIV/AIDS: the newest programming and policy challenge. In: Evans J, Pence A, Garcia M, eds. ECD in Africa. Washington: World Bank (in press).
- 103 Landrigan P. Children as a vulnerable population. *Int J Occup Med Environ Health* 2004; **17**: 175–77.
- 104 Lanphear B, Hornung R, Khoury J, et al. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. *Environ Health Perspect* 2005; **113**: 894–99.
- 105 Rogan WJ, Dietrich KN, Ware JH, et al. The effect of chelation therapy with succimer on neuropsychological development in children exposed to lead. *N Engl J Med* 2001; **344**: 1421–26.
- 106 World Malaria Report (2005). Roll Back Malaria, WHO and UNICEF. <http://www.rollbackmalaria.org> (accessed Jan 8, 2007).
- 107 Holding PA, Kitsao-Wekulo PK. Describing the burden of malaria on child development: what should we be measuring and how should we be measuring it? *Am J Trop Med Hyg* 2004; **71**: 71–79.
- 108 Jukes M. The long-term impact of preschool health and nutrition on education. *Food Nutr Bull* 2005; **26** (2 suppl 2): S193–201.
- 109 UNAIDS. 2006 report on the global AIDS epidemic. A UNAIDS 10th anniversary special edition. UNAIDS/06.20E.
- 110 EFA Global Monitoring Report Team. EFA Global Monitoring Report 2007. Strong foundations: early childhood care and education. Paris: UNESCO, 2006.
- 111 Jaramillo A, Mingat A. Early childhood care and education in Sub-Saharan Africa: what would it take to meet the millennium development goals? Africa Region: World Bank, 2003.
- 112 Heaver R. Strengthening country commitment to human development: lessons from nutrition. Washington DC: The World Bank, 2005.
- 113 Doryan EA, Guatam KC, Foege WH. The Political Challenge: commitment and cooperation In: Young M, ed. From early child development to human development. Washington DC: World Bank, 2002: 375–91.
- 114 Knowles J, James C, Behrman J. Economic returns to investing in youth, the transition to adulthood in developing countries: selected studies. Washington DC: National Academy of Science-National Research Council, 2005.
- 115 Behrman J, Alderman H, Hodinott J. Hunger and malnutrition. In: Lomborg B, ed. Global crisis, global solutions. Cambridge, UK: Cambridge University Press, 2004: 363–420.
- 116 Magnuson K, Waldfogel J. Early childhood care and education: effects on ethnic and racial gaps in school readiness. *Future Child* 2005; **16**: 170–96.
- 117 Victora M, Victora C, Barros F. Cross-cultural differences in development rates: A comparison between British and Brazilian children. *Care Health Develop* 1990; **16**: 151–64.
- 118 Martorell R, Behrman J, Flores R, Stein A. Rationale for a follow-up focusing on economic productivity. *Food Nutr Bull* 2005; **26**: S5–14.
- 119 Psacharopoulos G, Parrinos HA. Indigenous people and poverty in Latin America. Washington DC: World Bank, 1994.
- 120 Hall D. Health for all children. Report of the third joint working party on child health surveillance, 3rd edn. Oxford: Oxford University Press, 1996.
- 121 Colletta N, Satoto, Sockaling-Ham S, Zeitlan M. The child development milestone chart: An approach to low cost programming in Indonesia. *Early Child Dev Care* 1993; **96**: 161–71.
- 122 Dos Santos I, Goncalves H, Halpern R, Victora C. Pilot test of the child development of the IMCI "counsel of the mother" module. Study results and recommendations. Pelotas, Brazil, 1999.
- 123 Chopra M. Assessment of participants on the care for development IMCI training course. University of the West Cape, South Africa, 2001.
- 124 Ertem I, Atay G, Bingoler E, Dogan DG, Bayhan A, Sarica D. Promoting child development at sick child visits: A controlled trial to test the effect of the intervention on the home environment of young children. *Pediatrics* 2006; **118**: e124–131.
- 125 Tchibindat F, Martin-Prevel Y, Kolsteren P, Maire B, Delpuech F. Bringing together viewpoints of mothers and health workers to enhance monitoring and promotion of growth and development of children: a case study from the Republic of Congo. *J Health Popul Nutr* 2004; **22**: 59–67.
- 126 Minkovitz CS, Hughart N, Strobino D, et al. A practice-based intervention to enhance quality of care in the first 3 years of life: the healthy steps for young children program. *JAMA* 2003; **290**: 3081–91.
- 127 UNICEF. Annual report. Turkey: UNICEF, 2005. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 128 MINED, UNICEF, CELEP. Educate your child: The Cuban experience in integrated early child care. Cuba: UNICEF. [http://www.unicef.org/earlychildhood/index\\_resources.html](http://www.unicef.org/earlychildhood/index_resources.html) (accessed Jan 8, 2007).
- 129 Ghuman S, Behrman JR, Borja JB, Gultiano S, King EM. Family background, service providers, and early childhood development in the Philippines: Proxies and interactions. *Econ Dev Cultural Change* 2005; **54**: 129–64.
- 130 World Bank. Repositioning Nutrition as Central to Development. Washington DC: World Bank, 2006.
- 131 Global Monitoring Report Team. Global Monitoring Report 2006. Literacy for life. Paris: UNESCO, 2005.