Contents

Special Issue on Early Childhood Development

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Introductory statement

Although in recent years there has been a dramatic decrease in child mortality in low-income countries, many surviving children continue to have poor psychosocial and cognitive development. There are extremely limited data on the size of the problem, but it is likely that millions of young children are failing to reach their potential in development. They subsequently are unable to benefit fully from schooling and to become productive citizens. This failure has implications both for the individuals and for national development.

A workshop held in 1991 in Jamaica [1] concluded that there was substantial evidence that poor health and nutrition detrimentally affected children's development. However, good health and nutrition alone were insufficient to promote optimal child development, and quality of the psychsocial environment was also important. It was the need to look at the children's development in a holistic way and take an integrated approach to child services that stimulated the subcommittee on Nutrition and Mental Health of the Institute of Child Health, London University, and UNICEF, New York to plan another workshop. The aim of the event was to sensitize senior managers and policy makers to the need for development of programmes tht integrated child development, health, and nutrition activities.

The resulting workshop was held at Wye College, Kent, in the United Kingdom, on April 4–8, 1998, and was attended by researchers active in the field of nutrition and child development, UNICEF programme officers from regional and country offices, and representatives from other international agencies and non-governmental organizations. The papers in this issue were presented at the workshop. These papers review the nature of child development and factors that affect it, including health, nutrition, and the environment. The problems in measuring child development and identifying at-risk children are discussed. Case studies of integrated programmes and studies from developing countries are also included. Finally, the economic implications of such programmes are considered.

Following the Wye meeting, a small group of researchers met at UNICEF's request in New York and wrote a short summary of the scientific evidence on the nature and determinants of child development and their implications for interventions. This summary can be found in this issue after this introductory statement.

It is hoped that this issue will contribute to further work on designing and implementing integrated programmes for the promotion of child development in developing countries.

Several people contributed to the planning of the meetings, including David Alnwick, Roger Shrimpton, Ludmila Lhotska, and Marjorie Newman-Williams from UNICEF, and Andrew Tomkins from the Centre for International Child Health, University College, London. Ernesto Pollitt from the University of California, Davis, was particularly helpful in planning the scientific programme. The meeting was funded by UNICEF with a contribution from the International Union of Nutritional Sciences.

Sally Grantham-McGregor
Editor

Reference

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Summary of the scientific evidence on the nature and determinants of child development and their implications for programmatic interventions with young children

Working group: Sally M. Grantham-McGregor (Chairman), Ernesto Pollitt, Theodore D. Wachs, Samuel J. Meisels, and Keith G. Scott

Introduction

At the request of UNICEF, a summary was prepared of the scientific evidence on the nature and determinants of child development and their implications for programmatic interventions with young children. This summary is given below and reflects the views of the authors. We have included well-established points that we think are important as well as adding information that is new both theoretically and empirically.

The size of the problem

No figures exist on the number of children with developmental delays (lags in mental, motor, social, and emotional development compared with reference criteria) as a result of poor health and nutrition and poor environments. However, 39% of children under five years of age in low-income countries are growth retarded. Growth retardation is a marker for both disadvantaged environments and developmental risk, and hence it is likely that at least this proportion of children will have poor developmental outcomes. The size of the problem is obviously enormous, but more data are urgently required.

The nature of early childhood development

Child development is multidimensional. These dimensions, which are interdependent, include social, emotional, cognitive, and motor performance, as well as patterns of behaviour and health and nutritional status.

The optimal development of children refers to their ability to acquire culturally relevant skills and behaviours that allow them to function effectively in their current context as well as adapt successfully when their current context changes.

Development is multidetermined, varying as a function of nutritional and biomedical status, genetic inheritance, and social and cultural context.

Undernutrition, poor health, and non-optimal caregiving affect a broad range of outcomes, including cognitive, motor, psychosocial, and affective development. For example, children are naturally motivated to explore and to attempt to master their environment. Undernutrition, poor health, and non-optimal caregiving tend to reduce these motivations, which may inhibit development.

The early years of life are essential as the foundation for later development. However, the impact of past and concurrent undernutrition, poor health, and non-optimal caregiving is not confined to these years. Children's development is essentially cumulative in nature.

Some developmental trajectories can be made better or worse as a function of influences encountered past the early years.

Determinants of child development

The number of risk factors has a cumulative or interactive impact on child development.

The effect of risk factors varies with the age of the child, and their effects, or the results of interventions, may have delayed and not immediate impact.

When resources are limited, the highest-risk individuals in a population should be targeted for intervention. However, it is important to realize that the highest-risk individuals in a population may occur relatively infrequently. Focusing solely on these individuals may not have a large impact on the community. Further, some communities may have such a high prevalence of multiple risk factors (e.g., orphaned children, famine, widespread maternal illiteracy) that the whole population should be targeted. Risk can be assessed at both the individual and the community or ecological level (table 1).

It is important to understand the prevalence of risk and protective factors in a population in order to plan effective resource utilization. Thus, the first step in planning any programme of services should be to conduct

TABLE 1. Examples of community or ecological risk factors and individual risk factors

Community or ecological	Individual
Poor sanitation Famine Endemic violence Endemic poverty Lack of accessible services: pre-schools, schools, libraries, health services AIDS epidemic Lack of commitment to child development Population traditionally discriminates against refugees	Repeated infections Undernutrition Abuse and neglect Very low family income Low birthweight Unstable caretaking Low maternal education Large family size Short spacing between births Orphans Young sibling caregiver Low levels of developmentally enhancing parenting practices Developmental disabilities or severe physical injury.

an assessment of the prevalence of protective and risk factors.

Programmatic actions

Programme characteristics and content

The timing, duration, and breadth of an intervention modify its effect. Generally, the earlier and the longer the interventions, the larger the developmental benefits. This is true for both the initial and the later size of the effect as well as for its duration. If timing and duration are held constant, multifocal interventions (e.g., health, nutrition, and optimal child care) will yield larger and more sustained benefits than unifocal interventions (e.g., supplementary feeding). This statement is particularly valid when the interventions begin past the child's postnatal growth spurt of the brain. Short-term and unifocal interventions that begin during the later pre-school period will do little to repair the damage from a history of malnutrition, poor health, and less than optimal caretaking. The merit of late interventions, even during the school years, is to prevent or remedy the adverse effects of concurrent health and nutrition problems that often interfere with learning and performance.

The more frequent the contact and the more intense the intervention, the more likely the children will benefit.

Ideally, there should be an integration of maternal and child health services and early childhood development programmes.

Interventions may not benefit all domains of development.

As programmes are implemented in communities, they should be monitored carefully. Before going to scale, these programmes should be expanded in a staged manner, and it is critical to take into account culture, ecology, language, and demographic factors, among others, and to devise interventions that reflect these variables. Rather than simply adopting already existing approaches, there is an urgent need for evaluations of varied approaches to intervention and methods of delivering these services.

Recommendations of programme type (e.g., home-based, centre-based, or a combination) are dependent on the availability of several critical variables, such as responsible caregivers in the home, safety of the home, quality of caregiving in the centre, and stability, support, and training of caregivers in the centre. In general, centre-based programmes are not recommended for children from birth to three years of age except when the child is an orphan, the mother is in full-time employment, there is no suitable adult caregiver in the home, or there is extreme family disruption or child abuse and neglect.

Actions taken to facilitate child development in addition to nutrition and health interventions should contain at a minimum the following: age-appropriate responses of adults; stable relationships with adult caregivers; supporting the child's development of language through labeling, encouraging the child's vocalizations, expanding, explaining, and two-way conversations; providing an environment for the child to explore safely; providing interesting play materials and books that reflect the child's everyday experiences; warm, affectionate behaviour and positive affect; sensitive and responsive behaviour to the child's signals; play activities with peers and adults.

Many children with disabilities can respond productively to the same developmental interventions as children without disabilities and should be included in such

intervention efforts. Children who have been injured as a result of war are also included among those with disabilities.

Parents

Actions should be taken to strengthen the parent's or caregiver's sense of effectiveness as a promoter of child development.

Interventions with parental and non-parental caregivers are needed to help them use developmental materials appropriately, to provide challenging activities at the appropriate level of difficulty in which the child can be successful, to become increasingly involved with their children, to respond verbally to the child's vocalizations, to be responsive to the child's emotional needs, and to avoid physical punishment as a standard child-rearing practice.

Parents or caregivers should be taught how to integrate child development activities into activities of daily living as much as possible. Involving other family members in these activities has the potential to increase their impact.

Training

Another critical element of programme expansion is systematic and continuous training and supervision for both professional and paraprofessional staff. The success of the programme is highly dependent on the preparation and supervision of staff at all levels. Paraprofessionals need to be given field-based training to be closely affiliated with the communities in which they work, and should have credibility with the families in their communities.

Health and medical professionals should receive in-service training to enable them to appreciate and provide necessary support for paraprofessionals and professionals working in child development activities.

Evaluation and assessment

Larger-scale studies of effectiveness with careful evaluation of process and impact need to be conducted.

All programme evaluations should begin by specifying programme objectives and documenting that programme activities are delivered.

Adaptation of existing direct (developmental scales and cognitive tests) and indirect (e. g., parent's report) assessments of child development in children 18 months to 6 years of age (focusing on psychomotor, gross motor, reasoning, language, and adaptive tasks, including social and emotional behaviour) can be used to evaluate programme success when the programmes are intended to promote and enhance these outcomes.

There is need for an investment of resources to develop new instruments and improve existing instruments intended to assess children's cognitive and non-cognitive development below the age of three years. This is particularly true for large-scale evaluations of programme interventions. Further research on the use of parental reports and other approaches, including brief observations, is needed.

Process measures of developmental interventions are critical for continuous improvement of programmes and for providing assessment of the strengths and weaknesses of programme practices (e.g., children's and parent's responsiveness to the intervention, children's level of development and change over time, parental level of participation, and factors that inhibit participation). Such process measures can also serve the function of teaching parents and other caregivers about their children and providing them with information about how to modify their behaviour with their children. Simple checklists, combined with training and supervision, can be used for this purpose.

The nature and nurture of child development

Theodore D. Wachs

Abstract

Although the reduction of child morbidity and the promotion of physical growth are important and necessary aspects of child development, these criteria by themselves do not define the adequacy of children's development. There are also behavioural-developmental criteria that emphasize the promotion of competence. The competent individual is one who can effectively adapt to and interact with his or her environment. Traits that define individual competence fall into five domains: cognitive skills, temperament/personality, motivation, self-perceptions, and interpersonal style. These domains are not completely independent, and there is at least partial overlap. The expression of individual differences in competence is partially moderated by context. Further, not all children achieve competence. Over time some children fall further and further behind their peers in their developmental course. In understanding what biological and psychosocial factors influence the development of individual differences in competence, four principles are critical.

First, most aspects of individual competence are multidetermined. This means that interventions designed to facilitate development must be multifocal in nature, integrating influences from different domains. Second, influences upon children's development tend to be specific in nature. This emphasizes the importance of targeting specific interventions to specific outcomes. Third, individual developmental influences rarely operate in isolation from each other. Developmental risk factors tend to cluster together, as do developmentally protective influences. The extent of the impact of a given developmental risk factor will depend, in part, on the degree to which this risk factor covaries with other risk factors. Fourth, developmental risk and protective factors operate across time. Early exposure to developmental risks may increase the individual's susceptibility to later risk factors (sensitizing) or may limit the degree to which the individual can profit from later exposure to protective factors such as intervention (blunting). Early exposure to developmentally protective factors may attenuate the impact of later exposure to developmental risk factors (steeling).

Principles underlying the nature and nurture of individual competence emphasize the need to use an IT-AT intervention strategy (Integrate Target Across Time). This means the need to integrate multi-domain interventions, target our intervention strategies to different contexts, risk conditions, and outcomes, and provide for recurring interventions across time to maximize the chances of long-term gains in individual competence.

Introduction

When we speak of facilitating child development, particularly in less developed countries, our focus, typically, is on issues of health and physical growth [1]. Reducing child morbidity and promoting physical growth are important and necessary aspects of child development, but these criteria by themselves do not define the adequacy of children's development. In addition to physical criteria there are also behavioural–developmental criteria that emphasize the promotion of competence. Although a standard definition of competence remains elusive, there appears to be a general consensus among developmental researchers that the competent individual is one who can effectively adapt to and interact with his or her environment. Criteria for defining effective adaptation include the ability to meet major developmental goals viewed as appropriate for a given individual at a given age in a given context, as well as coping with environmental challenges and stresses [2, 3].

The specific adaptations and interactions that define individual competence are context-specific. What defines a competent pre-school child in rural Kenya (collecting firewood, caring for younger siblings) will be much different from what defines competence in a pre-school child in the United States (development of symbolic play skills) [4]. Similarly, the criteria that de-

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fine competence in a traditional culture may be less appropriate in a culture undergoing major transitions, such as industrialization or urbanization [1, 5]. For example, an important yet little-known study by Albizu-Miranda et al. (cited in Heber and Dever [6]) showed that the ability of individuals with below-average intelligence to succeed economically dropped radically as the level of urbanization-industrialization of communities increased.

Although the question of whether or not an individual is regarded as competent is context-specific, there also appear to be dimensions of individual competence that cut across different contextual settings. Evidence for this assumption is seen in a study in which clinicians in eight less developed countries in Asia, Africa, and the Caribbean were asked to define the criteria they would use to judge a child as being mentally retarded [7]. The same five behavioural dimensions were used by clinicians across all cultures, although there were cross-cultural differences in the degree to which they rated the importance of each of them. If there are common behavioural–developmental dimensions underlying individual competence, what are these dimensions? Typically we have defined competence primarily in terms of intelligence. Although intelligence is a critical component of competence, other behavioural domains may be equally important [8]. To understand what are the critical domains underlying competence in children, I will turn to studies of "resilience" [9] or "positive deviance" [10]. Both of these terms refer to children born into situations involving multiple cumulative biological (e.g., malnutrition, chronic morbidity) and psychosocial (e.g., poverty, lack of environmental stimulation, physical abuse)risks, who nonetheless manage to function at a level well above what we would expect given their background. As described by Werner and Smith, these are children who, in spite of the worst that life could throw at them, developed into adults who "worked well, played well, loved well, and expected well" [11]. Many of the factors that make children resilient involve aspects of the biological and psychosocial context (e.g., greater intake of foods of animal origin, smaller family size with longer birth spacing, secure attachment to caregivers, adults who are available to the child in times of crisis or stress [10, 11]). However, it is also clear that resilient children are likely to possess a set of individual characteristics that allow them to receive a major share of available physical and psychosocial resources, even in environments where such resources are, for the most part, lacking [12]. I would argue that the characteristic traits that produce resilience in children growing up under such extreme conditions are also likely to be the characteristic traits that underlie the development of competence in children living in less extreme situations.

What are the individual traits that underlie competence? As can be seen from table 1, the various traits that define resilience can be said to fall in five domains: cognitive skills, temperament and personality, motivation, self-perception, and interpersonal style. Although they are not listed in table 1, I would also note the importance of physical characteristics. Infants and children judged to be unattractive by their caregivers or peers are more likely to be rejected and receive less support than children judged to be attractive [13–15]. To some extent, competence can also be influenced by other

TABLE 1. Individual traits associated with resilience

Domain	Example
Cognitive skills	Alertness (infancy) Intelligence Communication skills Flexible coping strategies
Temperament/personality	High activity level (infancy) Self-regulation of attention and emotionality Affectionate/sociable Internal locus of control (childhood and adolescence)
Motivation	Need for competence Need for self-reliance (childhood and adolescence) Achievement orientation (childhood and adolescence)
Self-perceptions	Secure attachment (infancy) Sense of self-efficacy (childhood and adolescence) Positive self-concept (childhood and adolescence) Sense of responsibility (adolescence)
Interpersonal style	Ability to use adult as resource Interpersonal sensitivity (adolescence)

Source: refs. 2, 9, 12.

physical characteristics, such as race or sex, although for these traits competence will usually be a function of cultural or contextual bias against individuals of a particular race or sex.

Taken together, the presence of the types of traits shown in table 1 defines competence in children. Children who have a greater range of cognitive skills, who are more flexible in using these skills, who have characteristics that appeal to others in their environment (such as responsiveness to people or social sensitivity), who have a sense of themselves as responsible and able to influence their environment, and who are motivated to achieve in the ways that are valued in their society are those who have a high likelihood of developing competence. To the extent that we promote the development of the contextually appropriate forms of such traits, we promote the development of competence in children. Although attachment is a critical trait underlying resilience, anthropological evidence suggests that in some contexts, particularly those where there is a high infant death rate, attachment as traditionally thought of in Western cultures may not be a necessary criterion for the promotion of competence in those children who survive [16]. Children with the traits listed in table 1 not only are more likely to be defined as competent within a given cultural context but also are more likely to be able to adapt to major contextual changes such as urbanization and industrialization. The goals parents have for their children are often congruent with the traits that characterize resilient children [17].

There is research showing how intelligence develops and differentiates across the life span [18] and how early temperament maps onto later personality dimensions [19]. However, such descriptive information would be relatively limited. Rather than focusing on descriptive changes in the various traits and domains underlying children's competence, I will focus on three underlying principles about the nature and development of competence and then on the more fundamental question of what promotes competence in children.

Competence is partially moderated by context. Specific skills that serve to promote competence in one context may be irrelevant or even detrimental to the development and expression of competence in other contexts. For example, high activity levels, which would be appropriate for children living in nomadic tribes, become highly maladaptive when such children are placed in a school setting [20]. Similarly, the overlapping communication patterns that define the competent Hawaiian child in his or her family are viewed as developmentally inappropriate when such children are faced with the demands of traditional Western schooling [21]. On the other hand, it is important to keep in mind the caveat of Diaz-Guerrero [22] that in traditional societies undergoing modernization, those individuals who achieve most may be those who deviate to some degree from traditionally valued coping skills. Thus, our focus must be on those behaviours within a given domain that allow an individual to adapt to his or her current context, but do not hinder adaptation if the current context changes.

Not all development is progressive. Although we typically think of children's behavioural development as progressive in nature, moving towards higher levels of competence as the child gets older, such progression is not necessarily a given. The psychological analogues to physical growth concepts such as stunting are seen in terms such as cumulative deficit [23, 24] and negative-risk feedback cycles [25, 26]. These terms refer to the fact that some children fall further and further behind their peers in their developmental course, with the likelihood of catching up declining the longer development proceeds. One example of regressive development is seen for children with early-appearing antisocial behaviour patterns who, over time, become locked into progressively wider negative interactions, first with their parents, then with their peers, and finally with school authorities. The end result is a chronic pattern of antisocial behaviour that continues into and through adulthood [27]. Unless there are major contextual changes, such children are essentially locked into negative developmental cycles. However, the likelihood of major contextual changes is often substantially reduced, given that the behaviour of these children acts to close off alternative contextual niches that could serve to redirect their developmental trajectory [28].

Traits defining competence covary. I have defined competence on the basis of individual traits in different domains. This reflects a bias of developmental researchers, who tend to focus on specific areas of development taken in isolation. In reality, the domains that define competence in children rarely fall into such nice neat categories. Rather, many aspects of children's development from supposedly different domains share common elements [1]. Some shared elements may be definitional. For example, definitions of intelligence used in many non-Western countries encompass not only traits typically thought of as intellectual in nature (such as memory or verbal facility), but also traits that are considered interpersonal in nature (such as politeness and respect for elders) [29]. For other traits, covariance is inherent in the nature of the traits themselves. The behavioural characteristics defining self-regulation involve linked contributions from the domains of temperament and cognition [30]. Similarly, the ability to understand the perspective of other individuals involves both social and cognitive components [31], whereas the ability to react empathetically to others involves affectual and cognitive components [32]. Rather than the different domains defining competence having sharply defined boundaries, the concept of "fuzzy" borders may be more applicable [33] when attempting to distinguish between traits from different domains.

Although there is covariance across the different traits

and domains defining competence, such covariance does not mean that differently labeled domains or traits refer to the same thing. Evidence for this is seen in a study of children from high-risk backgrounds who were characterized by teacher reports and school records as being resilient during periods of stress. Although these children were all resilient in some domain of competence, such as intellectual or social skills, only 15% of these children were found to be resilient in more than one domain [34].

The concept of covarying but not isomorphic domains of competence is illustrated in figure 1 using three domains: temperament, cognition, and motivation. Although there is a small degree of overlap among all of these domains (central shaded area) and a larger degree of overlap between any two domains (off-central shaded area), each domain also has its own unique properties that are not shared by the others. The nature of relations among the different domains underlying competence has certain implications for interventions designed to promote competence. For maximum impact we would want to target our interventions at the point where there is a clear intersection of each of the relevant domains. However, such targeting requires a level of measurement accuracy and conceptual knowledge that we simply do not possess at present. Hitting the overlap point is more likely a matter of luck than of design. In practice this means that the impact of specific unidimensional interventions that promote competence in a single domain may not necessarily generalize to other domains of competence.

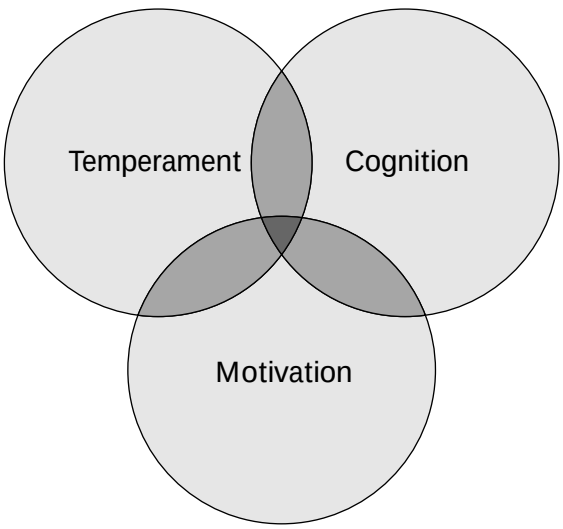

FIG. 1. Covariance among different domains of development

Processes that promote or hinder developmental competence

Rather than discussing the specific contributions of different types of developmental influences, such as nutrition, morbidity, psychosocial environment, or culture, this section will focus on the processes underlying the contributions of these influences to the development of competence, with discussion of four principles: multiple determinants, specificity, covariance, and temporal moderation.

Development is multidetermined

In understanding the effect of specific influences upon individual behavioural–developmental variability, behavioural geneticists emphasize genetic contributions, nutritionists emphasize nutritional contributions, psychologists emphasize environmental contributions, and anthropologists emphasize cultural contributions. The traditional goal within each discipline is to isolate the unique contributions to development of influences from one's chosen field of study. Potentially relevant influences from other fields all too often tend to be regarded as nuisance variables that hinder our ability to isolate the unique contributions of what we are focusing on. However, parsimony notwithstanding, the factors that influence individual developmental variability rarely operate in isolation from each other, and most aspects of individual behavioural development are multidetermined. Many specific individual influences are necessary, but few are sufficient as an explanation.

Let me support this conclusion in several ways. First, let us deal with those cases where intervention based on a single targeted influence can have a major impact upon development. The case of prenatal administration of folate or iodine as a means of preventing neural tube defects [35] or cretinism [36] documents the power of specific single targeted interventions. However, such cases tend to be the exception rather than the rule [37]. For example, although there are many single-gene disorders that can have a major impact upon development, these disorders tend to be relatively rare [38]. Even in a situation where we are dealing with a single influence that has a major impact upon behaviour and development (such as a rare genetic defect), this does not rule out the possibility of important contributions to the development of affected individuals from influences in other domains. For example, research has illustrated the contributions of environmental influences to the development of individuals born with rare sex chromosome anomalies [39] or with rare genetic disorders such as the cri du chat syndrome [40].

The contribution of multiple influences to individual behavioural developmental variability can be illustrated by the nature of genetic contributions to development. As shown in figure 2, the path from genes to outcomes

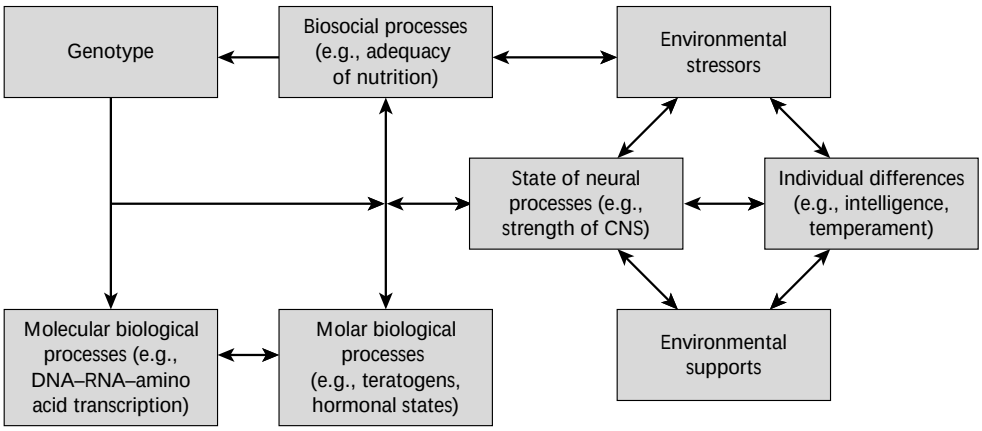

FIG. 2. Pathway from genes to development

is indirect, circuitous, and complex. Genes themselves directly affect only microbiological processes—essentially the transmission of DNA to RNA [41]. Thereafter, we have a complex multilevel pathway, including contributions from both biological variables (e.g., nutrition, teratogens) and environmental stressors and supports. Not only is this pathway complex, but it is also bi-directional. Thus, whether structural genes are actually expressed or not depends on the action of regulatory genes, which are directly sensitive to a variety of non-genetic influences such as hormonal levels or nutritional status [42].

Another example of the role of multiple influences that is of particular relevance to children at risk in both developed and less developed countries is school failure and drop-out rates. [1, 43, 44]. Level of school attendance has been associated with higher cognitive performance in both developed [45] and less developed countries [46]. Level of schooling facilitates cognitive gains associated with nutritional supplementation [47]. Particularly in less developed countries, the level of maternal education is negatively related to frequency of births [48] and is positively related to children's level of physical growth [49], children's survival rate [50], and quality of maternal rearing practices [51].

A summary review of some of the many factors contributing to school failure school drop-out is shown in table 2. It is clear that school failure or drop-out can result from any number of multiple influences combining in any number of ways. All too often, these influences cumulate over time, producing a progressive disengagement from school [43].

Obviously not all of the variables shown in table 2 will be of equal importance in influencing the probability of school failure or school drop-out. However, the lesson that can be drawn from the data shown in table 2 is that when multiple influences are operating, the chances of having a major impact upon school failure or school drop-out, as a function of changing just a single influence, are not particularly high. Indeed, going beyond just school failure, what the evidence consistently indicates is that significantly better prediction of individual behavioural– developmental variability occurs when developmental influences from multiple domains are looked at in combination rather than in isolation [47, 59–64]. The reverse conclusion also holds. If potentially salient influences from domains other than the one we are targeting are not taken account of, the results may well be outcomes that are either non-significant or opposite to what is desired. This is demonstrated most dramatically in a study by Grantham-McGregor and colleagues [65], showing that the impact upon school performance of feeding breakfast to undernourished children varied as a function of school context. As seen in figure 3, in an organized, non-crowded school environment (school A), breakfast feeding was shown to facilitate school performance. In non-organized, chaotic school environments, breakfast feeding either had no effect (schools B and D) or had a potentially detrimental impact (school C), perhaps energizing children to become more reactive to chaos in the classroom.

Specificity

There is increasing evidence that many developmental influences tend to act in a relatively specific fashion, impacting only upon a restricted set of developmental outcomes [66]. In many cases different aspects of development are predicted by entirely different developmental influences. For example, delayed toddler mental development is equally well predicted by a combination of biomedical and environmental risks; delayed toddler motor development is best predicted by biomedical risks; delayed toddler receptive language skills

TABLE 2. Factors influencing school failure and school drop-out

Individual characteristics	Contextual characteristics	School characteristics	Interactive influences
Gender Ethnicity Intellectual level School-related behavioural disorders (e.g., attention deficit disorder–hyperactivity, learning disability) History of school failure Nutritional status Morbidity status Destructive behaviour patterns Adolescent sexual habits Identification with school environment	Family socio-economic status Family educational level Quality of home environment Parental expectations Educational support from peer culture	Educational quality of school environment (e.g., well organized, teacher's time spent teaching, feedback provided to students) School size Educational expectations of school	Culture by gender Culture by ethnicity Fit between characteristics of culture and school environment

Source: refs. 43, 52–58.

are most strongly predicted by environmental risks [67]. Other examples of this phenomenon, which I have called "specificity," are shown in table 3.

The fact that the impact of individual developmental influences tends to be relatively specific means that we cannot assume that a given influence that changes developmental patterns for certain outcomes will necessarily work for a different set of developmental outcomes. Generalizability of the effects of specific developmental influences is something that must be tested rather than something we can assume on faith. A specific developmental influence that has facilitative impact upon behaviour and development in one outcome domain may be irrelevant to outcomes in a second domain and may, under some circumstances, hinder development in a third outcome domain. For example, although it has been assumed that high levels of parental responsivity to children's verbalization and interaction patterns will impact in a positive way upon most aspects of development, available evidence suggests that some aspects of parental responsivity (caregivers responding non-verbally to children's vocalizations) act to inhibit rather than facilitate development [66].

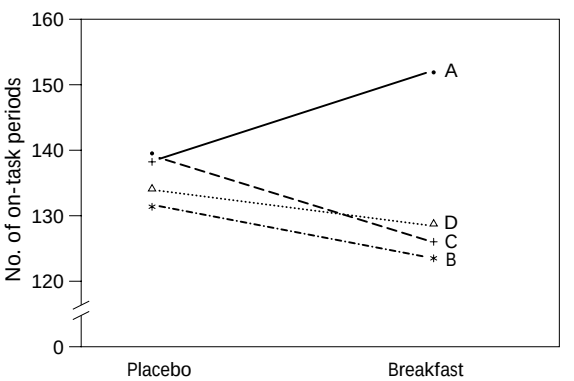

FIG. 3. Effects of nutritional supplementation on school behaviour in different school contexts. School A was organized and not crowded. Schools B–D were disorganized and chaotic.

Covariance among developmental Influences

The operation of specificity emphasizes the importance of focusing on unique patterns of relations between specific developmental influences and specific outcomes. However, before narrowing our focus too much, we need to consider the operation of covariance among multiple developmental influences. Covariance refers to the fact that in nature, individual developmental influences rarely operate in isolation. Rather, combinations of two or more developmental influences often co-occur at a greater than chance probability. Specific developmental risk factors tend to cluster together, as do specific developmentally protective influences [75]. For example, if an individual is deficient in vitamin B_6, there is a greater than chance likelihood that the individual is also deficient in other B vitamins [76]. Similarly, there is ample evidence documenting the covariance between inadequate psychosocial rearing environments and deficits in general nutritional status [77, 78].

The covariation among developmental influences from different domains may be inherent in the nature

TABLE 3. Examples of specificity of developmental influences

Influence	Evidence	Refs.
Central nervous system	Performance deficit varies as a function of what central nervous system area is damaged	68, 69
Biomedical influences	Differential impact upon physical versus behavioural development depends upon which type of teratogen the individual is exposed to	70
Nutritionally related growth markers	Different anthropometric patterns at birth related to different types of adult medical disorders later in life	71
Proximal environment	Maternal vocalization patterns and level of maternal response to distress differentially predict toddler language and emotionality	72
	Influence of parental rearing style upon change in adolescent competence varies as a function of what cognitive areas and what types of parental rearing styles are assessed	73
Demographic–cultural influences	Strong family religious beliefs inhibit adolescent behavioural problems but do not influence adolescence academic competence, which is uniquely predicted by family income	74

of the influences themselves, as seen in the bidirectional covariance between individual malnutrition and increased risk of morbidity, where malnutrition depresses immune system functioning while morbidity reduces appetite [79]. Alternatively, covariance may be the result of differential treatment of individuals with different characteristics, as occurs for adolescents with antisocial behaviour patterns who have a higher probability of eliciting rejection and anger from their parents [80]. Although covariance among developmental influences is a well-established fact, what must be kept in mind is that covariance is always probabilistic in nature [37]. For example, although there is an elevated risk of chronic marital discord in families where a parent is mentally ill, in the majority of such families we do not find elevated levels of discord [81]. Similarly, although infants with a "difficult" temperament are at elevated risk for evoking parental hostility and rejection, many difficult infants have excellent relations with their parents [66].

The facts that many separate developmental influences are probabilistically linked to each other, and that individual characteristics may influence the types of stresses or resources that individuals are exposed to over time, have certain implications for understanding individual behavioural developmental variability.

First, the stronger the covariance among multiple developmental influences, the more likely we are to find variability in outcomes. In this case the generalizability is not due to a general impact of a single influence but rather to multiple specific impacts associated with multiple covarying influences. For example, the generalized effects associated with poverty or community disorganization may reflect the fact that these terms refer to aggregated combinations of multiple and specific risk factors [82].

Second, when covariance exists among multiple developmental influences, a traditional approach has been either to ignore existing covariances or to control for such covariance statistically or experimentally as a means of isolating the unique contribution of a specific predictor [75]. Although it is relatively easy to isolate a single influence statistically or experimentally, such isolation may make little sense in a real-world setting, where individuals are simultaneously exposed to multiple covarying risks and protective factors. The operation of covariance leads to the suggestion that the appropriate unit of analysis should not be an individual developmental influence taken in isolation, but rather the covarying pattern of linkages among multiple influences [64]. One way of doing this is through a technique known as pattern analysis, through which individuals with similarly covarying biological individual and psychosocial characteristics are grouped into a specific cluster. Rather than individual influences, cluster membership is used to predict developmental outcomes [83]. Stronger predictions may occur when clusters of covarying influences are used as the unit of analysis rather than individual influences taken in isolation. For example, the impact of a single protective environmental factor upon individual development will depend upon the degree to which this factor covaries with other protective environmental factors encountered by the individual [84].

Temporal moderation

To understand the sources of variability in individual behavioural development, we must deal not only with multiple influences, many of which both covary and are highly specific in their impact, but also the fact that both development and the role of developmental in-

fluences operate across a background of time. Some aspects of temporal moderation are relatively well known. The concept of sensitive periods is one such aspect. The concept of sensitive periods refers to the idea that the impact of specific developmental influences will vary as a function of the age of the individual. Across multiple disciplines, we find the common assumption that developmental trajectories are most sensitive to modification by extrinsic influences during the period when the individual is most rapidly developing [85, 86]. For example, there is evidence that the central nervous system is more sensitive to the impact of injury or environmental toxins and more able to compensate after exposure to injury or toxins early in life, when central nervous system structures are still maturing [87]. The same assumption underlies the emphasis placed on supplementing growth-retarded infants during the first year of life while physical growth is at its maximal rate [88]. This assumption has led many researchers to emphasize the importance of early biological and psychosocial intervention, since the early years are presumed to be a period of maximal growth and development [89].

Early developmental influences can act to moderate the impact of later developmental influences in three ways. First there is sensitization, which refers to prior developmental influences making the individual more sensitive to later stressors [90]. For example, children with a history of malnutrition are more likely to be sensitive to the detrimental impact of subsequent short-term nutritional stress than children without such a history [91, 92]. Similarly, children who have a history of prior developmental problems are more likely to be at long-term risk when faced with later stressors, such as parental divorce, than those without such a history [93]. Both infrahuman [94] and human data suggest that long-term sensitization may be due to relatively permanent changes in individual physiological characteristics associated with exposure to early developmental risks [71, 95].

Second, although less evidence is available, early developmental influences may also act as a moderator through a process called steeling, wherein early influences act to protect the individual against the detrimental impact of later stressors [96]. There is a long history of infrahuman studies showing how pre-weaning exposure to mild environmental stresses acts to make organisms more stress resistant in adulthood [97]. At the human level, there is evidence that children with a secure attachment are more likely to show competent responding when faced with later environmental challenges than children who are insecurely attached [98].

Finally, there is also moderation as a function of blunting, namely, prior exposure to risk influences making the individual less able to benefit from subsequent facilitative developmental influences. For example, children with poorer early nutritional status were less able to benefit from later rearing in highly advantaged circumstances than more adequately nourished children from similar backgrounds [99–101]. Similarly, children who were either institutionally reared or reared in highly disorganized family environments were less able to benefit from the impact of either later intervention or later adoption into a more advantaged family environment [102–104].

Although there clearly is something unique and important about the role of developmental influences early in the life span [66, 105, 106], the complexity of temporal processes does not lend itself to a recommendation to focus intervention efforts just in the early period of life. Contradicting this recommendation are infrahuman studies suggesting not only that the central nervous system may be sensitive to the impact of environmental influences through late adulthood (well beyond the period of maximal central nervous system development) [107], but also that certain biological stresses, such as malnutrition occurring early in life, may act to extend the period of maximal central nervous system development, thus allowing for greater catch-up time [94]. Also, human research contradicts this idea, indicating that individuals do not become less sensitive to developmental influences over time, but rather that they become sensitive to different types of developmental influences [66]. For example, physical growth in the first six months of life is uniquely sensitive to the level of nutritional intake. However, for older children the level of growth hormones and sex steroid production has a more salient influence upon later physical growth [108, 109]. The importance of going beyond just the early period of life is also seen in the fact that the impact of early biological and psychosocial risks upon later development can be partially or even totally overcome by later exposure to more facilitative biological and psychosocial influences [66]. For example, more adequate food intake and better environmental stimulation later in life can at least partially compensate for the effect of early childhood malnutrition [101, 110].

Although early influences can act to moderate the impact of later influences, and later influences can act to moderate the impact of prior influences, ultimately it is important to recognize that much developmental variability is the result of a cumulative chain of developmental influences. For many aspects of development, it may well be the accumulation of influences over time that is most critical, rather than influences operating at a given point in time. The impact of cumulative influence processes can be seen in terms of the decline in active coping strategies used by children in response to chronic and continuing societal violence [111]; in the exhaustion of family resources as stresses on the family continue to occur [112]; in the greater retardation of physical growth rate found as malnutrition cumulates [113, 114]; and in the sharp increase in the

risk of future gastrointestinal disorders for individuals with a history of previous gastrointestinal disorders [115]. Looking across domains, the cumulative impact of both malnutrition and lower exploration opportunities may ultimately result in children developing a passive, helpless pattern of learning in relating to their environment [47, 116]. Similarly, a lack of educational support at home plus low parental expectations increases the probability of children starting off poorly prepared for school; this poor preparation in turn increases the probability of children doing poorly in the first few grades in school, which in turn increases the probability that the child will become less and less involved with school. This cumulative process of disengagement ultimately maximizes the risk of later school failure and drop-out [43].

Again, however, I must stress the probabilistic nature of developmental influences. Even where we have multiple influences cumulating towards a specific outcome, the probability of such an outcome is not necessarily 100 percent. An example is the research on women who were reared in institutions in childhood because of inadequate family environments [117]. Although as a group these women were at greater risk for later adult behaviour problems, those who had positive school experiences in their childhood had better adult adjustment than those who did not have such positive school experiences.

Although in no way denying the unique importance of the early years or of time periods of maximal growth as a focus for intervention efforts, the complex nature of temporal processes means that intervention efforts, whether biological or psychosocial, should not be restricted just to the early years or to periods of maximal developmental growth. Developmental interventions, particularly at the human behaviour level, rarely function as a form of inoculation. We cannot necessarily assume that the impact of a specific developmental influence at a given point in time will be maintained across time. A critical question is not so much whether recurring interventions are needed, but rather the question of when and how such recurring interventions should be provided.

Implications for intervention

After hearing about the complexities involved in human development, a typical response by individuals involved in public policy decisions is "If things are this complex, can cost-effective interventions really be developed?" I will respond to this question first in terms of economics and then at the level of programme development. Economically, it is important to stress that the complex picture I have painted, in regard both to development and to the nature of influences on development, is not an artifact. These complexities are real and there are potential economic consequences if we ignore them when designing intervention programmes to influence human behavioural development. Designing intervention programmes on the basis of a false assumption that human development is both simple and easily changed is a strategy that may save us initial costs, but over time for most developmental outcomes the inadequacies of such an intervention strategy will become all too apparent. There are exceptions to this (e.g., iodine supplementation), but these are truly exceptions and not the rule. As a general rule, the more a given domain of developmental competence is multidetermined, the less likely we are to find maximal gains associated with a single time-limited intervention. Multilevel repeated interventions that take account of existing developmental complexities may have a greater start-up cost, but in terms of long-term effectiveness and generalizability of effects, evidence indicates that this type of intervention will be far more cost-effective over the long run [118]. In terms of programme development, existing evidence can guide us, in terms of both what not to do and what to do.

What not to do

Avoid the assumption that one type of intervention taken in isolation will apply equally well to all outcomes. For example, school curricula that foster academic achievement may do little to foster either behavioural adjustment or emotional maturity [53].

Do not expect what works in one context to generalize equally well to another context. The generalizability of successful intervention programmes can be limited by a variety of cultural factors, such as the degree of gender segregation in childhood [21], the preferred mode for teaching young children [119], and whether the culture is family or child centred [120].

Do not design interventions that focus primarily on a single outcome domain. As in the case of cognition and motivation, gains in one domain can be strengthened and stabilized if interventions also target relevant overlapping domains [1, 121]. In addition, given the operations of specificity, there is always the possibility that intervention-related gains in one domain may be offset by intervention-related losses in a different domain. For example, providing additional play objects to black South African pre-school children, while increasing their cognitive competence and their appropriate use of objects, was also found to decrease their use of language and increase their level of solitary as opposed to social play [122].

Never design interventions without first asking what existing conditions can interfere with the potential gains individuals can realize from these interventions. To the extent that interfering conditions exist, dealing with these conditions as part of the intervention may be as

important as the actual intervention itself. I have already noted the study by Grantham-McGregor et al. [65] showing how chaotic school environments can compromise the impact of nutritional interventions. Other examples similarly document the need to take account of potential interfering conditions. Thus, in a population where there is a high intake of unleavened whole-grain products and tea, there may be limitations on the degree of functional benefits to be found by providing iron supplementation [123]. Focusing on providing macro- or micronutritional supplements to a family in a culture where the parents believe that disorders such as marasmus are the result of supernatural actions or of individuals not meeting religious obligations [124] or where parents believe that undernourished infants do not require any special help other than making food available [49] is a strategy that ignores existing realities that could compromise the impact of intervention. Providing home-based early environmental stimulation to at-risk infants living in crowded chaotic home contexts is a strategy that will result in limited gains, even if the interventions themselves are state of the art [125].

In evaluating the effects of intervention, do not focus just on main effect group differences. Even when there are significant group differences between individuals receiving intervention and those who are not, it is equally essential to pay attention to the level of intra-group variability within the intervention group. In all too many cases, we see a situation where a few children in the intervention group show major gains, a majority of children in the intervention group show very modest changes, and some children receiving intervention show either no change or even a regression over time [126]. In this type of situation, can we really say that we have carried out a generally successful intervention?

Principles for effective and cost-effective interventions

Many of the intervention principles that come from an understanding of the complexity of human behavioural developmental variability can be summarized by the simple acronym IT-AT, which stands for "integrate target across time." Integrate refers to the fact that aspects of human competence are affected by covarying influences from multiple domains. This means that we need to integrate multidomain interventions when attempting to influence the course of development. Target refers to the fact that intervention strategies need to be tailored for different cultural contexts, for different risk conditions, and for different outcomes rather than assuming that a given intervention will equally influence all outcomes for all individuals under all circumstances. Across time refers to the need for interventions to reoccur over time to maximize the chances of long-term gains.

Integrate

To the extent that an outcome is determined by multiple influences, intervention strategies should also encompass multiple influences. The critical question is which influences from which domains to include in the intervention. In an ideal sense, we would first determine what domains were relevant and within each domain what specific factors were most salient for the outcomes targeted. We would then do a survey of our population to determine which specific factors from each critical domain were lacking or were in excess, and which of those that were lacking or were in excess might most easily be manipulated to promote the desired gains. Such a strategy, although theoretically correct, is far too complex to be of use in most intervention situations in less developed countries.

An alternative easier strategy that allows us to integrate across multiple influences involves building upon existing covariances among developmental influences. We are far more likely to get maximal and lasting gains if we build on existing covariances than if we ignore the covariance among developmental influences. Let us take the covariance between nutritional deficit and inadequate psychosocial stimulation as an example. Available evidence documents that we can improve the health status of young children living in populations at risk for zinc deficiency by zinc supplementation [127, 128]. Functional consequences of better child health include more regular school attendance and better attention to the environment [129]. As shown in figure 4, zinc supplementation promotes better health, and better health status in turn makes young children more responsive to the environment. To the extent that micronutrient deficits covary with inadequate psychosocial rearing conditions [63, 95], it would be both logical and important to build on existing covariation by combining zinc supplementation with a programme of psychosocial stimulation designed to promote cognitive performance, since supplemented children will be more likely to be receptive to such stimulation than unsupplemented children. As has been shown in Asia [130], Africa [119], and the Caribbean [131], relatively low-cost, culturally appropriate psychosocial stimulation programmes can be provided in the context of other interventions designed to reduce the impact of morbidity or malnutrition [118]. This may be particularly true if we utilize available technology, such as television, which is often found even in the poorest villages, as a mechanism for delivering appropriate psychosocial stimulation to large numbers of children [132]. Integrated interventions based on covarying developmental influences will allow us to influence multiple aspects of development in a manner that is both cost

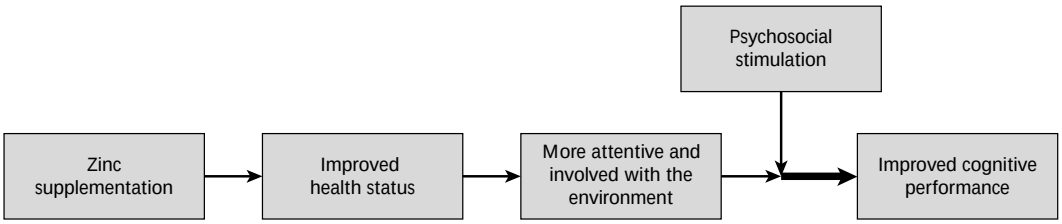

FIG. 4. Zinc, health, and psychosocial stimulation

effective and likely to have long-term developmental benefits.

Target

Targeting interventions involves issues such as what outcome we are targeting and whom we are targeting. In regard to the former question, all too often our intervention efforts are directed towards facilitating performance on a specific cognitive or behavioural measure (e.g., the Bayley) without asking the question as to whether gains on this particular outcome measure are really what is most desirable for a child in a given population. Rather than targeting for performance on available and commonly used behavioural or developmental measures, we should target three domains of competence, even when the measurement of gains in these domains is more difficult.

First, it is important to target those individual and behavioural characteristics that allow the individual to function adequately in his or her culture. Existing knowledge about cultural values will tell us, for example, whether we should target verbal or social aspects of intelligence or independence versus the ability to cooperate with others.

Second, particularly in cultures undergoing urbanization or industrialization, we should target those cognitive and behavioural characteristics that allow the individual to adjust to changing conditions. As noted previously, these are not necessarily the same characteristics that allow the individual to adapt to a traditional context. Particularly in regard to adaptability, we should focus on those contextual conditions and individual characteristics such as family size, maternal educational level, and enhanced child cognitive performance in the pre-school years that promote individual literacy [133]. Particularly in cultures where education is viewed as a valid goal for males but not for females, this may mean targeting not only the child but also the family.

Third, a final targeted dimension should be those cognitive, individual, and behavioural characteristics that allow individuals to adapt when encountering later stressors. Of particular relevance here is the promotion of less easily measured but critical individual characteristics, such as the capacity for self-regulation, the development of secure attachment, adequate self-esteem, and the ability to seek out appropriate environmental resources in times of stress. Although easily obtainable measures of many of these characteristics may not exist at present, by targeting these types of characteristics we are more likely to promote long-term generalizable gains than by targeting less critical characteristics that can be more easily measured.

In regard to the question of whom we target, in a situation where resources are finite, it seems almost too obvious to argue that it is most cost effective to focus primarily on those children who are most at risk in a given population. Unfortunately, too many of our most commonly used risk indices, such as low socio-economic status or living in an area characterized by inadequate nutrition or poverty, although valid at a group level, are relatively insensitive at an individual level. We know, for example, from the classic work of Craviotto and DeLicardie [134], that even within a low socioeconomic poverty group, there are individual differences in the risk of children becoming malnourished, with quality of rearing environment rather than poverty itself being the critical distinguishing feature. Similarly, we know from the anthropological work of Scheper-Hughes [16] that infants whose individual characteristics do not fit the characteristics that their mothers feel are essential for survival are at particular risk for both malnutrition and mortality. Within a given population, those children who are most exposed to multiple biological and psychosocial stressors will be most at risk [135]. This emphasizes the importance of developing risk indexes to identify individual children who fit the criteria of high risk within a given population. Examples of relatively easily measured and valid individual characteristics that could go into such a risk index are shown in table 4. Developing a risk index to target the most vulnerable children in a high-risk population, where it is not economical to treat everyone, not only allows for more cost-effective intervention but also avoids potential problems with targeting intervention to non-risk children, as seen in the case where there was a retardation in weight gain when iron supplementation was provided to children with adequate iron status [136].

TABLE 4. Indices used to define individual risk in a high-risk population

Low birthweight
Inadequate growth velocity in first six months
Level of morbidity above population mean in first two years of life
Iron-deficiency anaemia
Family in which sibling spacing is closer than population average
Family in which older siblings are developmentally delayed or atypical
Mother uneducated
Individual characteristics provide a poor fit to preferred cultural values
History of early school failure

Across time

There is no doubt that targeting early in development is very important, as is targeting during periods when specific developmental competencies are undergoing rapid change. However, just targeting early or during periods of rapid change may not be sufficient. In populations where children are exposed to multiple risks, even targeting during a sensitive time period may be ineffectual if the interventions are low intensity in either frequency of contact (e.g., occurring only on a monthly basis) [137] or scope (e.g., not involving individuals other than the target child) [138]. Further, even targeting early or during periods of rapid growth does not necessarily mean that we can expect significant effects or stability of interventions if we use relatively short-term interventions, even at the correct time period. For children with developmental delays associated with a single specific factor, such as prenatal iodine deficiency, relatively short-duration interventions may be appropriate. However, the situation appears to be quite different for children who are at risk due to exposure to multiple psychosocial and biological risk factors. Particularly for children encountering multiple biological and psychosocial risk factors, there is surprising convergence in the literature on the idea that a three-year intervention period may be necessary to see long-term effects of intervention [131, 139].

Even if we utilize interventions of suitable duration and intensity, restricting the interventions just to early development may be problematical, in part because the early developmental period is not the only period of rapid developmental change. We know from the literature that major developmental changes have been noted across cultures both in the five- to seven-year-old period [140] and in adolescence [141]. In addition, even if we get significant gains from early intervention, this does not rule out the likelihood that even greater gains can occur if the interventions are continued over a longer time period. For example, research on the impact of extending pre-school intervention for at-risk inner-city minority children to the early grades clearly showed better academic achievement occurring with the combination of both pre-school and early-grade intervention, rather than either pre-school or early-grade intervention taken in isolation [142].

Further, the fact that we can change an individual's developmental course by intervention at one particular point in time does not necessarily mean that these gains will be maintained across time. As a general rule, particularly in the case of children exposed to multiple biological and psychosocial risks, it seems clear that there is an increased probability of losing initial benefits unless follow-up interventions are built into the intervention programme. Calling for follow-up interventions immediately raises the question of how much later intervention is needed to maintain the impact of early interventions. Although there is all too little information in this area, one potential clue comes from studies on the concept of reinstatement, the stabilizing effects of periodic partial repetitions of a previous intervention [143]. Although reinstatement phenomena have been most often studied in regard to issues like the persistence of memory [144, 145] and relapse into drug addiction [146], the concept of reinstatement may also have implications for understanding how best to maintain the impact of prior psychosocial interventions. Within a reinstatement paradigm, complete re-exposure to a prior intervention experience may not be necessary. Rather, periodic partial re-exposure to key elements of the original intervention experience may be sufficient to maintain the impact of the original intervention.

Human behaviour and development is a highly complex phenomenon that will require more complex intervention strategies than those traditionally utilized. Although more complex intervention strategies can be more costly, it is also important to recognize that complex interventions do not necessarily involve tremendous costs. Further, providing low-cost interventions that have small effect sizes that are not maintained across time may be a far less cost-effective strategy than providing more complex interventions that match the complexity of human developmental variability and that are more likely to be maintained across time and to result in greater effect sizes.

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Assessing intellectual and affective development before age three: A perspective on changing practices

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Abstract

Developmental assessment is an ongoing process of systematic observation and analysis, the purpose of which is to understand the child's competencies and resources and the caregiving and learning environments most likely to assist the child in making the best use of his or her developmental potential. For many years young children have been assessed with normative instruments that focus primarily on evaluating their intellectual development. Many myths surround the use of these instruments with very young children, including the following: intelligence can be defined and measured with confidence; intelligence test data have diagnostic relevance; early intelligence tests have predictive value; such tests are useful for assessing young children with special needs; practitioners value and use these tests in their clinical practice; and IQ tests fulfill the legal purposes and intent of public laws. Each of these statements represents a misstatement of fact, and none of them has a strong evidentiary basis.

In place of the narrow classificatory function served by such tests, a variety of other approaches to assessing intellectual and affective development in the first three years of life are described. These instruments are consistent with a group of principles of responsive, developmentally oriented assessment that include recognizing the interdependence of development, understanding the importance of using multiple sources and multiple components in assessment, providing a meaningful sequence for assessment, respecting and evaluating child–caregiver relationships, basing assessments on a framework of typical development, emphasizing the organizational and functional capabilities of the child, focusing on the child's current and emerging competencies and strengths, viewing assessment as a process of collaboration and the beginning of an intervention, and understanding that assessment and intervention are two elements of a larger whole. Assessments that are defined in terms of these principles assist us in meeting our most important goal: assisting all children to achieve their potential.

Introduction

For more than 60 years, researchers have sought to develop systematic ways of learning about the development of infants and young children. In Nancy Bayley's first monograph concerning mental development, she attempted to specify those infant behaviours that could legitimately be tied to later mental functioning. To do this she posed such questions as "What specific behavior precedes later mental achievements? To what extent are these later achievements dependent on the earlier? Can we predict later development from early behavior? How do individual growth rates compare with the norm for a group of infants? To what extent are these rates affected by environmental conditions?" [1, p. 7]. The instrument that she developed, which has been revised twice since its experimental versions [2, 3], was intended to answer these questions.

The Bayley Scales of Infant Development II (BSID-II) [3] are used primarily to sample the intellectual growth of infants and toddlers. The scales are most successful in sorting, categorizing, and ranking children according to demonstrable parameters of infant intelligence. Despite its widespread use, very few researchers, including Bayley, came to believe that what we can learn about infant functioning in the first few months and years of life provides us with accurate information about children's later intellectual development or performance [4–6; but for a differing opinion, see refs. 7 and 8]. It seems that all we know with certainty is that the relationship between early-appearing, pre-verbal intellectual functions and typical intellectual performance that is manifested at school age and beyond is

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poorly defined. As Escalona and Moriarty noted, "When applied at age levels below 18 months, the term 'intelligence test' is misleading…. The true relationship between that which is measured by infant tests and that which we later call intelligence remains largely unknown" [9, p. 597].

Until recently, little attention has been paid to the assessment of affective components in infancy except by researchers. Although the BSID included an infant behaviour rating scale, it was not utilized by practitioners because of the absence of standardization data before the most recent version, and also because of limited understanding of the potential clinical applications of the information obtained from this scale. In the 1970s and 1980s, researchers examined temperament, focusing on the relationship between mother and child [10–14]. But again, most practitioners did not use information about temperament because of the absence of a developmental framework in which to place this research. More recent approaches to assessing infant affect (e.g., the Infant-Toddler Symptom Checklist [15]) focus on detecting deficits rather than identifying strengths, but in the social and emotional realm the presence of negative behaviours does not necessarily signal the absence of positive behaviours. Children sometimes have strong social skills while nevertheless exhibiting problem behaviours. It is important to assess the presence of both skills and problems within the context of the child's overall development.

This paper will review the assumptions that underlie the use of the prevailing normative paradigm in assessment and will present research that supports different perspectives on evaluating children's intellectual and affective growth and development. Integrated within a discussion of the principles of a responsive assessment model, we will present alternative approaches to assessing the intellectual and affective status of very young children. To begin, we will try to understand why the normative model of intelligence testing that is the foundation of testing in early childhood and beyond is inappropriate for the assessment of young children.

Myths concerning intelligence testing in early childhood

The conceptual hold over the thinking of practitioners, policy makers, and the public regarding conventional models of assessment may be attributable to several influential myths or presumptions. Neisworth and Bagnato [16] identified six such myths that relate to the use of intelligence testing with children younger than age three. The first myth is that "professionals know what early intelligence is and agree it can be measured" [16, p. 2]. This view reifies intelligent behaviour by claiming to be able to specify the characteristics of such behaviour, although intelligent behaviour is defined in different ways at different ages in the first few years of life. Inasmuch as no adequate theory of intelligence has yet been propounded [17], the notion that we can agree on how to measure intelligence is circular: it assumes that we know what the construct is that we are measuring before we have even been able to define that construct.

The second myth regarding early childhood intelligence testing states that "research supports the measurability, reliability, and diagnostic utility of early intelligence testing" [16, p. 3]. There is no evidence to support this claim. Rather, intelligence scores in infancy appear to be more the sum of a child's skills and behaviours in selected contexts, than a predictive index of future functioning and abilities. Because of different life experiences, equivalent IQ or developmental scores in different children may have different meanings. This suggests that the psychometric utility of such scores is very limited. Additional factors limit their diagnostic utility. For example, despite recent research emphasizing the importance of social-emotional development [18], most measures continue to emphasize cognitive functioning as the major determinant of development. The interdependence of domains is seldom afforded adequate attention.

The third myth is a corollary of the second: "Early intelligence tests have predictive validity" [16, p. 5]. This statement is challenged by the fact that measures of the home environment have demonstrated greater predictive power on later outcomes than have early intelligence tests [19]. In short, the tests do not have predictive validity; rather, the child's context and what takes place in that context carries the weight of the prediction. Moreover, since the test content used in assessments differs markedly as the child grows older, children may demonstrate vast differences in behaviour between early and later displays of "intelligence."

Neisworth and Bagnato's fourth myth concerns the use of IQ tests with children with disabilities or special needs: "Standardized administration procedures provide a reasonable and representative assessment of young children with special needs" [16, p. 8]. Among the problems with this statement is the general absence of disabled children in the normative samples of nearly all intelligence tests [20], as well as the inappropriateness of some procedures or requests built into the tests that do not account for a particular child's disability. As a result, they contend that these instruments "really measure the child's disability rather than ability" [16, p. 8].

The fifth myth concerns how intelligence scores are used to identify children in need of early intervention services: "Psychologists and other practitioners value and use intelligence tests to identify young children in need of early intervention" [16, p. 9]. In a survey conducted by Bagnato and Neisworth [21], 43% of psychologists and other practitioners considered early intelligence tests to be virtually without value. Their survey

also highlighted practitioners' views concerning the serious flaws in form, content, and function of these tests.

The final myth claims that tests of early intelligence "fulfill the legal purposes and the intent of public law" in the United States [16, p. 12]. The basis of the federal laws in the United States that regulate services to young children and their families acknowledge that early childhood assessment is specifically intended to take into account a wide range of environmental factors and to rely on information from a variety of significant actors in the child's life. Although clinical observations made during the administration may contribute to understanding the child, the test scores are of limited value, particularly when administered to an ethnically or culturally diverse group of children. In some states, the sole use of IQ tests with disabled minority students has been ruled illegal.

Overall, there appears to be a significant misalignment between early intervention programmes and the type of assessments (primarily intelligence testing) that are used most commonly for determining eligibility for these programmes. This misalignment can be seen in at least three fundamental areas. First, the conventional, norm-referenced assessments that are in widespread use primarily separate low-functioning from average- and high-functioning children. This is one of the purposes of diagnostic classification, and norm-referenced tests are judged by their accuracy in accomplishing this purpose [22]. Yet, many very young children cannot accurately be placed in conventional aetiological groups, categories, or types. Such classifications frequently have little utility. For example, we may know that a child is delayed in development, but information about the aetiology of the delay or the most reasonable ways of assisting such children in their development is not available from examination of such test scores and protocols [23]. Of greater value is to begin to treat these children non-categorically—as children in need of special services—and then gradually acquire the information that will enable more differentiated services to be created and provided [24].

Second, norm-referenced tests assume stability in human characteristics and a smooth curve concerning the predictability of these characteristics over time. Yet, the reality of working with young children and their families is not stability but change. For all but the most seriously impaired young children, we do not expect long-term predictability as much as the ability to forecast the next steps on the basis of experience with intervention [22]. A third misalignment concerns the manner in which the information is acquired conventionally in the assessment process. Traditionally, assessments are administered in single sessions, usually in standardized settings. But in order to understand development and the factors that contribute to it among very young children, it is essential to sample behaviour over time and to observe that behaviour in natural settings, noting the circumstances under which children are able to demonstrate skills and the occasions that particularly seem to challenge them. Otherwise, the likelihood of our being misled by the information acquired in the assessment process becomes at least as great as the possibility of acquiring insights into the development of young children and their families. It appears that if we are to be able to respond to Bayley's questions of more than 60 years ago, we will need to rethink our methodology for learning about children's growth and development.

Principles of assessment

A number of well-founded principles of early childhood assessment can be identified that offer a perspective that differs from that of conventional measurement. The Zero to Three Working Group on Developmental Assessment, a multidisciplinary group of professionals and parents, was convened in July 1992 to identify "problems and promising approaches in current assessment paradigms, policies, and practices" [25, p. 5]. The discussions initiated by this group led to the establishment of a set of principles that can be used to guide assessment of young children in both the intellectual and affective realms [26, pp. 17–25]. These principles are presented in table 1.

In general, the goal of early childhood assessment should be to acquire information and understanding that will facilitate the child's development and functional abilities within the family and community. Developmental assessment in particular is "a process designed to deepen understanding of a child's competencies and resources, and of the caregiving and learning environments most likely to help a child make fullest use of his or her developmental potential. Assessment should be an ongoing, collaborative process of systematic observation and analysis. This process involves formulating questions, gathering information, sharing observations, and making interpretations in order to form new questions" [26, p. 11]. The assessment principles listed in table 1 assume this definition of assessment. Below we will examine these assessment principles and offer examples of instruments and practices that utilize them, focusing on both affective and intellectual development of children below age three.

Interdependence of development

The child is a complete being—not a series of articulated skills, acquisitions, or elements—and the development of each area is dependent on other areas [27]. The child's skill in naming a picture is an indication of sensory, cognitive, and motor abilities, as well as language acquisition. Underlying all of this is the emo-

TABLE 1. Principles of responsive and developmentally oriented assessment

- » Assessment must be based on an integrated developmental model
- » Assessment involves multiple sources of information and multiple components
- » An assessment should follow a certain sequence
- » The child's relationship and interactions with his or her most trusted caregiver should form the cornerstone of an assessment
- » An understanding of sequences and timetables in typical development is essential as a framework for the interpretation of developmental differences among infants and toddlers
- » Assessment should emphasize attention to the child's level and pattern of organizing experience and to functional capacities, which represent an integration of emotional and cognitive abilities
- » The assessment process should identify the child's current competencies and strengths, as well as the competencies that will constitute developmental progression in a continuous growth model of development
- » Assessment is a collaborative process
- » The process of assessment should always be viewed as the first step in a potential intervention process
- » Reassessment of a child's developmental status should occur in the context of day-to-day family and/or early intervention activities

Source: ref. 26, pp. 17–22.

tional capacity that enables the child to relate to others and to organize his or her world. To consider only one area of development in isolation from the others leaves unrecognized the influence of the other areas and may impede our understanding of the child's abilities and challenges. The child's functional capacities should be examined in a variety of contexts in order to fully comprehend how the child integrates skills into his or her repertoire of behaviours and responses. In-depth examination of a child's skills in a single area of development proceeds from the more complete picture of the child's overall skills and knowledge acquisitions, recognizing the interdependence of the systems in development. Examples of assessment tools that focus on functional capacities in an integrated fashion include the Functional Emotional Assessment System (FEAS) [28], structured and non-structured play observations that are part of the Transdisciplinary Play-Based Assessment (TPBA) [29], and the Infant-Toddler Developmental Assessment (IDA) [30].

The TPBA is a comprehensive transdisciplinary approach to developmental assessment that is based on the premise that developmental functions are interdependent and children's development is influenced by a variety of factors. TPBA is a functional approach to the assessment of young children with disabilities or those at risk for developmental delay, which actively involves the child, the child's parents, and other professionals in a natural environment of assessment and intervention. TPBA is organized around the planning of a play session that is based on information about the child's developmental status acquired from the parents. "Toys and materials that are appropriate to the child's level are arranged to entice the child to play using various play strategies and developmental skills. One team member facilitates the child's play to encourage the expression of optimal abilities" [29, p. 4]. Guidelines are provided for observing the cognitive, social-emotional, communication and language, and sensorimotor development of the child. Fundamental to this assessment is the ecobehavioural validity of its methods, materials, and techniques.

Because the assessment is planned with the family, and information is acquired from family members as well as from others who are familiar with the child, the baseline for the assessment is close to the family's experience. Multiple opportunities for the child to interact with new and familiar materials are provided, and many observers are included in the assessment in order to capture as many perspectives as possible. Parents complete a pre-assessment inventory that provides valuable information about the child's developmental level and skills and also assists the team in preparing an environment that will elicit the child's optimal abilities. The assessment itself involves several phases: unstructured facilitation where the examiner follows and expands upon the child's lead; structured facilitation in which the examiner attempts to elicit behaviours that were not spontaneous in the preceding phase; introduction of a peer in order to observe interaction among children; structured and unstructured play between the parents and the child; structured and unstructured motor play; and snack, which allows for screening of oral-motor difficulties as well as social and adaptive development. Throughout the observation period, a staff member discusses with the parent the representativeness of the child's behaviours, some of the professional interpretation of behaviours, and the parent's perception of the child's behaviour. Observers are guided in their observations by questions that address both quantitative and qualitative aspects of the child's behaviour rather than just the presence or absence of behaviour. Once the assessment is complete and the guidelines provided have been reviewed in terms of the child's behaviour and accomplishments, transdisciplinary recommendations are developed and a programme planning meeting is convened to provide additional feedback for the child's parents and others working with the child. This experience is designed to be highly respectful of the child, the child's family, and the culture in which the child is being reared, and focuses on the interdependence of areas of development within the child.

Multiple sources and multiple components

The ability to take into account a variety of perspectives is essential to provide a complete view of the child's strengths and capacities and the optimal means of promoting further development. Information can be obtained from a variety of contexts with different tools guiding the process and informing the assessment. All members of the assessment team must make evident to the others their perspective on the child and the underlying assumptions of that perspective. As each member shares an understanding of the child's abilities, predispositions, and challenges, a more complete, informed, and multidimensional profile of the child emerges [31].

One example of an assessment that accounts for multiple sources and that is composed of multiple components is the Infant-Toddler Developmental Assessment (IDA) [30]. The IDA goes beyond traditional measures by addressing health, family, and social aspects of development as well as developmental dimensions. "The IDA is anchored in theoretical constructs and clinical perspectives which acknowledge the variety and interdependence of factors that influence the health and development of young children" [32]. The six phases of this assessment process provide a guide for team process, decision making, and how to include parents in the assessment. A team is formed of at least two professionals who function as developmental generalists and also contribute their own disciplinary expertise. This team may include social workers, developmental nutritionists, nurses, special educators, physicians, and physical, occupational, or speech therapists. The IDA helps these individuals organize information from multiple sources about the health, development, and social supports of the child and family. "The team shares responsibility for gathering, organizing, integrating, and synthesizing information, and for the problem solving inherent in all clinical work" [32, p. 19]. The team roles include family interviewer and primary family liaison, health reviewer, child evaluator, and assessment coordinator. The IDA is fundamentally an assessment that is premised on obtaining multiple perspectives on the wide variety of elements that comprise children's performance, learning, and relationships.

Assessment sequence

Assessments should begin by establishing reliable, working alliances with the significant individuals in the child's life. These individuals hold important information about the child and his or her capacities. Creating a reliable alliance with parents involves the use of sensitive interpersonal communication skills and the development of mutual trust and respect [33]. This calls for sensitive listening skills, responsivity to requests and concerns, openness to the family's interpretations, and honesty in interactions. Mutual respect for the family also involves understanding the family's strengths, challenges, and problem-solving strategies, as well as awareness and communication of the cultural assumptions undergirding assessment and professional recommendations. Hirshberg [34] describes precisely this kind of parent–professional relationship in his description of clinical interviewing. His critical insight is that human connectedness is essential for the process of assessment and intervention. This connectedness occurs at many levels: between parent and child, parent and clinician, and clinician and child.

After this relationship has been established, the assessment should be focused on practical outcomes. Assessment is not an end in itself. Rather, its goal is to obtain useful and accurate information about the child and the child's nurturing environment, including the resources and obstacles inherent in that environment, in order to find or create the most optimal situation for supporting the child in meeting family goals. The validity of an assessment is determined in terms of its application.

Greenspan and Meisels [26, pp. 18–19] translate these ideas into a sequence of assessment as follows:

» Establishing an alliance with the parents, listening to their views of the child's strengths and challenges, and discussing the issues to be explored in the assessment.
» Obtaining a developmental history of the child and an initial picture of the family's experience: although basic information may be readily available, some insights may only emerge over time, as part of an ongoing relationship and working alliance with the parents.
» Observing the child in the context of unstructured play with the parent(s) or other familiar caregivers.
» If appropriate, observing interaction between the child and a clinician.
» Making specific assessments of individual functions in the child, as needed.
» Using a developmental model as a framework for integrating all the data obtained from parents' reports, direct observation, and other sources, and conveying and discussing assessment findings in the context of an alliance with the child's primary caregivers, with the potential for starting an intervention process if needed.

Child–caregiver relationships

The interactions and relationship between child and caregiver form the foundation of the child's ability to organize and respond to his or her world [35]. Parents are usually more skilled at reading and responding to their child's cues than even the most skilled professionals. However, when the relationship between parent and

child is strained or maladaptive and there is no substitute relationship, the long-term consequences for the child can be very negative [36]. Observations of interactions between the child and parent allow professionals to learn methods of intervention from the parent that have proven successful for the family and child, as well as ways in which the professional can offer support for more successful interactions.

Parker and Zuckerman [37] suggest that one of the goals of the assessment process should be to determine the level of involvement in the intervention process that is most beneficial for the family. For some families, a very active role in the intervention process is constructive. Other families are so overwhelmed by their own and their child's demands that additional roles cannot easily be assumed and are often an additional burden that might seriously strain existing resources.

Assessment itself is an intervention in the lives of family members. Bailey [38] notes that every interaction with a family constitutes an assessment, and every assessment is itself an intervention. In the process of obtaining and sharing assessment information with families, professionals should communicate the range of development that is seen typically and should provide information about how to determine when a child might benefit from additional intervention. Greater awareness of developmental expectations for children of different ages may be all the intervention some families require. Although research clearly shows that the family relationship is central to children's development [39–43], every family is different. There is no single intervention that is applicable to all families or all situations.

Several assessments focus specifically on these issues. For example, the Nursing Child Assessment Feeding and Teaching Scales [44, 45] were designed to highlight the interaction between parents and very young children and have been used in many different research and clinical settings. The scales are intended to capture the reciprocity of communication between child and parent and to explore the range of behaviours available to both members of the dyad. Parents are assessed on four subscales: sensitivity to the child's cues, response to distress, fostering social-emotional growth, and fostering cognitive growth. Children are evaluated on clarity of cues and responsiveness to the caregiver. Performance on these scales has been associated with children's language usage at ages three to five, child temperament, and psychosocial high-risk factors in children's lives. The scales also discriminate among parents with different levels of schooling, those who are at risk for abuse as well as those who actually abuse their children, and those with high family stress. They can be of great utility to intervention programmes seeking to understand some of the difficulties that can potentially emerge between children and parents.

Framework of typical development

Early interventionists require a strong foundation in child growth and development. Growth in the early years is generally rapid and is accompanied by large variations in when and how children manifest different skills and behaviours. Cultural influences that may affect opportunities for learning may alter the arrival of developmental milestones. By viewing the development of all children on a continuum, those children who are born with disabilities or developmental delays can be viewed from the perspective of children who are not yet functioning as expected in given areas, rather than children who are unable to acquire the skills of typically developing children. Assessment frameworks that exemplify this view of development will provide more information for parents and interventionists because they will help us to see the child's accomplishments within a normal continuum of accomplishments. They suggest a series of steps or experiences that must be provided, rather than a set of milestones that the child has failed to achieve.

One productive approach to assessing typical development is to observe the child in naturally occurring, unstructured play situations (as contrasted to the relatively structured play experiences that are part of the TPBA). Segal and Webber [46, pp. 215–24] describe nine benefits of play observations that relate to both the normal developmental information acquired in this setting and the opportunity to create a parent–professional partnership. The benefits of play observations can be summarized in terms of:

» providing an opportunity to assess the functional behaviour of a young child who either cannot or will not perform in a formal testing situation;
» enabling infants and toddlers, because of the flexibility and spontaneity of a play situation, to achieve a level of object or symbolic play that they may not demonstrate on a standardized assessment;
» providing important insights into temperamental variables;
» revealing aspects of the parent–child relationship that help explain the behaviour of the child;
» providing insights into numerous domains of development;
» giving clinicians special opportunities to learn effective play strategies from a child's parent;
» suggesting ways of helping parents modify play strategies that are not fully effective;
» identifying strengths, coping skills, and risk factors that impact on a diagnosis and may be useful for designing a treatment plan;
» enhancing the parent–professional partnership.

Spontaneous play behaviours of the parent and child, whether alone or together, can add critically important information to an assessment. The naturalness of the

setting and procedures may enable children and parents to demonstrate their strengths as well as their areas of difficulty. Extremely knowledgeable observers are required to extract this information and place it within the continuum of normal and abnormal development.

Emphasis on organizing and functional capabilities of the child

As children learn to organize the world, they are increasingly able to learn about and from the world, and to take part in the world actively. Skills or behaviours with no functional application, learned and tested out of context, have no place in early intervention [47]. The goal should be to help children make meaning of their world and participate in it. Towards that end, assessment of discrete areas of functioning (e.g., auditory discrimination, visual-motor integration) should take place only to inform our understanding of the child's struggle with a given area or to better learn about the resources the child brings to the learning situation. In short, knowledge of a child's skills or abilities is only part of the picture. To complete that picture, we need to know how the child uses those skills and abilities, what motivates the child, what frustrates the child, and what brings the child satisfaction, as well as the availability of experiences for eliciting, supporting, and extending skills and abilities.

Greenspan's [28] approach to assessing children's development—particularly their emotional development—focuses directly on the functional capacities of the child. Called the Functional Emotional Assessment Scale (FEAS), this approach embeds assessment in the context of structured play interactions with the child's caregivers. Among the core capacities of the child that are evaluated are "the child's capacity for self-regulation, engagement, elaborating symbols and representations, and creating logical bridges or differentiations within his or her emerging symbolic world ('emotional thinking')" [18, p. 232]. Various levels of development are postulated in Greenspan's approach, but it is in interactions with adults that the child is evaluated in terms of a number of specific expected primary emotional capacities.

The following six areas are incorporated into the FEAS:

» primary emotional capacities, such as those capacities characteristic of children of a certain age, including responding to a caregiver's gestures with intentional gestures of his or her own, engaging in a complex pattern of communication, or imitating and copying another person's behaviour;
» emotional range, incorporating gestures, touch, and speech used by the child to master his or her primary functional emotional needs;
» affective emotional range, which concerns the various affective themes used by the child to organize his or her play and relationships;
» associated motor, sensory, language, and cognitive capacities, including other developmental challenges not already included in the primary emotional capacities (such as ambulating, feeding, copying simple gestures, etc.);
» general infant tendencies, which refer to constitutionally and maturationally based capacities of self-regulation, attention, capacity to enjoy sights and sounds, touch, movement in space, etc.;
» overall caregiver tendencies, referring to the caregiving patterns that facilitate or impede the child's growth and development.

Greenspan describes in great detail how to identify these various areas in children between birth and 48 months and how to use this information to enhance children's development. His focus throughout is on using the typologies he has identified to better understand the child's ability to function and make sense of the world within the context of his or her family. Greenspan's goal is to use this information to devise interventions that will build strong and supportive relationships with the child's caregivers and the core capacities to explore, utilize, and master challenges in the extra-familial environment.

Identify current and emerging competencies and strengths

The traditional model of assessment operates in terms of deficits by sorting and sifting children into different categories of disability or pathology. Identifying children's competencies and examining how they achieve those competencies is an integral part of more recently developed assessments [25]. The child's strengths and competencies alert us to the personal and ecological resources that a child may be able to call upon to meet developmental goals. They also aid us in fashioning interventions that make good use of those strengths and resources [30].

How a child manifests a particular skill or behaviour is at least as important as the mere presence or absence of the skill or behaviour [48]. For example, a child with motoric challenges may be able to walk but may have difficulty scanning the environment for obstacles or stopping and turning when necessary.

Many of the assessments described in this paper adopt this strength-oriented approach. This can be seen in the IDA [30], FEAS [28], TPBA [29], and naturalistic play observations [46]. Overall, these approaches begin with a recognition of what the child can do and with an attempt to understand the context in which the child is most familiar. The child's functional ca-

pacities and the child's natural environment form the anchors from which it becomes possible to learn more about the child's areas of difficulty in everyday functioning and relationships.

Collaborative process

Assessment of very young children should be premised on the quality of the working relationship between parents and professionals [35]. The professional's job is not to promote his or her view of the child to the parent, but to join the parents and other professionals in viewing the child multidimensionally in a way that contributes to the generation of strategies that will help the child make developmental advances and organize his or her world more adequately.

A variety of parent report instruments and protocols for parent interviews are available to help inform the assessment process (see, for example, the Vineland Scales of Adaptive Behavior [49] and the Minnesota Child Development Inventory [50]). These instruments are useful for obtaining different perspectives on a child's behaviours. Designed to be easily understood by most parents, they allow for active participation in the assessment process and give parents an awareness of the normative lens through which professionals view children. They provide a starting point in the conversation between parents and professionals.

Parents play a vital role in helping the professional understand how the familial and cultural contexts influence the child's repertoire of skills. Professionals must maintain positions of cultural reciprocity when interpreting assessment findings and making recommendations to families [51; 52; Kalyanpur M, personal communication, 1996]. This means that the professional must identify the values inherent in professional interpretations and recommendations, determine if these values are congruent with the value system of the family, and explain to families the assumptions underlying these recommendations. Professionals must explicitly respect the cultural differences identified and, together with the child's family, find the most effective means of adapting professional recommendations to meet the needs of the child in a manner that is culturally relevant [51, 52]. Parents are most apt to follow through on recommendations when parents and professionals hold similar perceptions of the child's needs and strengths, the professional is perceived by the family as a caring individual, and information is presented clearly and precisely [53].

Overall, the key to a successful assessment goes well beyond "establishing rapport"—the first step described in most test manuals. Successful relationships require rapport as a necessary condition, but rapport is not a sufficient condition for learning about the needs and strengths of the child and the family. Other features of the relationship include respect, reciprocity, and flexibility. These characteristics are key to establishing a framework in which honest interactions can take place.

Assessment as the beginning of intervention

A complete assessment includes information about how to facilitate the child's development and those supports that are needed to help the child exhibit desirable behaviours. When assessment occurs in isolation from intervention, particularly when it depends on traditional norm-referenced instruments, the outcome of assessment may be confusing, misleading, and ultimately counterproductive. It is only by testing out the hypotheses uncovered during the assessment that we can fully evaluate the validity of an assessment. The intervention not only confirms or disconfirms the assessment hypotheses, it elicits new hypotheses and new information that are in themselves an assessment of current functioning [21].

The notion of "current functioning" is one that is extremely narrow. A child's current functioning changes from moment to moment. The success of an assessment can be viewed in part as a function of its predictive invalidity. That is, as the information acquired from the assessment alters the context and content of the intervention, so the "current functioning" of the child changes and is transformed. Continuous assessment needs to be incorporated into the intervention so that the two functions become virtually seamless.

A critical new direction for early childhood assessment is that of a focus on utility. The treatment utility of an assessment refers to the degree to which an assessment is shown to contribute to beneficial treatment outcomes. The implications of this shift in outlook are very significant. Instead of asking whether a particular diagnosis is correct, we need to ask, "Is this assessment useful in practice?" [54, p. 964]. Instead of using assessments to sort children by achievement level or diagnostic category, we need to determine if assessments can help us do better, more appropriate, and more accurate interventions—information that we acquire through studying interventions. When assessment becomes fused with intervention. it becomes an iterative, cyclic process, rather than a static experience. To be effective—to have social utility—assessments must be closely tied to intervention.

Reassessment as an ongoing process

An important view represented here is that assessment and intervention should be interactive processes in which each informs the other. In the United States, reassessments are written into state and federal laws in order

to prevent children from being assigned to special classes or programmes and then forgotten, never to make a transition to a more appropriate or less restrictive environment.

However, reevaluation can have another meaning that is more functional and potentially even more critical for the overall growth and development of children. Reevaluation can serve as a time to reflect on the effect of the intervention. Every intervention provides some of the information that is needed to create a new, and more differentiated intervention. The metaphor that may be most powerful here is that of a moving target and of successive approximations to that target. Children's development is a moving target of skills, knowledge, experiences, dispositions, and personality variables. Every intervention alters the child in some way—sometimes for the better, as when the child breaks through to a new skill, and sometimes for the worse, as when the child's motivation to learn is diminished by continuing experiences of failure and frustration. Reevaluation on a continuing basis is essential if parents and professionals are to understand what they should try to do next with the child. Information about the child's prior history is useful but quickly loses its power and relevance with very young children. Constant infusions of new assessment information, acquired in the process of intervention, are essential to maximize the relationship between the child, the child's family, and professionals.

Conclusions

Assessments of very young children serve a variety of purposes. They can:

» determine eligibility for publicly supported services such as special education services;
» inform families about the range of their children's development, assisting them in determining where a child falls within that range, and helping them understand the uneven progress that children may make;
» help craft individualized family service plans that take into account both family and child factors as well as the greater ecology in which this family resides;
» evaluate the effectiveness of interventions;
» be used as documentation during assessment and intervention to help a family to appreciate their child's progress and plan future interventions.

In the past, assessments were used primarily to sort and categorize children for the purposes of determining eligibility and appropriate services. Given our knowledge about the impact of multiple factors on early development and the lack of predictive validity of early measures, a simplistic sort and sift approach is not greatly compelling. Other purposes for assessment are possible. Multisource, multidimensional assessment contributes to our ability to determine risk and identify possible interventions and potential sources of resiliency. It identifies children who are currently delayed in meeting developmental expectations and those who may benefit from additional intervention.

Fundamentally, assessment is justified by its ability to guide intervention. In order for assessments to provide a firm basis for interventions with young children, it is essential that information about children's strengths, and family beliefs and goals, be included in the information gathering that constitutes the assessment process. As progress is documented in the course of intervention, family members will be able to recognize their children's growth and will be able to appreciate the changes in their relationship with their children. In short, the conditions for more adequate assessment are central to helping us achieve our goal of helping all children achieve their potential.

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Epidemiology of child developmental problems: The extent of the problems of poor development in children from deprived backgrounds

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Abstract

The causes of negative child outcomes need to be reconceptualized in terms of the effects of multiple risks. This paper reviews the extent of the problems associated with adverse development in children from deprived backgrounds using two parallel lines of research: epidemiological evidence and early intervention. Epidemiological studies suggest that multiple risk factors interact, magnifying the chances of non-optimal development for at-risk populations. Furthermore, evidence from intervention studies suggests that full-service intervention models are the most effective format for reducing poor developmental outcomes for at-risk children.

Introduction

Children from impoverished backgrounds face obstacles from the moment of conception, and some speculate that risk may be transmitted across generations. Barriers that may be endured by such children include poor prenatal care, inadequate nutrition, deficient medical care, and insufficient education. Consequently, many factors have been indicated as influential in fostering poor developmental outcomes.

The causes of negative child outcomes need to be reconceptualized in terms of the effects of multiple risks. In particular, accumulating epidemiological evidence suggests that risks strongly interact, creating a need for multifaceted and comprehensive intervention services for at-risk children [1]. In order to change environmental conditions that directly affect child development, efforts must be directed at different combinations of risk. Risk can be understood as a "proxy for need" of services [1].

This paper reviews the extent of the problems associated with non-optimal development in children from deprived backgrounds. Two parallel lines of research will guide the paper: epidemiological evidence and early intervention. Such a review is intended to inform the discussion concerning the development of an integrative programme to promote maximum nutritional, medical, and educational opportunities for child development. In particular, this paper examines the effects of poverty on development. When evidence from developing countries is not accessible, examples from research in industrialized nations will be used.

Conditions of poverty as measured in industrialized nations are relevant when studying the effects of poverty in developing countries due to the "epidemiological transition." The epidemiological transition suggests that ambient factors commonplace in industrialized countries are inherited by developing countries as they advance [2]. Thus, developmental outcomes of poor children in the United States may be predictive of outcomes of children in developing nations. In addition, this paper will distinguish between outcomes based on single-component interventions, multicomponent interventions, and full-service interventions.

Scope of the problem

Currently poverty may be the most pervasive risk factor affecting child development. In the world today, there are approximately 1.3 billion people living in poverty [3]. In the developing world, estimates suggest there are over 500 million children under the age of five years, and approximately 97 million of them live in the least developed countries [4]. Although exact estimates of child poverty in developing countries are difficult to make, estimates from the United States suggest that approximately 14 million children, including 5 million pre-schoolers, were living in poverty in 1995 [5].

Such figures may seem astonishing, since the United States is one of the world's wealthiest nations. Even so, children in the United States are 1.6 times more likely to live in poverty than children living in Canada, three times more likely than those living in France or

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Germany, and two times more likely than those in Britain [6].

Minorities in poverty

Besides general mortality indicators, it is necessary to consider ethnicity as a risk factor for children from deprived backgrounds. There have been persistent differences between ethnic groups in infant mortality rates (IMR). Specifically, in 1994 the IMR (per 1000 live births) for black infants in the United States was 17.1, which was 9.2 times higher than that for white infants [6]. Analysis of the 1989–1991 birth cohort in the United States showed that American Indian/Alaskan natives had the second highest IMR (12.6), followed by infants of Hispanic origin (7.6). White infants and infants with only one parent from Central or South America and Asia or Pacific Islands all had IMRs of 6.6 [7].

It is obvious from the above statistics that mortality, specifically, and poverty, generally, are not distributed equally across different demographic groups. African-American children, Hispanic-American children, and children from single-parent homes are disproportionately impoverished [8]. Moreover, the effect of adverse environments on development is substantially impacted by the duration of time spent in poverty [9]. In the United States, 18.3% of children under the age of 18 were living in poverty, based upon 1989 family income [6]. A breakdown by ethnicity exemplifies the nonparallel representation of minorities in poverty: 12.5% of white children were living in poverty compared with 39.8% of black children and 32.2% of Hispanic children [6]. Further, estimates from 1992 suggest African-American children are more likely to experience long-term poverty than are white children. Twenty-nine percent of African-American children were poor for 10 or more years, as compared with less than 1% of white children [8].

Effects of poverty on development

Regardless of ethnicity or geographical region, the impact of poverty on development is associated with a disproportionate number of adverse outcomes. Factors associated with the duration, severity, and timing of poverty are important to consider when assessing outcome for children. Research has found tangible differences between developmental deficits in children living in long-term poverty relative to those who experience short-term poverty [9]. Differences between the extremely poor and the moderately poor have also been identified. For example, one study found that the incidence of low birthweight (less than 2,500 g) was greater among children experiencing severe rather than moderate levels of poverty [9]. Studies have also shown that toddlers and young children in poverty have a lower rate of school completion than children and adolescents who endure poverty in later years [10].

Given the many influences associated with poverty, the diversity in developmental outcomes for children from deprived backgrounds is understandable. Poverty is fundamentally linked with a reduced opportunity for optimal development. Specifically, poverty is known to impact major areas influential in child development, such as access to appropriate nutrition, medical care, and education. A detailed discussion of these issues can be found in this volume [11].

Epidemiological evidence

Traditional regression models and mean difference models have historically been used to study the impact of poverty on child development. These methods may not be the most effective to analyze the problem. The effects of poverty on development can most effectively be understood in terms of an epidemiological multiple-risk-factor model. Such a model allows a differentiation between the impact of the risks associated with poverty on the individual and the consequences of poverty to the population. This distinction cannot be achieved using regression.

To distinguish between risk associated with the individual and risk to the population is important for making recommendations to clinicians and policy makers. The prevalence of a risk factor will govern its impact on the population. It is possible to have a rare but serious risk factor that is of great clinical importance when present in the individual but is of minor importance to the population. On the other hand, exposure of a large segment of a community to a risk factor can have a great impact on the occurrence of a disorder in the population. Such a relationship can be evident even when the association of risk with an individual appears to be relatively weak when examined in terms of regression coefficients or mean differences. Small mean differences or very modest correlations (even in the range generally considered negligible by researchers in child development) can have large effects on populations.

Much of the importance of population effects is associated with changes in the shape of the normal distribution. For instance, a large increase in the number of cases in the lower tail of the normal distribution will show only a small effect when expressed in terms of product-moment correlations or mean differences [12]. A reader who finds this surprising might reflect on the observation [13] that the correlation between smoking and lung cancer results in a product-moment correlation of approximately $r = 0.10$. The difference

between smokers and nonsmokers, expressed in terms of risk ratios from the same data, shows that smokers are approximately 11 times more likely to contract lung cancer than nonsmokers.

Epidemiological measures of effect

Epidemiological statistics focus on differences in proportions, whereas regression focuses on prediction of means and variances. The risk ratio (RR) is an important measure of individual risk. It measures the rate of disability among those who are exposed to a given risk factor relative to the rate of disability among those who are not exposed [14]. The population-attributable risk fraction (PAF) is used to estimate the effect a particular risk has on the population. Particularly, the PAF estimates the proportion of cases in the population that would be prevented if the risk factor was eliminated. The PAF takes into account the prevalence of the risk factor in the community, the rate of the disorder among those who are exposed, and the rate of the disorder among those who are not exposed.

The effect of two risk factors, low maternal education (<12 years) and very low birthweight (<1,500 g), on determining special education needs provides a good illustration of RR and PAF [15]. A child who has a mother with low education and who was born with a very low birthweight is 3.10 times more likely to be identified as needing special education services at age 10 than a child whose mother has at least 12 years of education and who was not born with a very low birthweight. On the other hand, only 0.1% of the special education cases were attributable to the joint occurrence of low maternal education and very low birthweight. Thus, although the increase in risk associated with the combined occurrence of these risk factors on the individual is substantial, they rarely occurred in the study population. In a population in which the joint occurrence of these risk factors is more prevalent, as it is in some developing countries, the fraction of cases attributable to the risk factors could be much larger.

To summarize, a risk factor that may be of high relevance to the management of an individual case may not necessarily indicate its effect on the population. In order to address the importance of the risk in the population, data about the prevalence of the risk in the population must be examined. From a public health planning perspective, effects measured by regression are of limited use, since this method combines information about the strength and prevalence of a risk factor in the study population into a single coefficient.

Another important finding from epidemiological studies is that risk factors are not randomly distributed in populations. Using regression models it is possible to estimate the effects of one variable or risk factor while holding the others constant. This practice is sometimes referred to as using statistical controls or partialing out effects. Although such a method may be scientifically useful and interesting, it may lead to serious misunderstandings from a public health perspective.

Statistical control of risk factors can be problematic because they often co-occur or cluster together. In a recent study, Hollomon [16] illustrated this problem by analyzing a data set using several different methods. Children of teenage mothers were identified as the group at lowest risk for later cognitive problems when logistic regression was used to statistically control for educational level, birthweight, sex, gestational age, prenatal care, marital status, and maternal age. The cluster of risks controlled for in this analysis consists of those characteristic of births to teenage mothers in the United States. A cohort of births to teenage mothers without these risks is almost, if not totally, nonexistent. Not only do these risk factors occur in clusters in teenagers, but they also interact with each other. The public health importance and population impact cannot be understood by isolating effects statistically. In understanding the impact of poverty on children, an emphasis must be placed on understanding the clusters of risks that are present in a society and then addressing the problem with a multicomponent approach.

Single-component models

Single-component models approach intervention by targeting specific areas known to impact child development. Interventions to be discussed include research designs that focus on modifying areas of nutrition, health, or education. Nutritional interventions typically support dietary change by providing deficient nutrients or supplementary feeding. Medical interventions have focused on increasing access to primary, preventive child care, and educational interventions have emphasized an early awareness of skills important for successful school achievement. The population targeted for these interventions includes children at risk for adverse developmental outcomes. Outcome measures primarily focus on cognitive and physical domains of child development.

Nutrition

Short-term interventions

Early supplementary feeding is known to combat later developmental delays. Yet the duration of intervention may influence the impact on development. A short-term supplementary feeding programme was administered in West Java, Indonesia. The purpose of the investiga-

tion was to study the impact supplementary feeding had on weight, height, motor development, and mental development [17]. Twenty day-care centres with an enrollment of 15 or more children aged 6 to 20 months were selected for study. Nine of the centres received a 90-day supplementation, and 11 were used as controls. All of the children showed a marked deficit in weight and growth stunting at inception of the study, and no group differences in motor or mental development existed between the groups before supplementation.

The results indicated that the supplemented group experienced a large, positive weight change as compared with the control group. No differences in height were found between the groups. The supplemented group increased 14.1 points on the Bayley (psychomotor development index) as compared with the non-supplemented group. No differences between groups were found on the mental development index. Thus, short-term supplementation was effective at altering weight and motor development, but not height or cognitive development. Supplementing women during pregnancy and lactation but not supplementing the offspring has also been found to have a beneficial effect on the motor development but not the mental development of children [18].

Long-term interventions

There is evidence to suggest that long-term early supplementary feeding does affect cognitive development. Supplementary feeding during pregnancy and the first months of postnatal life has enhanced mental development among toddlers [19].

In a longitudinal study in Guatemala, 2,000 children aged seven years and younger from four villages participated in a nutritional intervention between 1969 and 1977 [20]. The children in two of the villages received a high-protein supplement (atole), and those in the other two villages received a lesser supplement containing one-third of the calories and no protein (fresco). In 1988, 70% of the children (1411) were contacted; at that time they ranged in age from 11 to 26 years.

Cognitive development was measured using school performance variables. Subjects who received at least two years of postnatal supplementation ($n = 611$) were examined. The analyses were more favourable for subjects who received atole. The results indicated that as children aged, the developmental benefits of early supplementation increased.

Specific analyses indicated that children in the atole villages performed better on tests of arithmetic, reading, and general knowledge. Treatment by maximum grade attainment was also observed. Children receiving atole scored significantly higher on tests of reading than those receiving fresco and were consistently at the upper end of the grade distribution. With regard to socio-economic factors, analyses revealed that the atole villages had significantly lower maternal education and significantly higher father employment than the fresco villages. Yet, subjects receiving atole performed significantly better than subjects of similar socio-economic levels receiving fresco in tests of literacy, standardized reading and vocabulary, and general knowledge. The authors concluded that differences in performance on tests of complex mental abilities in adolescence can be attributed to differences in individual transactions with the environment, and early supplementary feeding directly impacts on these transactions [20].

Health

Intervention efforts have been directed at providing primary and preventive care as a means of improving general health for children in adverse situations. Several studies have measured the effects of sustained contact with a primary physician or nurse on infant health. A study of infants up to eight months of age in low-income African-American families found that there were no differences between intervention and control subjects on measures of general health, morbidity, incidence of accidents, or immunization rates [21]. However, the intervention group performed significantly better on measures of gross motor skills and had significantly fewer upper respiratory symptoms than did the control group.

When public health nurses provide sustained services, the outcomes are not noticeably different. Ninety-eight infants up to nine months of age from low-income families participated in an intervention aimed at providing case management to facilitate child health clinic and immunization services [22]. Differences were found between the groups. Infants in the intervention group had significantly more adequate child-health clinic visits than the control group, who received segregated case-management services. Although there were no differences between the groups in rates of adequate immunization, differences in cost-effectiveness were identified between services provided by public health nurses and fragmented services.

Medical interventions have also been directed at infants with particular conditions. For example, interventions with low-birthweight (LBW) infants have attempted to reduce harmful stimulus in neonatal intensive care units and newborn nurseries [23]. Particularly, LBW infants are placed in soothing environments that promote behavioural and central nervous system organization. Short-term effects such as weight gain, decreased apnea, and positive changes in state organization have been found. However, long-term changes have not been detected [24].

Education

There is a long history of early educational intervention designed to meet the needs of children at risk for poor educational outcomes due to poverty. Some programmes focus primarily on the educational component. A follow-up to a three-year-long intervention was conducted, providing an educational curriculum to severely malnourished children through a home-visiting programme in Jamaica [25]. At age 15, children who received intervention scored higher on an IQ test and measures of school achievement than malnourished children who did not receive intervention.

Multicomponent models

Programme initiators motivated by different interests have provided many and varied intervention programmes to children at risk for developmental problems in both the United States and developing countries. There has been a shift away from isolated intervention efforts to more comprehensive models. Multiple intervention services are provided in order to address the multiple needs of at-risk children. These programmes can be discussed in terms of model programmes that test the best practices under optimal conditions in a small group of children. Other programmes represent the widespread practical application of model programmes.

Model programmes

Perry Preschool

The group most frequently targeted for intervention in the United States is children who are considered at risk due to chronic exposure to severe poverty. The Consortium for Longitudinal Studies provides the best evidence for the efficacy of early intervention with these children [26]. One programme evaluated by the Consortium, the Perry Preschool Program, provided a high-quality, active-learning pre-school experience to children living in poverty. Researchers found that children who participated in the intervention had fewer special education placements, fewer grade retentions, higher rates of high school graduation, and more optimal post-secondary employment [27–29].

Abecedarian

The Carolina Abecedarian Project varied the duration and intensity of early intervention to an impoverished population. Children received no educational intervention or intervention from infancy through grade 3, infancy through pre-school, or entry into school through grade 3. Services in pre-school included centre-based care, educational curriculum, nutrition, on-site medical care, and supportive social services. Children who received pre-school intervention had higher IQ and achievement scores through age 12 [30]. There was less support for the effectiveness of intervention only in children of school age. The researchers concluded that more intense intervention services resulted in better long-term outcomes [30, 31]

The Infant Health and Development Program

The Infant Health and Development Program (IHDP) was a multisite, randomized clinical trial designed to evaluate the efficacy of early intervention. The IHDP targeted children who were at risk because they were born with low birthweight (less than 2,500 g) and were premature (less than 37 gestational weeks). It combined early child development and family support with paediatric follow-up in an attempt to reduce developmental, behavioural, and health problems experienced by an at-risk population [32]. From birth to age three, the intervention group received paediatric follow-up, home visits, parent support groups, a developmental curriculum encompassing cognitive, social, motor, and linguistic skills, and 25 hours of centre-based care a week. The paediatric follow-up group received paediatric and referral services only [32, 33].

At age three immediately following intervention, the IQ scores of the intervention group were significantly higher than those of the follow-up group. The follow-up group was at increased risk for behaviour problems compared with intervention children. Finally, there were no differences between the groups in the number of serious health conditions, but mothers of children in the intervention group reported more minor illnesses. This result may reflect closer monitoring of mild symptoms by these mothers [32].

By age five, no intellectual difference was observed between the two groups for the lighter infants (<2,001 g), but the heavier children receiving intervention (2,001–2,500 g) continued to exhibit higher IQ scores than the corresponding follow-up children. No differences in behaviour or health status remained at age five [34]. A follow-up of the IHDP completed at eight years obtained measures of school achievement in addition to cognitive measures [35]. Among the heavier LBW children, those who had received intervention continued to show a significant advantage in IQ (4.4 points) and had higher scores on a mathematics achievement test than control children. There were no significant differences between any groups in performance on a reading achievement test, number of special education placements, behavioural measures, or health status [35].

Developing countries

In some other countries, exposure to conditions of poverty and malnutrition is more severe and more likely to interfere with the normal course of development than in the United States, where compensatory services are

more readily available. Unfortunately, the efficacy of multicomponent early interventions has been less well established under these conditions. McKay conducted a multicomponent intervention trial on an impoverished sample in Colombia that included health care, nutritional supplementation, and pre-school education [17]. They found that the earlier the intervention services began, the better the outcome for the child.

The Jamaican Study was a two-year intervention that varied levels of intervention services [36]. All children received free medical care. Groups who received one of four levels of intervention were compared: control group, nutritional supplementation, psychosocial stimulation, and a combined group. Results indicated that the control group had the lowest developmental quotient, the single-component interventions scored in the middle, and the combined intervention group scored the highest. Nutritional supplementation benefited motor and performance subscales, whereas psychosocial stimulation improved all subscales. Supplementation appeared to have a gradual and more long-term effect, whereas stimulation had an immediate effect that lessened with time [36].

Practical applications

Head Start

In addition to determining the efficacy of highly controlled early intervention programmes, it is essential to determine if these services can be implemented on a population basis. The Head Start programme was the first nationally implemented intervention programme with educational outcomes as the primary focus. A comprehensive services model was adopted to achieve the goal that all children be ready to learn at school entry [37].

The primary components deemed influential on child development were education, health, parent involvement, and social services [37]. The emphasis on parental involvement makes Head Start one of the first two-generation intervention programmes. The goal is to influence parental self-sufficiency in addition to child development [38].

In theory, the provision of these services improves a child's ability to learn and be successful in an academic realm. Evaluations of Head Start's effectiveness have yielded mixed results. The nationally mandated Westinghouse Report investigated the impact of participation in Head Start on later school achievement and found little effect of early intervention on school achievement [39]. This report has been criticized for a number of reasons [39, 40], and recent studies show more encouraging results [41, 42]. Other large-scale implementations of multicomponent interventions have been more clearly successful in improving the long-term educational outcomes of children from impoverished environments [43].

Integrative services model

It is becoming increasingly recognized that the problems experienced by children and their families do not occur in isolation; therefore, the services that address them should not occur in isolation. The goal of full-service integration is to increase the availability, access, and utilization of services to children and families living in poverty, while reducing the cost of implementation [44]. Models of continuous care have been implemented successfully in the area of health care [22] and child development services [45]. The following is an example of a model intervention program based on an integrative services model that goes beyond nutrition, health care, and education to incorporate all aspects of service delivery.

Linda Ray Intervention Program

Programme description

The Linda Ray Intervention Program (LRIP) was designed to provide a total service intervention for infants from low socio-economic status inner-city neighbourhoods who had been exposed to cocaine in utero. The LRIP is a model intervention programme that serves children from birth to age three. Children are randomly assigned to home-based or centre-based groups until full-capacity enrollment is reached. Subsequently, from the same referral sources, a primary-care group is enrolled that receives primary medical care, social work services, developmental assessments, and transportation to these appointments.

In addition to the services provided in the primary-care group, a teacher visited the home-based children twice a week for 1.5 hours per visit to demonstrate child-care activities based on the intervention curriculum (described under the educational component). Children in the centre-based group received curriculum instruction at the Linda Ray Intervention Center five days a week for five hours per day. Children in the latter group had the same teacher and peer group throughout the three-year intervention.

The LRIP was conceptualized as a model intervention based on a public health approach that is empirically driven with correspondence rules relating developmental outcomes to sources of risk to intervention strategies. The tradition of public health research and programme planning has focused on preventing specific undesirable outcomes, such as disease or risk factors for a disease. A risk factor is any characteristic or circumstance of a person or group that is associated with the development of an undesirable outcome. It may be medical, social, economic, cultural, or some

intersection of these variables. The public health model uses a retrospective paradigm working backward from an adverse outcome to risk factors associated with it that will be targeted for prevention [1].

There are four major steps in the process of developing an intervention based on the risk factor model. First, researchers select an adverse outcome to be targeted that has been identified through surveillance data. In public health, surveillance data are defined as the "ongoing, systematic collection, analysis, and interpretation of outcome-specific data for use in planning, implementation, and evaluation of public health practice" [46, p. 3]. Second, a source of risk is identified that is associated with an increase in the targeted outcome. Third, a service or strategy is designed that will prevent the occurrence of the risk factor. Finally, an intervention component is developed or a pre-existing agency is identified that will provide the prevention service.

Intervention components

On the basis of the surveillance data, several areas of risk were identified to be targeted by the intervention programme. Risk was conceptualized in terms of risk factors associated with the pre-school child, infant/toddler, birth characteristics, child care, maternal/family characteristics, and the overarching health and social context. Specific sources of risk were repeatedly identified within these broad areas of risk, including education, medical care, nutrition, family education and support, social services (crisis management, family planning, emergency assistance, etc.), and transportation. The repetition of risk sources and the services needed to address them across domains suggested an integrative services model that is qualitatively different from previous multicomponent interventions.

Education

First and foremost, the goal of the intervention programme was to prepare these at-risk children with the readiness skills necessary for school entry, especially literacy skills. A comprehensive educational programme was developed to address many areas of development affecting academic outcomes. The major intervention service developed to address educational risk was the outcome curriculum.

Children exposed to cocaine prenatally have heterogeneous outcomes, ranging from no documented problems to deficits in language development [47], fine and gross motor skills [48, 49], and social-emotional functioning [47, 48, 50]. Although early researchers attributed these delays to in utero substance exposure, recent studies focus on the role of the environment in exacerbating the outcomes of these children [51]. On the basis of these findings, it was determined that a curriculum strong in all developmental areas was needed. Thus, a broad, developmentally sequenced model was adopted, rather than one focusing on specific developmental deficits.

Medical care

The LRIP participants have daily access to nursing and medical care and 24-hour emergency medical assistance. They receive on-site primary well-child care, including immunizations. Parents are educated about appropriate hygiene and prevention of chronic minor health problems associated with this population. In addition, the programme coordinates family planning and prenatal care services for subsequent pregnancies.

Nutrition

The children are provided meals and snacks at the centre, which constitute two-thirds of the recommended daily allowances. A certified nutrition specialist serves as a consultant. Parents are educated as to developmentally appropriate feeding practices within cultural parameters. Medical staff monitor weight gain and review diets during routine visits. Teachers and social workers coordinate access to food-supplementation programmes.

Family education and support

Two-generation programmes that promote both the child's development and the self-sufficiency of the family (parent education, employment, etc.) are viewed as the most efficient method of maintaining intervention effects [38]. Providing parent education and support is one of the central components of the LRIP. Weekly parent education classes are held at the centre, where topics such as drug education, proper hygiene, making toys, and responsive caregiving are taught. Additional instruction is provided to alternative primary caregivers through the initiation of Father and Grandmother Groups that provide a social support network for alternative caregivers.

Social services

In addition to the services administered directly through the LRIP, social workers help inform the families of the resources available in the community and coordinate their access to those resources. They work closely with the public health nurses who visit families of the LRIP and with existing public service agencies. The social workers as well as the home-based teachers act as advocates for their clients with these agencies.

Transportation

The families of the LRIP need to be able to access the services available to them to ensure success. Therefore, transportation is provided daily to all centre-based children through LRIP-operated buses. Transportation to assessment and medical appointments is provided for all children. Mass transit passes are provided to fami-

lies to facilitate access to resources. Without adequate transportation, many families would not be able to take advantage of the intervention programme or services within the community.

Preliminary analyses

Although complete data on the first cohort of children will not be available until the summer of 1998, preliminary findings are being used to modify the curriculum for use with the second cohort currently being enrolled. Preliminary evaluations have been completed through 24 months for 50 centre-based, 45 home-based, and 30 primary-care children. The scores for the home and centre groups in the areas of early social communication, language, and emergent literacy skills are generally in the low normal range. The curriculum and the programme have been enhanced in these areas for the second cohort now being enrolled. Eventually, a study will examine the cost-effectiveness of each intervention strategy in terms of its influence on child outcome.

Cognition and language

Preliminary analyses suggest that intervention beyond primary care had a significant effect on cognitive and language scores at 24 months. Children who received intervention scored higher on the mental scale of the Bayley Test of Mental Development (II) and on the Reynell Scales of Language Development (receptive and expressive subscales) than those in the primary-care group.

The groups maintained a consistent order in terms of outcomes, with the centre-based group performing highest, followed by the home-based group, and the primary-care group scoring lowest. A comparison between centre-based and home-based intervention provided some evidence that the more intensive, centre-based intervention yielded better outcomes. There was a marginally significant advantage for centre-based over home-based intervention on the Bayley Test and a significant advantage on the expressive subscale of the Reynell Scale.

Behaviour

A comparison of the children receiving centre- and home-based intervention on the child behaviour checklist revealed differences between groups in teachers' reports of behaviour problems. Children who attended the centre-based intervention were rated as having fewer behaviour problems than those receiving home-based intervention. This difference was especially apparent in the types of externalizing problems, such as destructive and aggressive behaviour, which are associated with subsequent substance abuse.

Home environment

Children receiving centre-based intervention had more routines in their day-to-day transactions and had a higher quality of home environment than those receiving home-based intervention. Although the intervention services of the LRIP are primarily child-focused, they appear to have positive secondary effects on aspects of the child's caregiving environment. This advantage exists primarily for children who receive intervention at the centre rather than within the home.

Discussion

Developmental epidemiology

In addition to a direct comparison of three levels of early intervention on child outcome, a series of longitudinal studies of risks affecting long-term educational outcomes is being conducted in conjunction with the Florida Department of Education and the Department of Health. These two areas represent parallel lines of research that provide independent information about the interaction of risk factors and their influence on child development. Along the epidemiological line, a computerized linkage of the birth records of all children in the state of Florida with public school records yields an instantaneous longitudinal data set capable of identifying risk factors present at birth that serve as markers for poor educational outcomes. The data linkage procedure has been validated previously and yields 97% sensitivity and specificity estimates as compared with a gold standard linked by hand [52].

Scott et al. [53] provided the groundwork for the application of the public health approach to child development by describing a method of investigation termed developmental epidemiology. Developmental epidemiology is defined as "the study of the distribution of behavioral outcomes in infancy and childhood and the indicators of their occurrence" [53, p. 352]. The major goal of this field of study is to estimate the magnitude of risk of a poor developmental outcome due to antecedent exposure to one or more risk factors in a manner that will guide prevention and intervention efforts.

Studies from the epidemiological data set have identified low birthweight, low maternal education at birth, and iron-deficiency anaemia as risk factors for special education placement (as a proxy for disability) at age 10 [15, 54]. A dose-response relationship was found between birthweight and maternal education. Children who were born with low birthweight or to a mother who had not completed high school were more likely to be placed in special education. These risk factors also interacted, putting children who had both risk fac-

tors at the highest level of individual risk. Although clinically important, such children accounted for a small number of the overall cases of special education. Children born to mothers with low levels of education are an important group to target for early intervention from a public policy perspective, because they comprise a large percentage of children receiving special education services.

Within the general category of special education, low maternal education and male sex were factors strongly associated with risk for behaviour disorders [55]. Low maternal education, low birthweight, having an unmarried mother, and male sex were linked to mild and moderate mental retardation, whereas birthweight and delivery complications were risk factors for profound mental retardation [56; Chapman DA, Scott KG, Blair C, Krieger-Hurtado E, Urbano RC, personal communication, 1998). The risk factors associated with learning disabilities include male sex, low maternal education, unmarried mother, young maternal age, low birthweight, late prenatal care, and belonging to a minority group [Blair CB, personal communication, 1998]. Maternal education below high school completion is a risk factor common across educational outcomes. It may serve as a mediator between low socio-economic status and non-optimal development through the mechanism of inadequate provision of stimulation to the child.

A risk factor can have an independent effect, or combinations of risk factors can have joint effects that lead to an adverse outcome. Exposure to multiple risk factors can lead to a variety of poor developmental and educational outcomes. There can be diverse risk factors for similar outcomes (equifinality) or a common risk factor for diverse outcomes (multifinality) [23]. Therefore, the most effective method of intervention is an integrated service model that targets all identified risk factors.

Implications for public policy

Studies based on early intervention and developmental epidemiology have implications for public policy. First, families at risk experience multiple risk factors that require multiple services to address them. Second, studies in other fields (e.g., health care) have indicated that integrated services increase utilization of services and yield a positive cost-benefit analysis [22]. Third, multiple-component intervention models such as Perry Preschool, Abecedarian, and IHDP have resulted in positive long-term developmental and educational outcomes for children at risk for problems and delays. Cost analyses have indicated substantial benefits for early intervention in terms of reduced special education placement, reduced grade retention, higher graduation rates, more optimal post-secondary employment, reduced welfare costs, and decreased justice system contact [57, 58]. It is not uncommon in intervention studies to see delayed benefits of early intervention in areas such as these, known as "sleeper effects," in the absence of short-term benefits.

The conclusion from these findings is that a full-service early intervention is the most effective and cost-efficient way to meet the needs of children at risk because of chronic exposure to poverty. However, these programmes require substantial initial funding before long-term benefits can be observed. Integrated service models may provide the answer for reducing spending in the long run; however, the initial outlay of funding must be supported by the government.

A caveat to this conclusion is that the situation will not be resolved immediately. There is evidence for intergenerational effects of poverty on child development [59, 60]. For example, mothers who were born with low birthweight have an elevated risk of having a LBW child, regardless of nutritional, medical, and socioeconomic factors during pregnancy [60]. There appears to be a multigenerational process in which the conditions of a mother's birth and childhood growth contribute to her reproductive success [59]. The implication is that it may take more than one generation of intervention to achieve optimal child development.

On the basis of the evidence from epidemiological data and early intervention evaluation, it is recommended that funding for a full-service model with integrated services be made available to at-risk children. In the United States, children living in poverty have benefited from interventions based on this format. It is speculated that the best method to prevent developmental delays and suboptimal educational outcomes in children exposed to chronic and severe poverty conditions in other countries is through a fully integrated, multigeneration intervention programme.

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Stability, predictive validity, and sensitivity of mental and motor development scales and pre-school cognitive tests among low-income children in developing countries

Ernesto Pollitt and Nina Triana

Abstract

This paper documents the stability, predictive power, and sensitivity of mental and motor development scales and pre-school cognitive tests in the context of economically impoverished populations in low-income countries. Stability and predictive power comprise forecasting; stability includes repeated measures using the same test, whereas predictive power includes different tests. Sensitivity is the track record of the test in discriminating among groups of children exposed to different nutritional interventions. Psychometric data from three longitudinal studies of the assessment of the impact of early supplementary feeding on child development were used. Two studies were conducted in West Java, Indonesia, and the third study was carried out in El Oriente, Guatemala. Repeated measures allowed for the calculation of stability and predictive correlation coefficients. The mental development scales administered up to about 18 months had modest stability but no predictive power. This trend changed during the second year of life as the strength of the stability and predictive power increased. The pre-school tests were good predictors of a child's enrollment and school achievement. The findings on infant scales and pre-school tests agree with what has been reported in other populations in industrialized countries. There is no reason to believe that the developmental risk of the subjects that were assessed in each of the three target studies strengthens the psychometric attributes that were evaluated.

Objectives

This paper presents information on whether early childhood developmental and cognitive evaluations forecast a child's later cognitive and educational competence in the context of economically impoverished populations of low-income countries. In particular, the focus of the paper is on the *stability*, *predictive power*, and *sensitivity* of developmental and cognitive tests used in three different longitudinal studies of the effects of early supplementary feeding on mental and motor development. The information presented should be useful to professionals involved in the evaluation of early childhood development programmes targeted to the prevention or amelioration of developmental delays observed among children with a history of poor dietary intake, frequent infections, and limited educational opportunities. Two of these three studies were done in West Java, Indonesia [1, 2]. The remaining study was carried out in El Oriente, Guatemala [3]. The respective research designs included repeated measurements under controlled conditions. Accordingly, the data allowed for quantitative estimates of the forecasting power of the developmental scales administered during the first 24 to 36 months of life and of cognitive tests administered during the pre-school period (36–84 months). The data also shed light on which tests were sensitive to nutritional interventions.

Data source

Stability and *predictive power* comprise *forecasting*; stability includes repeated measures using the same test, whereas predictive power includes different tests. *Sensitivity* is the track record of the test in discriminating among groups of children exposed to different nutritional interventions.

Pearson correlations were used to test stability and predictive power. The correlations were classified according to the size of the coefficients as follows: modest correlations were 0.30 or less, moderate correlations ranged from 0.31 to 0.60, and high correlations were 0.61 or more.

The three studies consisted of nutritional interventions targeted to children who were classified as nutritionally at risk in rural low-income populations. Two studies were conducted in six tea plantations in

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Pangalengan, 50 km south of Bandung, the capital of West Java [1, 2]. The remaining study was done in Guatemala [3]. The first Indonesian study [1] tested the developmental impact of an energy-rich supplement given to infants and pre-schoolers for three months. The impact was assessed at the beginning and at the end of the treatment and again eight years later [4]. The second Indonesian study [2] began in 1993 and tested the effects of an energy and micronutrient supplement on the growth and development of two cohorts of children, 12 and 18 months of age. All measurements were taken every 2 months for 12 months. The study in Guatemala assessed the effects on mental development and cognition of infants, toddlers, and pre-school children of a high-energy, high-protein supplement and a low-energy supplement given to pregnant and lactating women and their offspring up to about seven years of age [5]. A follow-up study of the same subjects and their performance on psychoeducational tasks was carried out about 10 years after supplementation ceased [6]. The tests used in the three studies are listed in table 1.

Infant development scales: mental

In general, several developmental scales have been used to study the effects of different forms of intervention (e.g., nutrition, educational stimulation) on mental and motor development among young children in low-income countries. Among the most popular are the Bayley Scales of Mental and Motor Development, which we have singled out in this paper because the two scales were used in the two Indonesian studies. The Mental Scale was designed to assess sensory perceptual acuities, discriminations, and the ability to respond to these; the early acquisition of object constancy and memory, learning and problem-solving ability; vocalizations and the beginning of verbal communication; and early evidence of the ability to form generalizations and classification. In Indonesia the verbal instructions were translated to Sundanese, and some modifications were made of the pictures that are part of particular subtests. For example, some drawings were modified to portray dark-skinned, dark-haired children rather than Caucasian children, and a few utensils that are not present in Indonesian society were replaced by others. An effort was made to maintain the original instructions and degrees of difficulty in the items that were modified. The infant development scale of mental and motor development used in Guatemala was custom tailored for a study on supplementary feeding [7].

Infant development scales: motor

The assessment of motor development during the first two to three years of life generally includes measurements of several aspects of motor behaviour, such as gross (e.g., walking, stair climbing) and fine (e.g., finger coordination) motor skills, and motor organization and coordination. None of the studies under review assessed motor development beyond 30 months of age. However, the analysis of the motor development scales includes a section on the power of predicting cognitive performance during the school-age period.

Test administered during pre-school period

The Guatemala study included a battery of tests that assessed different aspects of cognition, such as embedded

TABLE 1. Developmental scales and cognitive tests used in studies on early supplementary feeding and development in Indonesia and Guatemala

Age	Indonesia-I [1, 4]	Indonesia-II [2]	Guatemala [5–7]
6–30 mo	Bayley Scales of Mental and Motor Development	Bayley Scales of Mental and Motor Development supplementary feeding	Infant development scale constructed locally for purposes of study on
36–84 mo	Peabody Picture Vocabulary Test		Battery of 10 to 22 tests of specific cognitive functions administered yearly beginning at 36–84 mo. For data reduction the respective scores were factor analyzed. A general and a memory factor emerged and was used for statistical analysis
School age	Arithmetic test developed from school curriculum Peabody Picture Vocabulary Test		Psychoeducational test battery including tests of literacy, reading comprehension, numeracy, general knowledge, and Raven Progressive Matrices

figures (assesses the ability to distinguish a figure from among a meaningful visual array), memory for digits (child must recall a sequence of numbers read by the tester), memory for sentences (child was asked to repeat meaningful sentences after the examiner read a substantive paragraph), persistence at working at a puzzle, and verbal inferences (a partial sentence was given to the child, who was asked to complete the idea by supplying the missing words).

Recognition Vocabulary was a picture vocabulary test, similar to the early items of the Peabody Picture Vocabulary Test (see below). In Guatemala the child was shown a notebook containing about four pictures per page, all of which depicted objects common in the village. The child was also shown one page at a time and asked to name each picture; various synonyms were acceptable. The total number correct was the naming score. After the child had seen all the pictures, the name of each picture that had not been named or had been named incorrectly was supplied, and the child was asked to point to the appropriate picture. The recognition score was the total number of items named, plus the number recognized.

A Sundanese adaptation of the Peabody Picture Vocabulary Test (PPVT) [8] was used for the assessment of vocabulary/development among pre-school and school-age children in the first Indonesian study [1, 4]. The test is considered an indicator of achievement to the extent it measures vocabulary acquisition. The PPVT can be used with children of pre-school and school age.

Tests administered during school period

Arithmetic test. Besides the PPVT, the follow-up study of the first Indonesian intervention included the construction of an arithmetic test that was based on the school curriculum and appropriate for the different ages of the children included in the sample. The internal validity of the test was confirmed by the expected improvement of the test scores for each grade in school.

Psychoeducational tests. The follow-up study in Guatemala included a psychoeducational test battery that was composed of the Raven's Progressive Matrices (i.e., visual perceptual organization) and tests of complex intellectual aptitudes, abilities, and achievements that are influenced by experience, education, and culture. For example, there were two standardized tests of reading and vocabulary and a knowledge test that was developed locally.

Results

Infant development scales: mental

Stability

The second study in Indonesia provides the most robust data on the stability of the Bayley mental scale. Two cohorts of children (12 and 18 months of age) were followed for a period of 12 months, during which the Bayley Scale of Mental Development was administered every two months. Figures 1 and 2 present stability coefficients for the 12- and 18-month cohorts, respectively. Each figure includes two curves. The first was based on the test-retest correlations with the interim period held constant at 2 months (e.g., testing at 12 and 14 months or at 20 and 22 months). The second curve was based on correlations between assessments having interim periods of different duration (2, 4, 6, 8, and 10 months). Clearly, the length of the interim period was closely related to the strength of the correlation: the longer the interval, the lower the correlation. For example, in the case of the 18-month cohort, the Pearson correlation between the scores obtained at 18 and 20 months was 0.70, and the correlation between the scores obtained at 18 and 24 months was 0.52. Likewise, for the 12-month cohort, the correlation between the scores obtained at 12 and 14 months was 0.53, and the correlation between the scores obtained at 12 and 18 months was 0.22. Furthermore, independently of

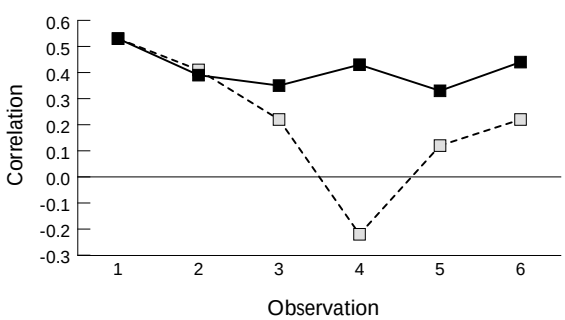

FIG. 1. Stability coefficients (Bayley Mental) between scores: 12-month cohort
—■— Test-retest correlations between adjacent 2-monthly tests
- -□- - Test-retest between baseline and each subsequent test

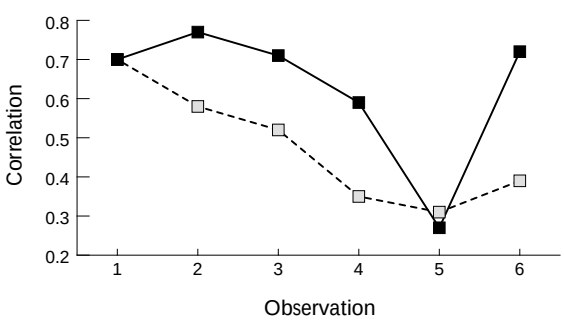

FIG. 2. Stability coefficients (Bayley Mental) between scores: 18-month cohort
—■— Test-retest correlations between adjacent 2-monthly tests
- -□- - Test-retest between baseline and each subsequent test

the length of the interim period, the coefficients were larger for the 18-month than for the 12-month cohort. For this younger group, the correlations between scores obtained at 2-month intervals fell into the moderate correlation category (0.31–0.60). For the 18-month cohort, the correlations between scores obtained at 2-month intervals fell into either the moderate or the high categories (except for one correlation).

The sizes of the stability coefficient reported for Indonesia are quite similar to those of the stability coefficients obtained with mental development scales among infants and toddlers in the United States, where the Bayley Scale of Mental Development was standardized (table 2).

The infant development scale (IDS) used in Guatemala was administered at 6, 15, and 24 months of age. The stability correlations were either modest or not statistically significant. For the mental scale, the highest coefficient was 0.27, which included the scores at 15 and 24 months. For the motor scale, the highest coefficient was 0.29, for these two same ages. All coefficients were consistently lower than the stability coefficients in the Indonesian study [7].

In summary, the age of the subject and the length of time between measurements have strong and distinctive effects on the *stability* of a mental development scale. If the period between tests was 4 months or more and the children were 18 months of age or younger, there was little resemblance or association between the first and the second mental score. As children approached 24 to 30 months of age, the same repeated measurements had a moderate to high association. The influence of age on stability was independent of the size of the interim period (up to 10 months) between the first and second assessment points.

Prediction of performance during the pre-school period

The predictive power of the IDS was also assessed. The mental scores from the IDS were correlated with the scores from a battery of cognitive tests administered to the same children every 12 months from 36 to 84 months of age. Each of these tests yielded scores that can be used to test inter-individual or inter-group differences.

To reduce the data, the scores from the several cognitive tests in the battery were submitted to a factor analysis. Two main cognitive factors emerged: a general (including verbal and perceptual organization tests) factor and a memory factor. Most correlations between the mental developmental scores of the IDS and the factor scores either were not statistically significant or showed very modest predictive power. This was particularly clear in those correlations that involved the mental development scores obtained at 6 and 15 months. The only moderate correlations were those that involved the IDS scores at 24 months with either the general (0.51) or the memory (0.33) factor scores at 84 months. A previous analysis of the power of the IDS developed in Guatemala to predict pre-school test performance had used a cognitive composite score for the entire pre-school battery. The cognitive composite at each age was a percentile score of the average of standardized scores for all cognitive tests in the battery. Consistently, the respective coefficients of correlation between the IDS mental and motor scores, on the one hand, and the composite scores at 36, 48, 60, 72, and 84 months were smaller than those found between the IDS scores and the general and memory factor generated from factor analysis [7].

The predictive power of the scales used in Indonesia and Guatemala is similar to the predictive power of the same or similar developmental scales used in the United States (table 3). In the United States several studies that dealt with the predictive power of early development scales showed that the median correlation between the mental development scores obtained at some point between 7 and 12 months and an IQ obtained sometime between 5 to 7 years of age was about 0.20 [9, 10]. This coefficient was close to the coefficients obtained in Guatemala between the assessments at 6 and 15 months and the general score at 72 months (0.18). Furthermore, in the United States the median correlation between the mental development score obtained sometime between 19 and 30 months and the IQ score obtained sometime between 5 and 7 years of age was 0.39, which was very close to that observed in Guatemala between the mental development score at 24 months and the general score at 84 months (0.35).

TABLE 2. Stability coefficients of various infant development scales among children in the United States

	Age (mo)	
Age (mo)	13–18	19–24
7–12	0.46	0.31
13–18		0.47

Adapted from ref. 9.

TABLE 3. Median correlation across several studies conducted in the United States between infant test scores and childhood IQ

Age at childhood test (yr)	Age at infant test (mo)				
	1–6	7–12	13–18	19–30	Median
8–18	0.06	0.25	0.32	0.49	0.28
5–7	0.09	0.20	0.34	0.39	0.25
3–4	0.21	0.32	0.50	0.59	0.40
Median	0.12	0.26	0.39	0.49	

Source: ref. 9.

Prediction of performance during the school-age period

The data from the first study in Indonesia allowed us to assess the power that early development scales have to predict cognition at school age. The results showed that the mental development score of the Bayley Scale of Mental Development administered at 20 months or before had no statistical power to predict a child's score at ages 8 to 12 years on either the Peabody Picture Vocabulary Score (r = .09) or an arithmetic test (r = .10). This was true even when the mental development scale score used for prediction was the average of the scores derived from two separate evaluations administered three months apart. Likewise, even if the children were classified according to age (6–12 months and 13–20 months) at baseline, the respective scores of these two age groups did not predict the scores on the verbal or arithmetic test.

Table 4 shows the predictive power of the mental scores from the infant development scale administered in Guatemala when the subjects were 15 months old and the scores obtained in different psychoeducational tests at 18 years of age. Briefly, none of the coefficients involving the mental score at 15 months were greater than 0.10. Data from the United States (table 3) show that the median correlation between a mental development score obtained sometime between 13 and 18 months and an IQ score obtained sometime between 8 and 18 years of age was 0.32 [9].

Sensitivity

The infant scales of mental development administered up to about 18 months did not discriminate between infants who had and had not received a nutritional supplement. After 18 months these scales were in fact sensitive to early supplementary feeding [11].

Infant development scales: motor

Stability

As shown in figures 3 and 4, the psychomotor development index (PDI) derived from the administration of the Bayley Scale of Motor Development to children between the ages of 12 to 30 months was moderately stable. In general, the stability coefficients of this scale were larger than those observed for the mental scale.

Prediction of performance during the school period

As shown in table 4, the motor scores from the IDS constructed in Guatemala had low but significant power to predict performance in several psychoeducational tests administered at about 18 years of age [12]. In fact, the respective coefficients of correlation were larger than those obtained with the mental IDS score. It is noteworthy that other investigators in Canada have reported similar findings regarding infant development scores [13].

TABLE 4. Predictive power of mental and motor development scores obtained at 15 months and scores obtained in psychoeducational test at 18 years in rural Guatemala (n > 170)

Infant development scale	Type of test			
	Vocabulary	Raven Literacy	Maximum matrices	Grade
Mental	0.04	0.01	0.10	0.10
Motor	0.18	0.16	0.03	0.14

Source: ref. 12.

Pre-school assessments (36 to 84 months)

Stability

The pre-school battery constructed for the Guatemala study was used to assess the stability and predictive power of pre-school cognitive tests. As noted, two main cognitive factors (general and memory) emerged from the factor analysis of the pre-school test scores.

Table 5 presents the stability coefficients for the general score; these coefficients ranged from 0.29 (correlation

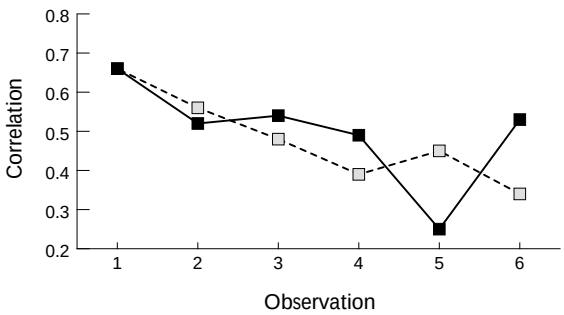

FIG. 3. Stability coefficients (Bayley Motor) between scores: 18-month cohort
—■— Test-retest correlations between adjacent 2-monthly tests
- -□- - Test-retest between baseline and each subsequent test

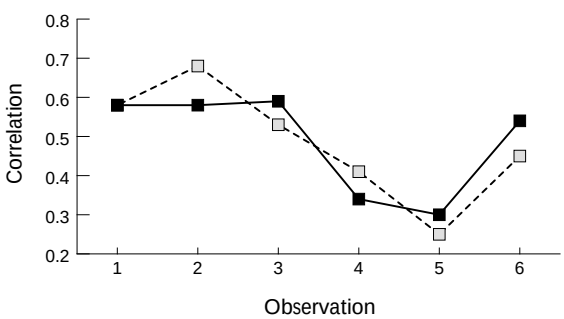

FIG. 4. Stability coefficients (Bayley Motor) between scores: 12-month cohort
—■— Test-retest correlations between adjacent 2-monthly tests
- -□- - Test-retest between baseline and each subsequent test

between 48 and 72 months) to 0.63 (60 and 84 months). The coefficient obtained between the scores at 48 and 72 months was much lower than the other correlations. This large difference suggests that the low value should be treated as non-reliable. Within rows, the highest coefficients were consistently found in the correlations that included the scores at 84 months.

In the case of the memory factor score (table 6) the coefficients ranged from 0.26 (48 and 72 months) to 0.66 (60 and 72 months). There are no striking differences in the stability of the memory and the general factor scores. An exception is that the coefficients that involved the scores at 36 months tend to be larger in the general than in the memory factor. In general, the effect of the size of the interim period between the first and the second evaluation observed in the analysis of the stability of the Bayley Scale is also observed in the correlations of the pre-school battery. The size of the coefficients declines as the duration between tests increases. However, note that the interim period between the first and second assessment of mental and motor development was measured in months, whereas the interim period between tests with the pre-school battery was measured in years.

Table 7 presents the stability coefficients for the Binet Scale, which has been one of the most popular tests in different parts of the world for the assessment of general intelligence. These coefficients were obtained from a longitudinal study conducted in the United States [14] that included IQ testing from 3 to 12 years of age. Clearly, these coefficients are much larger than those reported in tables 3 and 4. Thus, although it may be argued that the coefficients reported in tables 5 and 6 suggest that the cognitive test battery administered in Guatemala was moderately stable, it is also true that pre-school tests of cognition could be more stable than what was suggested by those particular stability coefficients.

TABLE 5. Stability coefficients of general factor score generated from battery of pre-school cognitive tests: Guatemala

Age (mo)	Age (mo)			
	48	60	72	84
36	0.40	0.39	0.45	0.62
48		0.42	0.29	0.42
60			0.57	0.63

Source: ref. 14.

TABLE 6. Stability coefficients of memory factor score generated from battery of pre-school cognitive tests: Guatemala

Age (mo)	Age (mo)			
	48	60	72	84
36	0.42	0.39	0.34	0.38
48		0.46	0.26	0.18
60			0.66	0.57

Adapted from ref. 14.

TABLE 7. Stability coefficients of Intelligence Test (Binet Scale) from 36 to 84 months among children in the United States

Age (mo)	Age (mo)			
	48	60	72	84
36	0.83	0.72	0.73	0.64
48		0.80	0.85	0.70
60			0.87	0.83

Adapted from ref. 17.

Prediction of performance at school age

The general factor score obtained at 48, 72, and 84 months of age predicted whether the children were or were not to enroll in school (fig. 5). In addition, the same factor score at 72 and 84 months predicted whether a child would pass from one grade to the next in primary school and his or her achievement in school. This predictive power was confirmed even after the effects of the social and economic background factors were controlled for [15].

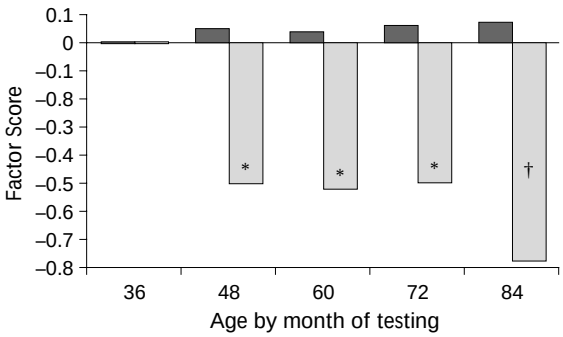

FIG. 5. Estimated mean for verbal factor score by school enrollment. Black bars, schooling; gray bars, no schooling.
* $p < 0.05$, † $p < 0.001$

Sensitivity

The general factor score and the memory factor score derived from the pre-school battery at 48 and 60 months discriminated between the effects of the high-protein, high-energy supplement and those of the low-energy supplement given to the subjects of the study in Guatemala [5]. Furthermore, such differential effects were more evident among those children who fell at the lower end of the social and economic distribution within the villages. The factor scores at 36, 72, and 84 months did not discriminate between groups. It is important to point

out that other studies have shown that intelligence scale batteries such as the Griffith Scale were also sensitive to the effects of supplementary feeding during several pre-school ages [see, for example, 16].

Discussion and conclusions

Infant development scales that yield a mental score (e.g., the Mental Development Index in the Bayley Scale) are often used as tests of intelligence under the assumption that the psychological constructs that these scales assess are the same as or similar to the constructs assessed by intelligence tests that yield an IQ score (e.g., Stanford-Binet, Wechsler Intelligence Scale for Children) and that are administered to pre-school (36 months and later) or school-age children. This assumption has been seriously weakened by the consistency of findings from different studies showing that the mental development scores, particularly those obtained before 18 months of age, have little if any power to predict later IQ [9, 17]. Several investigators, however, have documented that the predictive power of the early mental development assessments (particularly during the first year of life) is strengthened among developmentally delayed children [18–20].

The psychometric data reported here show that among nutritionally at-risk children, the Bayley Scale of Mental Development and the Infant Development Scale administered before 18 months also had very poor predictive validity. On the basis of the knowledge that the mental development scale has higher predictive power among developmentally at-risk children, it seemed reasonable at first to assume that the scales used in Indonesia and Guatemala should have had comparatively higher predictive power. Although this assumption is justified because the children who were studied were developmentally at risk because of their continuous exposure to nutritional deficiencies, poor health, and limited educational opportunities, the data showed that the assumption was wrong. As has been shown in the United States, the predictive power of the scores obtained after 18 months modestly forecast the cognitive test performance of pre-school children. However, the power to predict achievement or performance in school was zero.

What is said above should not be used as a basis to conclude that early developmental assessments will not discriminate between infants and toddlers who have or have not been exposed to early interventions (e.g., supplementary feeding, educational stimulation). The scales may well be sensitive to inter-group differences in the breadth of their behavioural repertoire, but any group advantages in mean scores do not reflect advantages in intelligence.

On the basis of the above considerations, it is recommended *not* to use infant scales that allegedly tap mental development constructs during the first 18 months of life in the evaluation of early child development programmes, carried out with the purpose of forecasting whether the programmes foster cognition and educational competence. If such scales are used for evaluation of programmes, they should be used beginning at about 24 months of life.

The recommendations submitted above should not be extended to Version II of the Bayley Scales of Mental and Motor Development. This is a new scale, and there are no data yet available from longitudinal studies to draw any conclusions regarding stability and predictive power among children in low-income countries. New developmental scales are likely to include test items that assess particular infant cognitive skills that are allegedly related to later intelligence, such as visual attention. Evidence gathered during the last decade has shown that responses to novel visual stimuli and habituation assessed during the first 12 months of life will predict later IQ [17].

The motor development scores had modest power to predict performance in the psycho-educational tests administered at about 18 years of age, but the mental scores had no power to do so. It has been proposed that if undernutrition delays the development of early motor actions (creeping, walking) that lead to developmentally meaningful behaviours (e.g., exploration of the environment), then early motor development scores of infants who are nutritionally at risk should be correlated with their cognitive test scores in later childhood [12]. Our finding on the modest predictive power of the IDS supports this assumption. There are other longitudinal studies on early supplementary feeding and child development that also gathered data on motor and cognitive development that would allow us to test this proposition further. However, to our knowledge such information has not been published. The data reported from Guatemala do not constitute an endorsement for the use of motor scales to assess the impact of early childhood development programmes on cognition.

The difference between the moderate stability scores of the pre-school battery of cognitive tests used in Guatemala and the high stability of the Binet Scale administered in the United States suggests that there is much room for improvement in the development of pre-school tests for the evaluation of early childhood development programmes. This statement is also validated by data that were collected in Cali, Colombia, in a study on the effects of a multifocal (health, nutrition, and education) intervention on cognitive development from 42 to 88 months of life among urban undernourished children. The battery of tests included several tasks, many of which were borrowed from tests of intelligence (e.g., Wechsler test for pre-school children) that have been standardized and have demonstrated construct validity in the United States. In Cali the stability coefficients (one-year

interim period) ranged from 0.48 to 0.86. These coefficients are closer to those reported for the Binet Scale than to those observed in Guatemala. The difference suggests that the room for improvement in the predictive power of pre-school tests is also found in the context of populations where malnutrition is endemic.

The programmatic conclusion from this paper is that pre-school tests of cognitive test performance have the power to predict school enrollment and achievement and are helpful instruments to evaluate the success of early childhood development programmes in fostering educational competence. Theoretically, it is justified to claim that the age of the child at the time of the evaluation has a strong moderating effect on the size of the relationship between early mental and cognitive assessments and later achievement and competence.

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Effects of health and nutrition on cognitive and behavioural development in children in the first three years of life

Part 1: Low birthweight, breastfeeding, and protein-energy malnutrition

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Abstract

The following paper and its accompanying paper (Grantham-McGregor SM, et al. Effects of health and nutrition on cognitive and behavioural development in children in the first three years of life. Part 2: Infections and micronutrient deficiencies: iodine, iron, and zinc. Food Nutr Bull 1999;20:76–99) review the literature on the conditions that are prevalent and considered to be likely to affect child development and are therefore of public health importance. The reviews are selective, and we have generally focused on recent work, particularly in areas that remain controversial. The reviews are restricted to nutritional and health insults that are important in the first three years of life. Where possible, we have discussed the better studies. This paper considers the effects of low birthweight (focusing on small-for-gestational-age babies) and early childhood protein-energy malnutrition on mental, motor, and behavioural development. We have also included a section on breastfeeding because of its importance to child health and nutrition programmes.

Introduction

In developing countries, millions of young children suffer from nutritional deficiencies and frequent infections. There is now a large and increasing body of evidence to indicate that nutrition and health affect children's cognitive, motor, and behavioural development, both pre- and postnatally. The impact of a biological insult depends on the stage of a child's development, as well as the severity and duration of the insult. However, because nutritional deficiencies and infections frequently occur together, the problems resulting from any one insult may be exacerbated by the presence of another, and the effects can be cumulative.

The situation is further complicated in that children who suffer from nutritional deficiencies and infections usually come from poor sociocultural environments and suffer from a myriad of deprivations and disadvantages that could themselves be detrimental to intellectual and behavioural development [1, 2]. These conditions include poor physical resources, such as overcrowded homes with poor sanitation and water supply, few household possessions, and low income. In addition, parents may have limited education and intelligence, and little knowledge of child development and the importance of play [1]; they may also suffer from depression [3]. Stimulation in the home is generally poor, with few toys or books and infrequent participation by the parents in play activities. Since nutritional deficiencies nearly always occur in the presence of these disadvantages, demonstrating a direct causal link between poor nutrition and poor development is difficult and requires a randomized controlled trial in which nutrition supplementation is given to undernourished children. Although establishing independent causality is important, it may not reflect the real-life situation, because there is increasing evidence that interactions exist among environmental conditions, a child's biological status, and various biological insults. Thus, in order to understand the true situation, these many factors should be studied together.

In studies evaluating the effects of poor nutrition on a child's development, investigators traditionally focus on motor and cognitive development. However, it is critical to evaluate social and emotional development as well, because these factors may be equally, if not more, important to an individual's success in life.

Low birthweight

Almost 25 million low-birthweight (LBW) infants (<2,500 g) are born each year, 95% of them in developing countries [4]. In developing countries, LBW infants are more likely to be born at term than those in

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developed countries and more likely to be small due to intrauterine growth retardation (IUGR) secondary to maternal undernutrition and infection [5]. The diagnosis of IUGR requires longitudinal measures of intrauterine growth. As these are rarely available in low-income countries, we will restrict this review to infants born at term but small for gestational age (SGA).

A recent review of 80 studies, mostly in developed countries, showed that LBW children generally have poorer levels of development than normal-birthweight (NBW) infants [6]. Fewer studies exist of SGA infants, and they suffer from many design problems. Probably the greatest problem is that researchers have used different definitions for SGA, and there is no generally accepted definition, although the World Health Organization (WHO) recommends using the 10th centile for gestational age [7]. There are also several confounding variables that are frequently not taken into account adequately. SGA babies have a greater incidence of perinatal complications than NBW babies [8, 9], which may detrimentally affect their subsequent development [10]; they also come from poorer homes than NBW children and are less likely to be breastfed. A further problem is that samples of SGA children have often been small and had a large percentage of drop-outs [11, 12] that is often biased [13]. The babies from the poorest homes and those who have the poorest development are the most likely to drop out. It is surprising that so few studies have been undertaken in developing countries, where SGA infants are more common and the children are exposed to more deprived environments, so that their development may be very different. All aspects of the development of SGA babies were recently reviewed at a meeting of the International Dietary Energy Consultative Group [14–17]. SGA infants were found to suffer from more infections and higher mortality rates in the first year of life than NBW babies [18].

Studies of children in the first two years

Most studies evaluating SGA children before 12 months have failed to find differences in developmental levels between SGA and NBW infants [19–22] (table 1) [15, 19–24]. However, a recent Brazilian study showed that SGA babies scored significantly lower on the Bayley mental and motor subscales at 6 months and that the difference increased by 12 months [15].

Four other studies compared SGA and NBW children between 12 and 24 months, and all found deficits in the mental development of SGA children [20, 21, 23, 24], but in most cases the differences were attributed to particularly vulnerable subgroups. For instance, in a study of American toddlers, only male or African-American SGA children showed a deficit [23]. Others reported that the deficits were almost entirely found in children who had neonatal asphyxia or congenital anomalies [24], and that children with birthweights below 2,300 g were entirely responsible for the deficits in the SGA group [21]. In the remaining study, the difference between groups was only significant in those who had appropriate ponderal indices (API) at birth, indicating that the foetus may have been undernourished in early pregnancy [20].

Studies of children two to seven years of age

Some studies followed the children for several years, and the findings sometimes changed with the age of follow-up. In American children who were assessed at 4, 5, and 7 years of age, IQ, language development, and reading readiness were worse in LBW children when gestational age was controlled for, even without differences at 8 months of age [19]. Similarly, SGA Guatemalan children who had not been different from NBW children before 12 months had significantly poorer developmental levels in their second year and had lower scores on a cognitive battery verbal factor score than the NBW group at 3 years of age [20, 26]. Differences between the groups disappeared on subsequent evaluations at 4 and 5 years [26].

Details of studies of children 3 to 8 years of age, mostly from developed countries, are given in table 2 [11, 17, 20, 26–31]. Children who were SGA generally performed worse than those who were NBW in tests of cognition [20, 26], IQ [11, 17, 28–32], and language [27]. In two studies the SGA group performed worse than the NBW group, but the difference did not reach significant levels, perhaps because the sample sizes were small [28, 31].

Studies of children 7 to 17 years of age

Hack's comprehensive review [16] identified 12 long-term follow-up studies of SGA children under 18 years of age, all but one [33] from developed countries. All studies in which IQ was measured showed that SGA children had lower scores [34–36] or higher rates of mental retardation [37] or learning deficits [38] than adolescents who were NBW, although the differences were sometimes small and not significant [39]. Studies of older adolescents or adults have had inconsistent findings and suffer from a large number of drop-outs [16].

The only other study from a developing country in which SGA children were followed up to this age was in Guatemala; surprisingly, no long-term effects of SGA on cognition were found [40]. It may be that the definition used for SGA (10th centile for gestational age) is too high for an index of risk or that undernutrition and other disadvantages in childhood overwhelm the relatively small effect of SGA. One study attempted to

TABLE 1. Studies of term SGA babies in the first two years of life

Study	Definition	SGA	NBW	Age at follow-up (mo)	Tests	Results
Rubin et al. (1973) USA [19]	>2,500 g	46	85	8	Bayley	NS
Parmelee & Schulte (1970) Germany [22]	10th centile	22	25	10	Gesell	NS
Nelson et al. (1996) USA [23]	15th centile	373	576	12	Fagan Bayley PDI*	NS MDI NS
Low et al. (1978) Canada [21]	10th centile (6 preterm)	86	97	612	Bayley Bayley & Behaviour	NS PDI*, MDI* activity* & energy
Villar et al. (1984) Guatemala [20]	10th centile	59	146	6, 15 24	Infant scales Infant scales	NS SGA, API infants' MDI*, PDI NS
Tenovuo et al. (1988) Finland [24]	2.5 centile	519	3,375	24	Denver & abnormal*	More doubtful
Grantham-McGregor (1998) Brazil [25]	>2,500g	131	131	612	Bayley Bayley Behaviour	PDI* & MDI* PDI* & MDI* Less happy* cooperative*, responsive*, & vocal*

* SGA significantly lower or worse than NBW.

Abbreviations: API, appropriate ponderal index; LPI, low ponderal index; MDI, mental development index of the Bayley Scale; NBW, normal birthweight; NS, not significant; PDI, psychomotor development index of the Bayley Scale; SGA, small for gestational age.

Source: modified from ref. 15.

address this point [31]; Indian children who were chronically undernourished and were LBW were compared with similarly undernourished children who were NBW. The groups' scores on cognitive tests were not significantly different, but the LBW group's scores were consistently lower, suggesting that a small disadvantage remained. However, further research on this point is needed for more certainty. Both groups' scores were markedly lower than a third of the adequately nourished group.

Other outcomes

Apart from poorer cognition, SGA children have other disadvantages. Few studies have looked at behaviour, but most of those that have looked at behaviour have found behavioural differences. In the first two years, SGA children were found to be less active, vocal, responsive, happy, and cooperative [15, 21]. At school age, they were more fidgety or active [39, 41], were more anxious and less happy [21, 41], and had a poor attention span [21, 39, 41]. These behaviours themselves could lead to poor development. More than half of the studies looking at school achievement found that SGA children performed less well than controls. They were also more likely to have minimal neurological dysfunction [17].

Interactions with the environment

Several studies have found that birthweight interacts with other conditions and that generally the effects of SGA are greater in children from poor homes. In a recent study in Brazil [25], the development of SGA infants was affected by the stimulation in the home, whereas the development of NBW infants was not. Similarly, the SGA infants were detrimentally affected by

TABLE 2. Studies of term SGA children 3–8 years of age

Study	Definition of SGA	Samples	Age (yr)	Tests	Results
Villar et al. (1984) Guatemala[20]	10th centile API & LPI	59 SGA 146 NBW	3	Cognitive battery	Both API* & LPI* lower than NBW, API lower than LPI in 7 of 8 tests
Gorman & Pollitt (1992) Guatemala [26]	10th centile API	41 SGA 85 NBW	3–5	Cognitive battery forming memory & verbal factors	Verbal factor score* Memory factor score*, SES SGA, & growth in 1st year SGA significant
Walther & Ramaekers (1982) Netherlands [27]	10th centile, PI <10th centile	25 SGA 25 NBW	3	Reynell language	SGA lower scores*
Pryor (1992) New Zealand [11]	3rd centile 44 NBW	67 SGA	4	Stanford-Binet	SGA lower IQ*
Babson & Kangas (1969) USA [28]	2,000–2,700 g 43 NBW	43 SGA	4	Stanford-Binet	NS
Fancourt et al. (1976) UK [29]	10th centile & ultrasound	SGA; 13 IUGR <26 wk; 18 IUGR 26–34 wk; 10 IUGR >34 wk; 19 no IUGR	4	Griffiths	IUGR <26 wk significantly lower scores; other groups NS
Harvey et al. (1982) UK [30]	Same samples as above	51 SGA 50 NBW	5	McCarthy scales	IUGR <26 wk significantly lower scores; other groups NS
Fitzhardinge & Steven (1972) Canada [31]	–2 SD 36 NBW siblings	96 SGA,	4	Hearing, vision, speech	Increased speech & hearing problems*
			4–8	Stanford-Binet	NS
				WISC	NS
				School achievement	School failure increased in SGA*
Goldenberg et al. (1998) USA [17]	15th centile	196 SGA 303 NBW	5	WPPSI	SGA lower scores*

* SGA significantly lower score than NBW.

Abbreviations: API, appropriate ponderal index; IUGR, intrauterine growth retardation; LPI, low ponderal index; NBW, normal birthweight; NS, not significant; PI, ponderal index; SES, socio-economic status; SGA, small for gestational age; WISC, Weschler Intelligence Scale for Children; WPPSI, Wechsler Preschool and Primary Scale of Intelligence.

Source: modified from ref. 15.

having illiterate mothers and frequent diarrhoea, whereas the NBW babies were not. This finding suggests that SGA babies are more vulnerable to the environment.

Conclusions about the effects of IUGR on development

Studies of SGA have had many design problems, making it difficult to draw conclusions. Cognitive effects tend to vary by age; they are less likely to be apparent in the first year of life and more likely to be apparent in middle childhood. In developed countries, cognitive deficits are usually small but may be important on a population scale. In late adolescence and adulthood, the findings are inconsistent. In addition to poorer cognitive function, children often have behaviour problems, minimal neurological dysfunction, and poor school achievement. The effect of birthweight sometimes varies according to the quality of the environment and the

health and nutrition of the child. There are only two long-term studies from developing countries, too few to draw any conclusions about the long-term effects of SGA. In view of the large number of children affected, more information is required.

From a policy perspective, these children are at risk for poor health and nutrition as well as poor development; therefore, integrated programmes including stimulation, health, and nutrition would be the most useful. Programmes of increased stimulation for LBW babies in early childhood have been successful in the United States [42, 43] and should be helpful in developing countries.

Breastfeeding

According to UNICEF figures for 1990–1996, 44% of children in developing countries are exclusively breastfed from 0 to 3 months, 45% are breastfed while receiving complementary foods at 6 to 9 months, and 50% are still breastfed at 20 to 23 months [44]. Values from developing countries for exclusive breastfeeding up to 3 months range from 2% in Nigeria to 90% in Rwanda, whereas values for breastfeeding at later ages are much more consistent across countries. These data suggest that cultural, country-specific variables may influence the exclusivity but not the basic practice of breastfeeding.

Study design

One major difficulty that emerges when comparing studies of the effects of breastfeeding on mental development and behaviour is defining what it means for a baby to have been breastfed. Several variables are critical, including length and exclusivity of breastfeeding. Whereas some studies have strict definitions and multiple possible categories for length and exclusivity, some use length of breastfeeding as a continuous variable, some rely on dichotomous definitions with 1 day of breastfeeding valued the same as 6 months, and others compare exclusively, extensively breastfed with exclusively, extensively bottle-fed infants. The studies are also inconsistent in their reports of bottled-milk composition, making it difficult to compare direct nutrient intake and to make direct comparisons. Some studies compare babies who are breastfed with babies who are fed enriched pre-term formula, whereas others compare babies who are breastfed with babies fed unmodified, diluted cow's milk [45] or condensed milk [46].

The studies are also difficult to compare because they vary in their exclusion criteria, with some studies setting particular cut-offs for birthweight, Apgar scores (an indicator of intrapartum stress, comprising a rating of colour, tone, irritability, heart rate, and respiratory effort of the baby at birth), gestational age, or health at birth, and others including all children born during a particular time period. If these factors are not controlled for in the study design, bias may be introduced, because children who are sick at birth are less likely to breastfeed. Similarly, the studies vary in terms of their inclusion of covariates in the analyses. Breastfeeding is positively correlated with several familial characteristics, including maternal education level [47–49], paternal education level [45], maternal age [50], and socioeconomic status [45, 47, 50–56], and is negatively correlated with family size [45, 48], birth rank [45], maternal smoking [48, 54], and crowding [51, 52]. Since these factors have been shown to have an independent, positive effect on cognition and development [57], it is difficult to separate the direct effects of breastfeeding from the indirect effects of the familial characteristics associated with breastfeeding. Although some studies have attempted to control for these variables in design and analyses, most studies have included only a limited number of these factors.

With these limitations in mind, studies of the effects of breastfeeding on mental and behavioural development will be reviewed. All studies reviewed tested the basic hypothesis that breastfed infants have advantages over bottle-fed infants. The review is divided into short-term (0–24 months) and long-term (3–50 years) effects of breastfeeding. We have presented detailed information about each study in the tables and limited discussion in the text to the main points only. Mechanisms will also be discussed, followed by conclusions and programmatic implications of the current data.

Short-term effects of breastfeeding

We found eight studies assessing the concurrent effects of breastfeeding on development; these papers review research on children 24 months old and younger (table 3) [Morris S, personal communication, 1998; 49; 52; 54; 56; 58–60]. Most studies in this category used correlational analyses, which means that there are limits to the conclusions that can be drawn from the data. However, the studies are comparable in their fairly consistent use of the Bayley Scale of Infant Development as the major outcome measure, although they varied in their use of the mental development (MDI) and psychomotor development (PDI) subscales. Some of these studies controlled extensively for socio-economic and maternal characteristics [Morris S, personal communication, 1998; 52; 54; 58], whereas others had limited measures [49, 56, 59, 60].

Of the five studies [Morris S, personal communication, 1998; 54; 56; 58; 59] evaluating infants at 6 months, two showed significant differences between infants who had been breastfed and those who had not [Morris S, personal communication, 1998; 54]. In all other studies, the breastfed infants scored higher, albeit non-

TABLE 3. Studies of the effects of breastfeeding on physical and mental development in children 0–2 years of age

Study	Sample	Measurements	Results
Morris (1998) Brazil [personal communication]	*n* = 208 BF: frequency of feeds recorded by observer Born at ≥37 wk Family income below set standard No congenital or neurological abnormalities Assessed at 6 & 12 mo	Bayley Scale (MDI & PDI) Other variables: family income, household resources, housing/ sanitation/water index, parental literacy	6 mo: positive correlation between MDI & average number of feeds in 1st 4 wk*; weaker correlation with PDI 12 mo: no association with control for SES
Young et al. (1982) Italy [56]	*n* = 1041 (divided analyses by sex, M/F) VLBF: >7 mo LBF: mixed (formula after 2 mo) NBF: no BF Retrospective study with infants divided into 3 SCs (high, middle, low) Assessed at 6, 8, 10, 12, 14, 16 mo	Bayley Scale (MDI & PDI) General physical examination SC	VLBF> LBF & NBF at all ages, variable significance 6 mo: NS 8 mo: $p<.02$ (M, low SC) 10 mo: $p<.05$ (F, high SC) 12 mo: $p<.05$ (F, low SC) 14 mo: $p<.01$ (F, low SC) 16 mo: $p<.05$ (F, low SC)
Morrow-Tlucak et al. (1988) USA [58]	*n* = 219 VLBF: >4 mo (*n* = 23) LBF: 1 wk–4 mo (*n* = 39) NBF: no BF (*n* = 157) Born at ≥37 wk No neonatal problems No maternal narcotic use Assessed at 6, 12, 24 mo	Bayley Scale (MDI) Home environment (HOME) Other variables: maternal IQ (PPVT), maternal age, child-rearing techniques (authoritarian family ideology), race, birth order	VLBF>LBF>NBF at all ages, significant at 12 mo & 2 yr No. of weeks of breastfeeding entered as continuous variable predicting MDI 6 mo: NS 12 mo: $p = .018$ (11.7% var.) 24 mo: $p = .009$ (5.6% var.) Controlled for SES
Rogan & Gladen (1993) USA [59]	*n* = 855 at enrolment *n* = 788 (6 mo), 720 (12 mo), 676 (18 mo), 670 (24 mo) *n* values from enrollment: VLBF: >20 wk BF (*n* = 177) LBF: 5–19 wk BF (*n* = 294) MBF: 0–4 wk BF, late weaning (*n* = 184) SBF: 0–4 wk BF, early weaning (*n* = 97) NBF: no BF (*n* = 103) Assessed at 6, 12, 18, & 24 mo	Bayley Scale (MDI & PDI) Other variables: maternal age, race, occupation, education, smoking, alcohol use Child's sex, birthweight, birth order	All BF>NBF 6 mo: NS 12 mo: NS 18 mo: NS 24 mo: MDI*/PDI* when all covariates controlled for

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significantly, than non-breastfed infants.

Of the five studies assessing infants at 12 months, two found a clear, significant effect [54, 58], and one found an effect limited to girls of the lowest social class [56]. In the other two studies [59] (S. Morris, personal communication, 1998), although the breastfed infants had higher developmental scores, the difference was not significant. At 18 months, breastfed infants per-

TABLE 3. Studies of the effects of breastfeeding on physical and mental development in children 0–2 years of age *(continued)*

Study	Sample	Measurements	Results
Ounsted et al. (1988) UK [53]	*n* = 137 SGA BF: any BF at all (*n* = 96–114) NBF: no BF (*n* = 20–21) BW < –2 SD below mean gestational age & sex Assessed at 6 & 12 mo	Neurological development: "neurobehavioural score," "motor score," "social score" (assortment of various tests) Other variables: maternal age, weight, height, smoking, & several factors about pregnancy, BW, birth order	Neurobehavioural score: 6 mo: BF>NBF*; 12 mo: BF>NBF* Motor score: 12 mo: BF>NBF** Social score: 12 mo: BF>NBF NS No control for SES
Florey et al. (1995) UK [48]	*n* = 592 BF: any BF at all NBF: no BF Firstborn singletons Stratified into 5 SCs Assessed at 18 mo	Bayley Scale (MDI & PDI) Other variables: maternal smoking & alcohol use, SC, education, age, height	MDI: BF>NBF for all SCs except V PDI: no clear effect
Temboury et al. (1994) Spain [51]	*n* = 229 BF: ≥3 mo (*n* = 130) NBF: BF <1 mo (*n* = 99) Born at >36 wk BW >2,400 g Apgar >7 No major health problems Assessed at 18–19 mo	Bayley Scale (MDI & PDI) Other variables: SC (Graffard Test); mother's education, job, age, number of children, psychosocial risk; child's behaviour	Lower score on MDI predicted by bottle-feeding (OR = 1.97, *p* = .019) Other significant factors: lower SC, having siblings, temper tantrums
Morley et al. (1988) UK [60]	*n* = 771 LBW BF: mother's choice BF in 1st 72 h (*n* = 227–245) NBF: mother's choice no BF in 1st 72 h (*n* = 469–513) BW: <1,850 g Assessed at 18 mo	Bayley MDI, DP II Other variables: SC, parental occupation & education, birth rank	BF>NBF MDI: 103.3>95.4*** DP: 108.3>101.5*** After inclusion of covariates, advantage of 4.3 points**

* $p < .05$, ** $p < .01$, *** $p < .001$.

Abbreviations: BF, breastfeeding; BW, birthweight; DP, developmental profile; IQ, intelligence quotient, LBF, long breastfeeding; LBW, low-birthweight; MBF, moderate breastfeeding; MDI, mental development index of the Bayley Scale; NBF, no breastfeeding; NS, not significant; PDI, psychomotor development index of the Bayley Scale; PPVT, Peabody Picture Vocabulary Test; SBF, some breastfeeding; SC, social class; SES, socio-economic status; SGA, small for gestational age; VLBF, very long breastfeeding; VVLBF, very, very long breastfeeding.

formed significantly better than non-breastfed infants on the Bayley MDI [49, 52, 60], but not in all cases [59].

At 24 months, infants breastfed exclusively for more than 3 months appeared to have a significant advantage over non-breastfed infants, even when socio-economic variables were controlled for [52, 58, 59]. Although the socio-economic variables often made significant contributions to the children's development, the results suggest that breastfeeding had an independent effect. There is some evidence that a positive linear relationship exists between time of breastfeeding and test score [59].

In summary, breastfed infants appear to have a small but consistent advantage over non-breastfed infants in mental development at all time points up to 24 months. The effects are more consistently statistically significant at the later ages, although benefits were shown as early as 6 months in some studies. The reason for differential significance over time may be that the Bayley is not sensitive enough to detect developmental delays affected by breastfeeding in the first 12 months of life [61]. There is no clear evidence of a differential effect of breastfeeding in different social classes, because in some cases the higher social classes benefited [49, 56], whereas in others, the lower classes did [56].

Long-term effects of breastfeeding

We located 14 papers evaluating the longitudinal effects of breastfeeding on mental development and behaviour, with assessments when the children were 4 to 18 years of age (table 4) [45–48, 50, 51, 53, 55, 59, 62–68]. In evaluating the longitudinal effects of breastfeeding, two additional problems emerge. First, it is difficult to validate breastfeeding recall techniques. Specifically, some studies have been careful to collect breastfeeding frequency data from many sources (e.g., hospital records, parental questionnaires), whereas others have relied solely on maternal recall several years later. Second, since the age range in this section is so large, the tests varied considerably. Although most of the studies included some general measure of IQ, the specific tests are not always comparable, and some looked only at neurological function [67] or behaviour [66].

All studies we found, which included follow-up of people 3 to 50 years old, indicated a small yet consistent developmental benefit to those who had been breastfed. In most studies, the benefit of breastfeeding remained significant with the inclusion of socio-economic factors as covariates [45, 48, 50, 51, 55, 59, 62, 68]. However, the results of some studies lost significance when socio-economic factors were taken into consideration [47, 51, 63], and some did not include any control for social factors in the analyses [46, 64, 65].

In order to compare the effect sizes of these studies, we calculated the difference between groups in terms of cognitive outcome as a percentage of the standard deviation. As is evident in figure 1, the effect of breastfeeding ranges from 6% to 66% SD, with an approximate mean of 22%. The largest effect [55] was evident in children born to mothers who had "high-risk" pregnancies, suggesting differential vulnerability to the effects of breastfeeding according to health status at birth. Extensive breastfeeding (>12 months) has been shown to have a detrimental effect on mental development when it is exclusive [46] but not when it is non-exclusive [51].

Unfortunately, no longitudinal studies have been undertaken in developing countries. It is very likely that the benefits of breastfeeding on mental and behavioural development may be greater in developing countries, particularly with poor formula alternatives.

Mechanism

The benefits of breastfeeding may be a consequence of several different but related pathways. There may be a directly beneficial effect of the nutrient composition, particularly fatty acid consumption, or there may be indirect benefits from the increased immune response or mother–child interaction associated with breastfeeding.

Fatty acids

The brain is composed largely of lipids, a large proportion of which are long-chain polyunsaturated fatty acids (PUFAs), which are critical because of their role in membrane phospholipid composition (reviewed in [69]). The most important PUFAs are docosahexaenoic acid (DHA, 22:6n-3) and arachidonic acid (AA, 20:4n-6), which are derived from the parent compounds linoleic acid (LA, 18:2n-6) and linolenic acid (LnA, 18:3n-3). During the last trimester of pregnancy and for many months after birth, the uptake of DHA and AA by the fetal brain and retina increases dramatically in humans [70]. LA and LnA are considered essential fatty acids (EFA) because they cannot be synthesized de novo in any mammals and must be provided in the diet.

Breastmilk is a rich source of EFAs [71]. In contrast, EFA concentration in formula is generally insufficient for infants [72, 73], as evidenced by studies showing

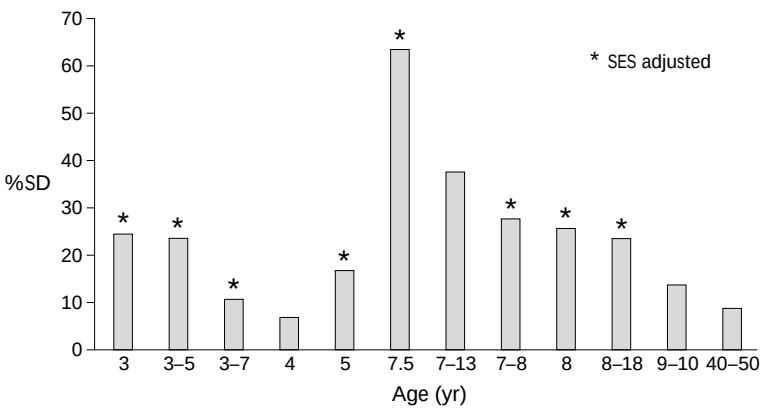

FIG. 1. Long-term effects of breastfeeding. The figure shows the difference in IQ between breastfed and non-breastfed children expressed in standard scores [45–48, 50, 51, 53, 55, 59, 62, 63, 68]

TABLE 4. Studies of the long-term effects of breastfeeding (organized by age of assessment)

Study	Sample	Measurements	Results
Niemelä & Järvenpää (1996) Sweden[47]	*n* = 726 LBF: ≥5 mo BF (*n* = 363) SBF: <5 mo BF (*n* = 363) Born at term, hospital <14 days, no chronic disease or "severe anomaly" Groups matched for sex & maternal education Assessed at 56 mo	General cognitive capacity 1. Non-verbal (Columbian Mental Maturity Scale) 2. Visual motor-integration (Beery Test) 3. Active vocabulary Other variables:maternal education, parents' living status, maternal smoking habits	LBF > SBF 1. 50.0 > 47.6** 2. 7.5 > 7.1* 3. 50.5 > 49.5 With control for SES
Rogan & Gladen (1993) USA [59]	*n* = 855 at enrollment *n* = 645 (3 yr), 628 (4 yr), 636 (5 yr) (*n* values from enrollment) VLBF: >20 wk BF (*n* = 177) LBF: 5–19 wk BF (*n* = 294) MBF: 0–4 wk BF, late wean (*n* = 184) SBF: 0–4 wk BF, early wean (*n* = 97) NBF: no BF (*n* = 103) Assessed at 3, 4, 5, 7, 8–10 yr	Mental development: McCarthy (3, 4, & 5 yr) Report cards (8–10 yr) Other variables: maternal age, race, occupation, education, smoking, alcohol use. Child's sex, BW, birth order. Prenatal exposure to polychlorinated biphenyls & dichlorodiphenyl dichloroethane	Any BF always > NBF in McCarthy & report cards, higher scores associated with increased BF Controlled for SES
Fergusson et al. (1982) New Zealand [62]	*n* = 1,037 (3 yr), 991 (5 yr), 954 (7 yr) LBF: ≥4 mo BF (*n* = ?) SBF: 0–4 mo BF (*n* = ?) NBF: no BF (*n* = ?) Assessed at 3, 5, 7 yr	Mental development 3 yr: PPVT; 5 yr: Stanford-Binet IQ; 7 yr: WISC Language development 3 & 5 yr: Reynell Developmental Language Scales; 7 yr: Illinois Test of Psycholinguistic Abilities Articulation 5 & 7 yr: Dunedin Articulation Screening Scale Other variables: maternal intelligence, education level, training in child rearing, "child experiences," family SES, child's BW & gestational age	LBF > SBF > NBF for all unadjusted scores at all ages (LBF/NBF difference, 2–5 points) Range of differences (from 3 tests adjusted for all other variables) (LBF vs NBF): 3 yr, 1.85**–2.71***; 5 yr, 1.54**–2.53***; 7 yr, 0.63NS–2.31** Difference between LBF & SBF NS
Jacobson & Jacobson (1992) USA [63]	*n* = 323 BF: 5 categories (not described, but average of 26 wk) NBF: no BF White, middle-class Assessed at 4 yr	Mental development: McCarthy Scales, PPVT-R Other variables: maternal IQ, SES, parenting style, mother-child interaction	BF > NBF McCarthy: 105.3 >100.7* PPVT-R: 104.4 > 98.0* NS after inclusion of maternal IQ & parenting score

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TABLE 4. Studies of the long-term effects of breastfeeding (organized by age of assessment) *(continued)*

Study	Sample	Measurements	Results
Taylor & Wadsworth (1984) UK [50]	*n* = 13,135 LBF: >3 mo BF MBF: 1–3 mo BF SBF: <1 mo BF NBF: no BF Assessed at 5 yr	Mental development (EPVT, copying designs) Speech problems Child behaviour (maternal report) Other variables: child sex, BW, birth order, maternal age, smoking, "social index"	All BF > NBF in EPVT* & copying* SES controls No clear effect on behaviour or speech
Broad (1979) New Zealand [64]	*n* = 319 BF: not defined (*n* = 133) NBF: not defined (*n* = 186) Assessed at 5–6 yr	Speech ability Reading ability	BF improves speech clarity***, tonal quality**, & reading ability* in boys No difference in girls No SES control
Pollock (1994) UK [65]	*n* = 3,838 BF: >3 mo exclusively (*n* = 353) NBF: >3 mo bottle (*n* = 3,485) Mother >17 yr, gestation >36 wk, BW >2,538 g, no incubation, father lives with baby Assessed at 5 & 10 yr	Mental development 5 yr: EPVT, copying & drawing tests 10 yr: BAS, school achievement, EPVT Other variables: huge number of socio-economic variables, e.g., parental background, education, "circumstance," pregnancy duration, labour intensity	5 yr: EPVT score of BF above average for combined groups*; drawing & copying NS 10 yr: benefit in BAS*; school achievement NS EPVT NS No control for covariates
Fergusson et al. (1987) New Zealand [66]	*n*=772–1,064 Duration of BF assessed at 6, 7, 8 yr	Child behaviour: (Rutter Behaviour Questionnaire: conduct disorder, timidity, hyperactivity, social isolation) Other variables: social background, maternal IQ, "stability"	Maternal rating: small association between increased BF & reduced levels of conduct disorder Teacher rating: no consistent association
Hoefer & Hardy(1929) USA [46]	*n* = 383 VVLBF: 10–20 mo BF exclusively (*n* = 190) LBF: 4–9 mo BF exclusively (*n* = 77) MBF: ≤3 mo BF exclusively (*n* = 78) NBF: no BF (*n* = 38) Assessed at 7–13 yr	Mental development (IQ: Stanford-Binet, EQ: "educational quotient," PQ: Pintner-Patterson performance test of nonverbal intelligence) Age of talking (mo)	LBF > NBF/MBF/VVLBF IQ: 107.6 > 102.3/101.9/100.6 EQ: 112.1 > 106.5/109.6/105.5 PQ: 128.3 > 122.0/125.3/121.5 Talking: 13.7 < 15.2/13.7/14.5 No SES control

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TABLE 4. Studies of the long-term effects of breastfeeding (organized by age of assessment) *(continued)*

Study	Sample	Measurements	Results
Ounsted et al. (1984) UK [55]	*n* = 239 BF: >2 mo BF (*n* = 21) NBF: no BF (*n* = 218) Study of "high-risk" pregnancies Assessed at 7.5 yr	Mental development: (reading quotient, Holborn reading test, BAS, reasoning, spatial imagery, perceptual maturity, memory, retrieval knowledge) Other variables: 15 maternal, foetal, perinatal, postnatal, & environmental factors	NBF associated with decreased scores on all mental development tests, with control for social class Reading quotient*, "reasoning" subscale* when SES controlled
Lucas et al. (1992) UK [53]	*n* = 300 who had been LBW BF: mother's choice BF in 1st 72 h (*n* = 227–245) NBF: mother's choice no BF in 1st 72 h (*n* = 469–513) BW: <1,850 g No major congenital malformations Assessed at 7.5–8 yr	WISC-R Other variables: social class, parental occupation & education, birth rank, gestational age, mother's age, days of ventilation	BF > NBF when controlling for SES Dose-related advantage
Rodgers (1978) UK [45]	*n* = 2101 (1st assessment) *n* = 1961 (2nd assessment) BF: BF exclusively (*n* = 1291) (95% had weaned by 12 mo) NBF: no BF (*n* = 1133) Singletons, born to married mother, bias to include those born to non-manual & agricultural workers Assessed at 8 & 15 yr	8 yr: picture intelligence, mechanical word reading 15 yr: reading attainment, sentence completion, non-verbal ability, mathematics Other variables: BW, birth order, social class, parental educational background, parental interest in schooling, home conditions	When covariates controlled for: 8 yr: BF > NBF: picture intelligence***; 15 yr: BF > NBF: reading attainment***, sentence completion***, non-verbal ability***, mathematics***
Lanting et al. (1994) Netherlands [67]	*n* = 526 BF: ≥3 wk BF exclusively (*n* = 135) SBF: BF + formula <3 wk (*n* = 33) NBF: no BF (*n* = 358) Gestational age ≥37 wk No admission to pediatric or neonatal ward after birth Assessed at 9 yr	Neurological examination	BF rated better at follow-up neurological examination than (SBF & NBF)**
Malloy & Berndes (1998) USA [47]	*n* = 518 BF: >1 day BF (*n* = 342) NBF: no BF (*n* = 176) High SES Assessed at 9–10 yr	WISC-R (IQ) verbal performance subscales Other variables: maternal education, paternal education, annual income	BF > NBF Verbal IQ: 122.4 > 117.6*** Performance IQ: 116.6 > 114.3 Total IQ: 121.9 > 117.8** Significance lost with inclusion of covariates

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TABLE 4. Studies of the long-term effects of breastfeeding (organized by age of assessment)

Study	Sample	Measurements	Results
Horwood & Fergusson (1998) New Zealand [68]	*n* = 772–1,064 VLBF: ≥ 8 mo LBF: 4–7 mo MBF: <4 mo NBF: no BF Assessed at 8–18 yr	Mental development: 8–9 yr: WISC-R; 10–18 yr: reading, comprehension, mathematical reasoning, school achievement tests, attainment on school-leaving examinations Other variables: maternal age, SES, family living standards, maternal smoking	VLBF > LBF > MBF > NBF for all time points, 8–18 yr 10 of 12 tests significant when covariates controlled for Linear relationship between duration of breastfeeding & cognitive ability
Gale & Martyn (1996) UK [51]	*n* = 994 BF: BF exclusively (*n* = 658) (80% weaned by 12 mo) SBF: (*n*=283) NBF: no BF (*n*=53) Singleton, born to married mother Assessed at 40–50 yr	Mental development AH4 IQ test (logical, verbal, arithmetic reasoning) Other variables: BW, maternal age, father's social class, birth order, pacifier (dummy) use	BF > NBF > SBF IQ: 22.3 > 21.5 > 20.8 (difference between 3 feeding groups*) Significance lost with inclusion of covariates

*$p < .05$, **$p < .01$, ***$p < .001$.

Abbreviations: BAS, British Ability Scales; BF, breastfeeding; BW, birthweight; EPVT, English Picture Vocabulary Test; IQ, intelligence quotient; LBF, long breastfeeding; MBF, moderate breastfeeding; NBF, no breastfeeding; NS, not significant; PPVT, Peabody Picture Vocabulary Test; PPVT-R, Peabody Picture Vocabulary Test—Revised; SBF, some breastfeeding; SES, socio-economic status; VLBF, very long breastfeeding; VVLBF, very, very long breastfeeding; WISC, Weschler Intelligence Scale for Children; WISC-R, Weschler Intelligence Scale for Children—Revised.

that infants born pre-term who are fed EFA-supplemented formula have better visual acuity [74–76] and higher plasma levels of EFA than infants fed unsupplemented formula. However, the limited data comparing the developmental outcome of pre-term infants supplemented with EFA suggest no clear results [73, 77, 78]. The one intervention study comparing pre-term infants fed pre-term formula, term formula, and expressed breast milk [53] found a significant increase in the MDI of breastfed babies at 18 months, but only in comparison with those infants receiving term formula.

Growth

Improved development may also be related to improved growth. However, the effects of breastfeeding on linear growth are not consistent. In developing countries, increased breastfeeding has been associated with increased weight-for-age at 6 to 12 months of age [46, 51, 79–83] and mid-upper-arm circumference at 18 months [84]. However, other studies have shown no benefit to growth in the first 6 months [85], and increases in malnutrition related to breastfeeding during the second year [86–90], particularly in the presence of other risk factors, such as low food intake and high diarrhoeal morbidity [90]. On the basis of an excellent Peruvian study examining the causality of the relationship between linear growth retardation and breastfeeding, it appears that poor growth and ill health lead to increased breastfeeding, rather than prolonged breastfeeding leading to malnutrition [91].

Immune response

In both developing and developed countries, breastfeeding has been associated with an increased infant immune response [92], resulting in decreased levels of gastrointestinal illness [93], respiratory tract and ear infections [94–98], diarrhoea (particularly in the first year of life) [95, 96, 98–102], and chronic constipation [47]. Protection against infection in infancy appears to be dose-related [95], implying that even small amounts of breastmilk can have a beneficial effect. It is very likely that the increased health status of breastfed infants and children may have a positive effect on mental and motor development.

Maternal–child interaction

Breastfeeding promotes maternal–child responsivity [58]. Children who have temper tantrums are more likely to be bottle-fed [52]. The effects of a secure at-

tachment between mother and child may be that the child has improved behaviour, which could then lead to improved learning and responsivity in school

Conclusions and policy implications

Most studies of the effects of breastfeeding on mental development have used correlational analyses, which means that there are limits to the conclusions that can be drawn from the data, particularly because of the numerous confounding variables. However, the consistency of the data suggests that there is a small benefit to children's development. There is a surprising lack of information from developing countries, where the benefits from breastfeeding for mental development are likely to be more substantial, in the context of all the other health benefits of breastfeeding.

There is no doubt that programmes to promote breastfeeding should be encouraged. An example of such programmes is the Baby-Friendly Hospital Initiative (BFHI), a UNICEF-WHO initiative designed to transform maternity hospitals around the world so that they offer breastfeeding support. BFHI has outlined 10 steps to successful breastfeeding [103](table 5).

According to UNICEF reports [44], the BFHI has been extremely successful and has helped transform over 12,700 hospitals in 114 countries into centres of breastfeeding support in just six years. According to UNICEF, BFHI has resulted in substantial health gains. For instance, the Ministry of Health in Panama reported that in one year in one health facility, the BFHI resulted in a 58% reduction in respiratory infections and a 15% reduction in diarrhoea in infants. Similar results have been reported in Brazil, Gabon, Chile, China, Iran, Cuba, and the Republic of Moldova [44].

Protein-energy malnutrition

It is estimated that 19% of children under five years old in South Asia and 10% of children in sub-Saharan Africa are severely underweight (weight-for-age below –3 SD of the reference) [44]. Although the prevalence of moderately (weight-for-age below –2 SD of the reference) and severely underweight children is estimated to have declined globally from 38% in 1980 to 34% in 1990 to 30% in 1997, not all countries have shown this decline.

Although the term protein-energy malnutrition is used to classify kwashiorkor, along with marasmus and milder forms of malnutrition, it is recognized that many nutrient deficiencies are present in protein-energy malnutrition. There have been propositions to replace the term "protein-energy malnutrition" with "energy-nutrient malnutrition." However, protein-energy malnutrition is still the standard term in use. Waterlow and Rutishauser [104] suggested that protein-energy malnutrition be classified by the degree of wasting and stunting. Wasting (weight expressed as a percentage of the expected weight-for-height) indicates current or recent nutritional conditions, whereas stunting (height-for-age) indicates nutritional experiences over a longer period of time. It is probable that the duration of malnutrition is more highly related to children's mental development than short-term severity.

TABLE 5. Ten steps to successful breastfeeding

Every facility providing maternity services and care for newborn infants should:

1. Have a written breastfeeding policy that is routinely communicated to all health care staff
2. Train all health care staff in skills necessary to implement this policy
3. Inform all pregnant women about the benefits and management of breastfeeding
4. Help mothers initiate breastfeeding within a half-hour of birth
5. Show mothers how to breastfeed and how to maintain lactation even if they should be separated from their infants
6. Give newborn infants no food or drink other than breastmilk, unless medically indicated
7. Practice rooming-in: allow mothers and infants to remain together 24 hours a day
8. Encourage breastfeeding on demand
9. Give no artificial teats or pacifiers to breastfeeding infants
10. Foster the establishment of breastfeeding support groups and refer mothers to them on discharge from the hospital or clinic

In addition, facilities should refuse to accept free and low-cost supplies of breastmilk substitutes, feeding bottles, and teats.

Severe malnutrition

The literature on the effects of severe protein-energy malnutrition on child development mostly concerns children who were in hospital with kwashiorkor, marasmus, or marasmic-kwashiorkor based on the old Wellcome classification [105]. These studies were recently reviewed in depth [106]. The main conclusions were, in spite of limitations of study design, that the evidence was strong but not unequivocal that severe malnutrition in early childhood leads to deficits in cognitive development and behaviour differences if the children return to poor environments. However, marked improvements are possible with vast improvements to the children's environment, such as occurs in adoption. More feasible simple interventions in the children's own homes can produce some benefits. However, the evidence for this is limited. The policy implications are that wherever severely malnourished children are being treated, attention should be paid to promoting the children's mental development

Moderate stunting and wasting

It is estimated that 37% of children under five years of age in developing countries, and up to 55% in South-East Asia, are moderately stunted [44] (height-for-age below –2 SD of the median of the reference population [107]). The prevalence of moderate wasting (weight-for-height below –2 SD) in children under five years of age in developing countries is 11% [44]. In this review we will focus particular attention on stunting, because it is highly prevalent and there is controversy as to whether it affects development. Height reflects the genetic potential of a population as well as the socio-economic, health, and nutritional conditions affecting the population [108]. The role of the environment is illustrated by the secular improvements in average height shown by populations over the last century in both European and non-European countries [109, 110]. The age of onset of stunting varies but is usually in the first two to three years of life [111, 112].

The aetiology of linear growth retardation is multifactorial but has been explained by three major factors: poor nutrition, high levels of infection, and problematic mother–infant interaction, which is closely related to the socio-economic status of the family [113]. In developing countries, poor nutrition plays a major role in the aetiology of stunting, although there is no clear consensus as to which nutrients are important. Energy, protein, zinc, and iron deficiencies have all been implicated [114], and the data implicating deficiencies of zinc [115] and protein [116] are the strongest. To a lesser extent, frequent or prolonged infections, particularly those causing diarrhoea, also play a role [114]. It is likely that the cause of stunting varies in different countries according to which nutrients are limiting for growth and morbidity prevalence.

Almost complete catch-up in growth can be achieved when children experience dramatic environmental change and an improved diet, such as occurs during adoption [117]. This phenomenon is very unusual in the context of the developing world, where poor conditions prevail and undernutrition is associated with several additional environmental disadvantages, such as poor housing and low maternal literacy [118]. In poor communities, even long-term nutritional supplementation of stunted children is unlikely to result in complete catch-up growth [119, 120], particularly in conditions of poverty [117, 121].

Stunting in poor populations is usually associated with poor mental development. However, the many sociocultural and economic disadvantages that coexist with stunting [108] may also detrimentally affect mental development, making it difficult to determine whether the poor development of stunted children is due to nutritional deficiency or whether stunting is just an indicator of poverty.

To understand the association between height and mental development in children, investigators have taken a variety of approaches. Some have examined cross-sectional correlations and have either disregarded or controlled for the children's socio-economic backgrounds, with varying degrees of rigour. Others have looked for longitudinal associations between change in height and change in mental development or have examined associations between height in early childhood and later mental development. A few investigators have conducted nutritional supplementation studies, which are probably the most efficient way to determine whether the link between stunting and poor mental development is related to nutritional factors.

Cross-sectional associations between height and development

Most cross-sectional studies have found significant associations between height-for-age and children's cognitive development. Associations between height-for-age and school achievement have been found in older children without controlling for socio-economic status [122–124]. Even after controlling for socio-economic conditions, investigators found significant associations between height-for-age and IQ, cognitive function, or school achievement levels in school-aged children in many countries, including the Philippines [125], Jamaica [126, 127], Guatemala [128], Nepal [129], Kenya [130], Bangladesh [131], and India [132].

Significant associations have also been found between stunting and poor psychomotor development in young children in Guatemala [133], Chile [134], Jamaica [118], and Kenya [135](table 6).

Only a few studies failed to find significant associa-

TABLE 6. Studies of associations between height-for-age and cognitive and motor development in infants and pre-school children

Study	Sample	Measurements	Results
Positive findings			
Sigman et al. (1989) Kenya [130]	*n* = 110 18–30 mo	Height Bayley Scales, MDI & PDI home observation of play	Bayley scores correlated positively with length (r = .25, p < .05) Simple play correlated negatively with length (r = –.24, p < .05), & more advanced functional & symbolic play correlated positively (r = .05, r = .13, respectively)
Powell & Grantham-McGregor (1985) Jamaica [118]	*n* = 168 6–30 mo	Height-for-age Griffiths Mental Development Scales, DQ	Height-for-age predicts DQ (p < .01, 33% variance explained) when child's age, sex, birth order, & family SES are controlled for
Lasky et al. (1981) Guatemala [133]	*n* = 418 assessed at 6 mo Same infants assessed at 15 (*n* = 383) & 24 (*n* = 334) mo	Height Mental & motor assessment: Composite Infant Scale	Mental & motor performance at 6, 15, & 24 mo correlated with length at 6, 15, & 24 mo (range, r = 0.18 to 0.35, p < .01 for all)
Mönckeberg (1972) Chile [134]	*n* = 118 1–3 yr	Height-for-age General DQ	1–3 yr: Positive correlation (r = .56, p < .001)
Negative findings			
Colombo et al. (1988) Chile [135]	*n* = 228 247–274 days 51–65 mo	Height-for-age DQ (Chilean scale) Height-for-age IQ (WISC)	No significant correlation *n* = 42 No significant correlation

Abbreviations: DQ, developmental quotient; IQ, intelligence quotient; MDI, mental development index of the Bayley Scale; PDI, psychomotor development index of the Bayley Scale; WISC, Wechsler Intelligence Scale for Children.

tions between height and measures of mental development or school achievement [136–139]. The reasons for the negative findings are not always clear, but small sample sizes may explain some findings [134]. In contrast to the findings with height-for age, weight-for-height has been only occasionally associated with children's development [130, 133, 140]. In most studies, severe and moderate stunting were much more common than severe and moderate wasting, which may partly explain this finding.

Behaviour

A small number of studies have been undertaken assessing the behaviour of mildly to moderately underweight infants or school-aged children who were also stunted to some degree. The results are fairly consistent: unsupplemented young children have been described as more quiet, reserved, withdrawn, and timid, with great difficulty making up their minds and a fear of novel situations [141]. When they were older, the children spent less time on task in the classroom, and cried and slept more than the supplemented children. Underweight children tended to be more anxious, less imaginative in their problem-solving approaches, and less environmentally involved than children of normal weight [142].

In a more recent study, stunted children between 9 and 24 months of age were found to have behavioural

differences, including decreased activity levels [143], and explored their environment with less enthusiasm and were less happy than non-stunted children [Meeks-Gardner JM, personal communication, 1998]. A subsample of these children at 8 years of age was also found to be more inhibited, less verbal, and less happy [144].

Other functional associations

Stunting has also been associated with poor fine motor skills in children from Bangladesh [131] and Jamaica [126], and poor neurosensory integration in children from Mexico [145]. In the Mexican study, the association was present in poor rural children but not in middle-class children. The authors suggested that stunting in middle-class children was due mainly to genetic tendencies and thus was not associated with functional deficits, whereas stunting in poor rural children was attributed mainly to poor nutrition that was associated with consequent functional deficits.

Cognitive function is more likely to be detrimentally affected by short-term hunger in stunted children than in non-stunted children [146]. Preliminary data from Jamaica also suggest that stunted children have higher levels of stress hormones (cortisol) and higher heart rates, implying that they may be less able to cope with environmental stressors and may have heightened arousal of the hypothalamic-pituitary-adrenal or autonomic nervous systems [144]. It is unknown whether this study can be replicated in other populations.

Longitudinal associations

In children who have recovered from marasmus, marasmic kwashiorkor, or kwashiorkor, height-for-age in the acute stage is usually a better predictor of mental development than weight-for-height or oedema [147, 148]. In both Guatemala [133] and Jamaica [149], change in height over a two-year period in the first three years of life was related to change in development.

Supplementation studies

The most effective way to demonstrate a causal relationship is through a treatment trial, and several supplementation studies have been conducted, some preventive and some therapeutic.

Preventive supplementation studies

Three preventive supplementation studies have been conducted in populations with endemic undernutrition. Although these studies were not planned specifically to examine stunting, the findings are relevant in cases in which both the height and development of the children improved. In three early studies of preventive supplementation in Guatemala [150], Colombia [151], and Mexico [152], pregnant women were given nutritional supplements and then their offspring were supplemented for three or more years. The supplemented children showed concurrent gains in height and cognition as compared with non-supplemented children.

All three studies have followed up the children. The Mexican study was extremely small, and the supplemented groups were separated by time. However, at follow-up at 18 years of age, supplemented boys had significantly higher scores on Raven's Matrices Test than non-supplemented boys; there was no difference between supplemented and non-supplemented girls [153]. In Bogota, Colombia, the children were studied at seven years of age, and the supplemented children had higher scores on tests of reading readiness but not in arithmetic and basic knowledge. Unfortunately, full details of this study have not been reported (Super CM, Herrera MG, Mora JO, personal communication, 1991). The Guatemalan study had the most in-depth follow-up [154]. The children were reassessed at 11 to 24 years of age, and the supplemented children were found to have small but wide-ranging benefits in tests of numeracy, knowledge, vocabulary, and reading achievement. The benefits were greatest among children from the poorest homes (fig. 2).

Intervention with stunted or wasted children

The only supplementation study aimed specifically at stunted children was conducted among stunted Jamaican children 9 to 24 months of age [155]. On enrolment the development of the stunted children was already poorer than that of a matched, non-stunted group. The stunted children received nutritional supplementation for two years, with or without psychosocial stimulation. Supplementation and stimulation produced independent benefits to the children's mental and motor development. The benefits from a combination of supplementation and stimulation were additive, and only the children receiving both treatments caught up to the non-stunted control group in developmental levels. The implications of these findings are that at least part of the deficit in the development of stunted children is due to poor nutrition. However, both stimulation and supplementation are necessary to improve the development of stunted children to culturally appropriate levels.

Follow-up of the Jamaican children at seven years of age showed that only small global benefits from intervention remained [126]. However, even the control children showed marked catch-up in height, reflecting the improving nutritional status of the Jamaican

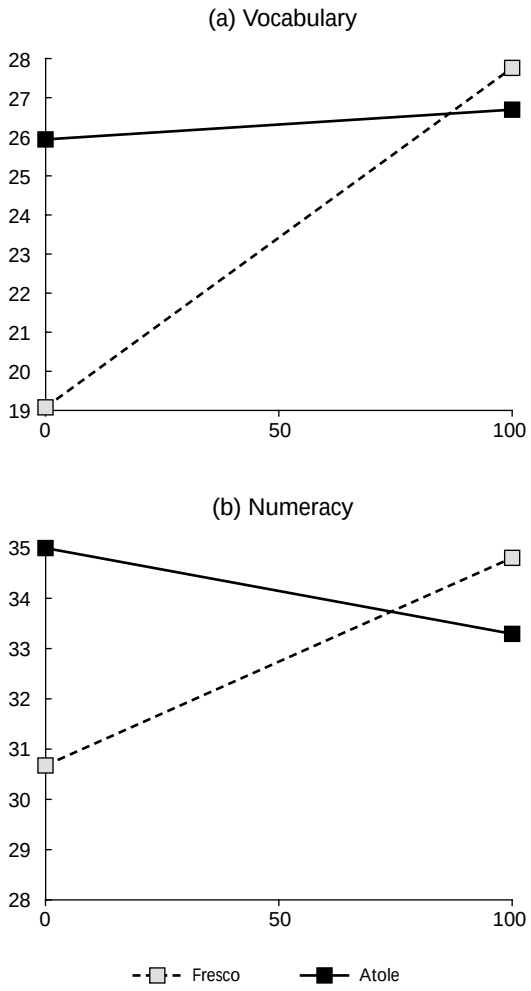

FIG. 2. Long-term benefits to (a)vocabulary and (b) numeracy of high-calorie, high-protein supplement (atole) compared with low-calorie supplement (fresco) according to children's socio-economic status [154]

population. A preliminary analysis of data from a further follow-up at 10 years shows a significant benefit in the stimulated children only. In the Guatemalan study [150], benefits from supplementation were not apparent at six years but were present at adolescence [154], suggesting that there is a sleeper effect and that larger benefits from supplementation in the Jamaican study may reappear at a later age.

Two other studies have been conducted with undernourished children. One in Indonesia [156] showed a weight but not a height response, and the other study in Cali, Colombia [157], had no control group that did not receive supplementation. In the Indonesian study, infants 6 to 20 months of age in day-care centres supplemented for only 3 months showed a benefit to their motor development but not their mental development. Their average height was below –2 SD on enrolment, but weight-for-height was not reported. At long-term follow-up [158], the authors reported the progress of all children who were supplemented when they were under five years of age, and there was no treatment effect. Post hoc analyses of the younger children showed benefits in one of several tests. Since height showed no response to initial supplementation, this benefit may be an effect of improving dietary intake sufficiently to improve wasting but not stunting.

Vulnerable age

Evidence for a vulnerable period when nutrition is particularly important for mental development is not conclusive. In one supplementation study, children receiving supplements after 24 months of age showed fewer and smaller benefits than children receiving supplements earlier [154]. However, there were fewer children receiving supplements after 24 months. In the study with undernourished children in Cali, Colombia [157], an integrated programme of stimulation and supplementation was given to children for different periods of time, beginning at different ages. Those children receiving supplementation from the youngest age (42 months) showed the greatest and most sustained benefits. However, it was not possible to separate supplementation from stimulation, and age was confounded with duration of intervention.

We found four studies in which height in early childhood predicted cognitive development at a later age. In a Guatemalan study [159], the children's height at 3 years of age predicted their performance on tests of numeracy, literacy, general knowledge, and adolescent school grade attainment. Similarly, in a Kenyan study [160], height in children between 18 and 30 months of age predicted cognition scores at 5 years of age, and in a Jamaican study [161], height at 1 year of age predicted school achievement scores between 9 and 11 years of age in girls, but not in boys. In a recent study of stunted Jamaican children, height-for-age between 9 and 24 months of age predicted IQ at 7 years of age better than concurrent height [126]. These findings suggest that nutrition in the first 2 to 3 years is critically important to children's development.

Mechanism

The precise mechanism linking stunting to poor mental development is unknown. It is possible that the mechanism varies according to which nutrients are deficient, or that several hypothesized mechanisms could act sepa-

rately or together. One hypothesis is that undernutrition causes poor motor development and subsequent low activity levels. It also causes apathy and lack of interest in the environment. The children thus explore their environment less and fail to acquire skills at the normal speed [162]. These behaviours have been described in children with deficiencies of iron [163], zinc [164, 165], and energy [166, 167]. The caretakers may in turn be less stimulating towards an apathetic child, which may exacerbate the effects on development [152]. Another possible mechanism is that the children's small size could lead adults to treat them like younger children and not provide age-appropriate stimulation.

Undernutrition could have a direct effect on children's central nervous systems. There is a considerable amount of evidence for this from animal research [168]. Stunted children have small heads, and in one study, head size in early childhood was a stronger predictor of IQ at 7 years of age than other previous or current anthropometric measures [126]. Another hypothesis is that altered HPA and autonomic nervous system activity could lead to behavioural differences, but more research is needed to confirm these preliminary findings.

Conclusions about mild-to-moderate stunting

Stunted children have multiple functional disadvantages that persist throughout childhood. Poor nutrition almost certainly plays a role, as well as poor environments. It is probable that nutrition in the first three years is particularly important. The poor development and educational level of stunted children is likely to limit economic productivity in individual adults and nations [169, 170]. Furthermore, low educational level in parents limits their ability to promote good development and health in their children [171–173], which in turn leads to an inter-generational effect.

Policy implications and recommendations

In countries where stunting is highly prevalent, there is an urgent need to institute programmes to improve children's nutritional status. Such programmes are probably most effective if they are instituted among children in the first three years of life [154] and are integrated with child care and psychosocial interventions.

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Effects of health and nutrition on cognitive and behavioural development in children in the first three years of life

Part 2: Infections and micronutrient deficiencies: Iodine, iron, and zinc

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Abstract

The following paper and its accompanying paper (Grantham-McGregor SM, et al. Effects of health and nutrition on cognitive and behavioural development in children in the first three years of life. Part 1: Low birthweight, breastfeeding, and protein-energy malnutrition. Food Nutr Bull 1999;20:53–75) review the literature on the conditions that are prevalent and considered to be likely to affect child development and are therefore of public health importance. The reviews are selective, and we have generally focused on recent work, particularly in areas that remain controversial. The reviews are restricted to nutritional and health insults that are important in the first three years of life. Where possible, we have discussed the better studies. This paper considers the effects of infections and the major micronutrient deficiencies: iodine, iron, and zinc.

Introduction

This review is restricted to early childhood infections that are common in low-income countries and are likely to affect children's development, thereby having public health implications. Repeated or chronic infections in pregnancy may lead to low-birthweight babies, and many specific infections, such as rubella, syphilis, and HIV, can have detrimental effects on the foetus. These issues are important but are not the focus of this paper and therefore they will not be discussed further.

Gastroenteritis, respiratory infections, and malaria are the most prevalent and serious conditions that may affect development in the first three years of life. It is estimated that children under five years of age in developing countries suffer from 3.5 episodes of diarrhoea per year and 4 to 9 respiratory tract infections in the first two years [1–3].

Other conditions have detrimental effects on children's development by affecting vision and hearing but are not life-threatening, such as repeated otitis media, which may impair hearing, and onchocerciasis, which causes blindness. Recently, there has been increased interest in the possible role of geohelminth infections in young children's development, which are estimated to affect greater than a quarter of the world's population [4]. However, infections are not usually intense in very young children, and school-aged children are at greater risk [5].

Mechanism

Infections are likely to affect children's development through several different mechanisms. Reduced dietary intake may occur secondary to anorexia or malabsorption, actual nutrient loss may occur secondary to protein-losing enteropathy, and increased demands may be present due to fever and the immune response. Anaemia and iron deficiency can also occur secondary to infection, haemolysis, and actual bleeding into the gut in the case of certain geohelminths. There is also the suggestion that the immune response itself may directly affect cognition and mood. In a series of studies in adults, Smith [6] showed that colds and influenza affect cognition and that even subclinical infection can impair performance. The impairments are present in the incubation period and for some time following recovery when symptoms are no longer present.

Infections also cause general malaise and apathy, and apathetic children generally demand and receive less stimulation from the adults in their environments. If a child suffers from long and repeated periods of decreased activity and exploration, this inactivity alone can lead to poor development. In Kenya, parents of children who suffer from frequent illness are less likely to interact socially with them but spend more time giving basic care [7].

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It is important to remember that infections are more likely to occur in children from poor, overcrowded homes, with inadequate sanitation and water supply [8–10]. Furthermore, the symptoms are more likely to be prolonged where good medical care is unavailable. Children in these homes are already likely to be at risk of poor development from sociocultural deprivation. In addition, infections occur more often in children who are undernourished, another risk factor for poor development. It is likely that infections will have a greater effect on the development of children who are already vulnerable. Although there are ample reasons to suspect that infections would affect children's development, there are very few data on the topic, with the possible exception of the effects of parasites in older children.

Parasitic infections

There are several recent in-depth reviews of studies on the effect of parasitic infection on children's behavioural development [5, 11, 12], so we will discuss them only briefly here. *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and hookworm are all associated with poor levels of development in children as well as poor sociocultural and economic conditions. Therefore, randomized treatment trials are necessary to establish a causal relationship. The relationship of schistosomiasis to children's development and social background is even more difficult to understand, because often the more active, adventurous child is the one who becomes infected [13]. Thus, infected children may not always appear disadvantaged compared with peers [14].

Unfortunately, many studies have not had rigorous designs, and almost all concern older children. Two randomized controlled trials showed benefits to children's cognition following anthelminthic treatment. One concerned *T. trichiura* infections [15] and the other hookworm [16]. However, in the latter study iron treatment was also given, so that anthelminthic treatment cannot be separated from iron treatment. Other investigators failed to replicate these findings in children infected with *T. trichiura* or *Ascaris* in carefully designed studies [Watkins WE, personal communication, 1998; 11; 17; 18]. However, in post hoc analyses, subgroups of undernourished or heavily infected children showed some improvements with treatment. It is highly likely that extremely heavy infections that cause undernutrition or anaemia, such as *Trichuris* dysentery syndrome, will have a detrimental effect [19], but this level of intensity is less common. At present, it is an open question whether mild to moderate infections with geohelminths affect children's development in the absence of anaemia or undernutrition. One caution is that very young children are likely to be more vulnerable to infections, and where infections are prevalent in the first three years of life, we need to examine their effect.

The World Health Organization (WHO) estimates that 2,200 million of the world's population in some 90 countries are exposed to malaria [20]. Malaria is one of the most important causes of mortality and morbidity among young children, and it is estimated that 600,000 children under five years of age die of malaria annually [21]. Malaria affects children's growth [22, 23] and haemoglobin levels [24, 25]. Although it is likely that repeated attacks would detrimentally affect children's development, there is a surprising lack of data on the topic except for studies looking at the sequelae of cerebral malaria [26–28].

Diarrhoea and respiratory infections

Few studies have been conducted on the effects of diarrhoea and respiratory infections. In an exploratory longitudinal study of 164 infants in Taiwan, children who had episodes of respiratory infections or gastroenteritis in both the first and the second three months of life had lower scores on the Bayley motor (respiratory $p < .05$, gastroenteritis $p < .10$) and mental scales (both $p < .10$) at eight months of age [29]. When nutritional status was controlled, the trends remained and the effect of respiratory infections on the motor scale remained significant.

In an in-depth study of Kenyan toddlers, morbidity was recorded by weekly recalls from 18 to 30 months of age, behaviour was observed at home, the Bayley Test was administered at 30 months, and a comprehensive battery of cognitive and language tests was administered at five years of age. The toddlers were sick with mild to moderate infections an average of three days a week, with girls having more illness [7]. Girls with more illness played and vocalized less at home and had poorer cognitive skills than girls with less illness. This difference remained significant when extensive covariates and nutritional status were controlled for.

In a Jamaican study of stunted children, aged 9 to 24 months on enrolment, the number of days the children were too sick to play or run around in the following two years was related to their developmental levels on the Griffiths Test. This finding was probably an indicator of the more severe infections, as there was no relationship between the number of days with symptoms of respiratory infections and the number of days with diarrhoea.

In another study from Brazil [Morris S, personal communication, 1998], the number of days ill with diarrhoea in the first six months of life was related to poorer performance on the Bayley Test at 12 months of age in low-birthweight babies but not normal-birthweight babies. This later finding is another example of an interaction between two concurrent biological risk factors.

In conclusion, it appears that repeated infections in early childhood put the child at risk for poor psychomotor development. However, there are very few studies, and we were unable to find studies of long-term effects. It would be helpful to have more research on the topic, including countries with endemic malaria. From a policy perspective, it would appear that special attention should be paid to the development of children who suffer from repeated infections.

Iodine deficiency

According to the 1993 WHO report, 1.6 billion people live in areas of iodine deficiency, and approximately 20% of them have goitre. There are limitations in estimating prevalence using an indicator such as the total goitre rate, and more recent studies have begun reporting urinary iodine excretion. It is likely that the prevalence of iodine-deficiency disorders has fallen, as major efforts have been under way to iodize salt universally. Goals set by UNICEF and WHO to achieve universal salt iodization aim to have all salt for human and animal consumption iodized [30].

Most people at risk for iodine deficiency live in areas where the soils are low in iodine content due to leaching caused by high rainfall, melting snow, flooding, or glaciation. Mountainous areas are particularly at risk, with severely deficient areas in the Andes, the European Alps, the Himalayas, and mountain ranges in China. All crops grown in iodine-deficient soil are iodine deficient, which means that organisms that are dependent primarily on food grown in the earth will also experience iodine deficiency [31].

Iodine is a constituent of the thyroid hormones, thyroxine (T4) and triiodothyronine (T3), which are essential to human functioning because they influence skeletal maturation and the development of the central nervous system and regulate many other physiological processes [32–34]. Iodine deficiency in adults and children is usually characterized by low levels of T4 and high levels of thyroid-stimulating hormone (TSH) [35–39].

Iodine deficiency is the most common preventable cause of mental deficits and is a major public health issue [31, 40]. Iodine-deficiency disorders [41, 42] include a wide range of conditions, including increased pre- and postnatal mortality, goitre, and cretinism. The effects on development are now thought to include cognitive, sensory, and motor deficits. Iodine-deficiency disorders can also take their toll socio-economically, with lower work output per capita income and less productive farm animals in iodine-deficient areas [43].

Observational studies

Studies of goitrous and non-goitrous children

Studies have shown inconsistent differences between goitrous children and non-goitrous controls in terms of outcome measures of intelligence [44, 45]. The results may not be consistent because there is no clear relationship between the level of hypothyroidism and the presence of goitre [46].

Studies comparing children in iodine-deficient and iodine-sufficient areas

Consistent results have been obtained in studies evaluating the IQs of children living in severely or moderately iodine-deficient villages, as compared with children in iodine-sufficient or only mildly iodine-deficient areas (table 1) [47–56]. Children in areas of iodine deficiency have significantly lower levels of mental development when assessed with Raven's Matrices, cognitive tests, the Weschler Intelligence Scale for Children (WISC), Griffiths, or Bender-Gestalt Test [48–56]. In a meta-analysis of 18 studies evaluating the relationship between iodine levels in children and adults and cognitive function, individuals who had experienced some iodine deficiency had average IQs 13.5 points lower than controls [57]. Although the meta-analysis may be criticized for using such a wide range of study types, ages, and developmental outcome measures, it affirms the relationship between iodine deficiency and poor mental development. However, in most studies the complexity of factors that may affect both iodine intake and mental development of children was underestimated. Many confounding factors were not taken into account, such as socio-economic status, degree of isolation, access to health care, income levels, availability of water and electricity, quality of education, amount of inbreeding, and other cultural issues.

Another problem in evaluating neurodevelopmental outcome is that most studies used infant developmental assessments or IQ tests that may not have been culturally appropriate or standardized for the population. Furthermore, it is not possible from these studies to separate intrauterine effects of iodine deficiency from childhood effects.

Intervention studies

Maternal supplementation studies

Oral administration of oil to pregnant women pre-conception or during the first trimester has been shown to increase placental weight, reduce rates of prematurity, stillbirths, and abortions, and eliminate abnormal hormone levels in newborns [58, 59].

Several studies have investigated the effects of iodized oil given to women before and during pregnancy on their children's mental development (table 2) [60–69]. Early studies often used the weakest intervention design of comparing supplemented people in one village with non-supplemented people in another matched village. Based on the extensive investigations of children from two Ecuadorian villages, for example, iodi-

TABLE 1. Observational studies of children from iodine-deficient areas

Source	Study type and sample	Outcome measures	Results
Azizi et al. (1995) Iran [48]	*n* = 271, 6–16 yr, similar SES, education levels, schoolteachers, exposed to many of same influences (radio, TV, toys) 95 from A: 93% visible goitre, 39% low T4, 70% high TSH 103 from B: 66% visible goitre, 7% high TSH 73 from C: 22% visible goitre, normal thyroid function	Raven's IQ Bender-Gestalt ENT evaluation Endocrine evaluation	Raven's IQ: C > B* > A** (116 > 96 > 89) More errors when taking Bender-Gestalt Test in A & B than C** Hearing threshold lower in I-deficient group**
Tiwari et al. (1996) India [49]	*n* = 200, boys 9–15 yr, case-control design 100 children from 10 severely I-deficient villages: goitre >60%, cretinism 3.4%; cretins excluded from study 100 children from 4 mildly I-deficient control villages: goitre <10%, no cretinism Matched for SES, formal education level, age	Human maze learning Verbal learning rate Pictorial learning Achievement motivation scale	Children from I-deficient villages: lower scores in human maze learning**; slower verbal learning in serial learning** (not in free recall); worse performance in pictorial learning**; less motivation**; interaction between I deficiency & age
Azizi et al. (1993) Iran [50]	*n* = 105, 6–15 yr, children from 3 different villages 54 from Randan, area with hyperendemic goitre 20 from Zangoon, 2 mountainous regions with hyperendemic goitre 31 from Tehran, high goitre, normal thyroid function	Bender-Gestalt Test Hearing Thyroid function (T3, T4, etc.)	Thyroid function & somatic growth are normal Difference in IQ*** Tehran > Zangoon > Randan (117> 102 > 89) Many other differences in social background
Vermiglio et al. (1990) Italy [51]	*n* = 1089, 6–12 yr, living in 2 areas 368 from A, endemic cretinism 351 from B, no endemic cretinism 370 from C, no goitre or cretinism	Bender-Gestalt Test Neurological examination	Bender-Gestalt Test results of A & B v. C.*** (223 v. 27 performing defectively or borderline) More neuromuscular & neurosensory abnormalities in A & B***

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nation was associated with a reduction in severe developmental defects such as cretinism and better scores on IQ tests [60, 61, 70, 71]. The study's design had many problems, including non-blinded treatment and inadequate matching of villages. Therefore, it is not possible to draw firm conclusions about the effects of supplementation on mental development from these data.

Using a more rigorous study design, Pretell et al. [62] compared the children of mothers from three iodine-deficient villages who were supplemented before conception with unsupplemented controls from the same villages. Although there were no significant differences between the groups in terms of their developmental quotient, the children of treated mothers scored higher

TABLE 1. Observational studies of children from iodine-deficient areas *(continued)*

Source	Study type and sample	Outcome measures	Results
Fenzi et al. (1990) Italy [52]	6–14 yr, living in 2 areas 384 from representative sampling of 1 area of moderate I deficiency, goitre prevalence of 52% 352 sex- & age-matched from control, I-sufficient area, with 5.6% goitre prevalence (some tests on subsample in class 3 & 5)	WISC-R Thyroid size Thyroid function Neuropsychological studies (in 50 children from each group) PM47	No overall difference in WISC or PM 47 In children from class 3: verbal IQ* (105 < 111); information* (9.5 < 12.1); vocabulary* * (11.1 < 13.9); coding* (8.3 < 10.3) No differences in children from class 5
Boyages et al. (1989) China [53]	*n* = 270, 7–14 yr, from urban & rural areas 141 born during iodized-salt prophylaxis in I-deficient rural village 51 from I-sufficient rural village 78 from I-sufficient urban populations (2 cities) Rural villages matched for several variables Urban areas not matched for any variables	Griffiths Mental Development Scales Hiskey-Nebraska Test of Learning Aptitude	Mean IQ lower*** in children from I-deficient village, in spite of iodized salt prophylaxis Treated rural: 72.4 Untreated rural: 84.4 Urban control 1: 108.6 Urban control 2: 106.3
Bleichrodt et al. (1987) Spain [54]	*n* = 355, 0–12 yr, from 7 different villages 162 from I-deficient area, goitre rate 66%, endemic cretinism 13% 193 from non-I-deficient area, goitre rate 13%, endemic cretinism 4% Matched for SES, degree of isolation, health care, education quality	Mental development: Bayley, McCarthy, Catell Motor development: Bayley, Oseretsky, Bender-Gestalt, fine motor	Lower scores of mental development in children from I-deficient areas for all age groups* More mentally retarded children in I-deficient group Infants: lower psychomotor score** Older group: lower manual dexterity & speed of reaction**
Bleichrodt et al. (1987) Indonesia [54]	*n* = 245, 6–20 yr, from 2 villages 106 from I-deficient village, goitre rate 68%, endemic cretinism 4.5% 139 from non-I-deficient area, goitre 3%, no endemic cretinism Matched for SES, degree of isolation, size	Test Intelligensi Anak & Test Intelligent Koletip, Indonesia Raven's Matrices Mental development (fluency, block design, vocabulary)	Lower scores of mental development in children from I-deficient area in all age groups* Differences in motor development after age 2.5 yr (eye-hand coordination, reaction time, balance)

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at all ages. In a double-blind randomized trial in Zaire, the developmental quotients in infants from treated mothers were significantly higher than the developmental quotients in infants from non-treated mothers [63].

Perhaps the best and earliest longitudinal, double-blind, randomized, controlled trial was conducted in Papua New Guinea by Pharoah and Connolly and colleagues [65–69,72–75]. Intramuscular iodized oil was effective in preventing both types of endemic cretinism, and children whose mothers received iodized oil had better cognitive and fine motor skills than control children. Infant and childhood cumulative mortality

TABLE 1. Observational studies of children from iodine-deficient areas *(continued)*

Source	Study type and sample	Outcome measures	Results
Mehta et al. (1987) India [55]	*n* = 60, 6–16 yr, from 2 villages Both villages severely I deficient Children selected randomly from school, all goitrous; compared IQs of these children with those of normal rural Indian schoolchildren	WISC IQ Bhatia's Test Bender-Gestalt Test Goitre graded Urine samples Anthropometry Nutritional status	49 test children with IQ < 89, 11 with IQ ≥ 90 Children from test village scored worse** than normal schoolchildren on digit span, similarities, & Koh's Block Design
Querido et al. (1978) Indonesia [56]	*n* = 245, 6–20 yr 139 from village with 3% goitre rate 106 from village with 58% goitre rate Villages matched for employment, population, altitude	Motor development tests: pinboard, tapping, balance, reaction time, throwing balls, figure comparison	Treated children (6–8 yr) scored higher in pinboard **, tapping * Treated children (9–12 yr) scored higher in all tests** Treated adolescents (13–20 yr) scored higher in reaction time, tapping, figure comparison

*$p < .05$, **$p < .01$, ***$p < .001$.

Abbreviations: ENT, ear, nose, and throat; IQ, intelligence quotient; SES, socio-economic status; WISC, Weschler Intelligence Scale for Children.

Source: modified from ref. 47.

over the first 15 years of life was significantly reduced in the treated group. This study also showed links between maternal level of thyroid hormones and children's developmental outcomes.

The most recent maternal supplementation study, conducted in China [64], indicated that children born to women supplemented in the first and second trimesters had decreased prevalence of moderate or severe neurologic abnormalities, and increased developmental quotients compared with children whose mothers received iodine later in pregnancy.

All the studies discussed above indicate that maternal supplementation during gestation and the first trimester affects mental development in children. The studies from Papua New Guinea, China, and Zaire are sufficiently robust to establish that iodine deficiency in utero causes cretinism and poor development in childhood.

Childhood supplementation studies

A limited number of researchers have conducted iodine-supplementation trials in children (table 3) [76–80], but many of the studies had design flaws. The earliest supplementation trials evaluating developmental outcomes with children took place in Ecuador [77]. In these trials, 51 children aged 6 to 10 years from an iodine-deficient village were injected with iodized oil. Two years later, they were compared with children from a control village. The mean intelligence of the treated subjects was higher than that of the controls, but the results were significant only in the girls. In a Chinese study, children from an iodine-deficient area had significantly lower mean hearing thresholds, and the levels improved with treatment. However, no placebo group was measured at the same time [76]. A more recent treatment trial in Spain compared children from severely iodine-deficient areas who had been treated 32 months previously with children who had not been treated; no differences were found in scores on tests assessing manual dexterity and reaction speed [78]. Given the amount of time that elapsed between treatment and testing, it is likely that the effectiveness of the iodine supplement was reduced.

In a double-blind randomized controlled trial of schoolchildren in Bolivia, there were no improvements in any of the neurodevelopmental or IQ measures. However, the iodine status of the placebo group improved during the study, confusing the results [79]. In Malawi a double-blind placebo-controlled study in an area of endemic goitre found significant differences in the final test scores in three aggregate ratings on mental development that compared children who received iodine with those who received a placebo. However, there were no valid pre-test scores, so the findings are not conclusive [80].

The data from childhood supplementation studies

TABLE 2. Iodine intervention studies with mothers

Source	Sample	Intervention	Outcome measures	Results
Ramirez et al. (1969) Ecuador [60]	Two I-deficient villages: pregnant women in 1 treated not in the other. Group I: children of mothers treated during mo 4–7 of pregnancy Group II: children of mothers treated before conception Controls: children of untreated mothers	Mothers treated with iodized oil (regular doses to maintain urinary excretion of 50 µg/g creatinine until 4–5 yr after 1st injection) Iodized salt available in area for 1 yr before treatment	Stanford-Binet	Difference between group II & controls ($p < .002$) No differences between group I & controls
Ramirez et al. (1972) Ecuador [61]	Group I: children of mothers who received I before 6th mo of pregnancy Group II: children of untreated mothers	Same as above	Gesell	Higher % of children <4 yr old in village receiving iodized oil performed in normal range of IQ scores than children in control village
Pretell et al. (1972) Peru [62]	*n* = 456 newborns 56% iodized group 44% placebo, I-deficient	Mothers received dose of I during pregnancy & another dose 3 yr later	Stanford-Binet Brunet-Lezine Physical examination Urinary I	No significant differences, but scores higher in iodized group
Thilly et al. (1980) Zaire [63]	Double-blind randomized trial in area of severe I deficiency All children assessed at 4–25 mo *n* = 115 treated at average 28th wk of pregnancy *n* = 104 placebo	500 mg iodized oil, or I-free vitamins 1 treatment	Brunet-Lezine scale (DQ) Thyroid function	In children whose mothers were treated: higher DQ (115> 104**), lower infant mortality rate*, higher maternal I concentration**
Cao et al. (1994) China [64]	All children 2 yr *n* = 120 infants whose mothers were treated during 1st or 2nd trimester *n* = 752 whose mothers were treated in 3rd trimester	400 mg iodinated oil Treated again at 6 mo or annual reevaluations	Bayley Scales (DQ) Anthropometry	In children whose mothers were treated earlier: higher DQ (90 > 75***), decreased prevalence of moderate or severe neurological abnormalities (2% v. 9%**), decreased prevalence of microcephaly (11% v. 27%**)
Pharoah et al. (1971) Papua New Guinea [65]	Families in 16 villages randomly assigned to treatment or placebo 498 births to treated mothers 534 births to untreated mothers	Same as above	Incidence of cretinism, maternal T3 & T4 levels	Higher number of cretins born to unsupplemented mothers

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TABLE 2. Iodine intervention studies with mothers *(continued)*

Source	Sample	Intervention	Outcome measures	Results
Connolly & Pharoah (1979) Papua New Guinea [66]	Children from 5 of above villages 115 births to treated mothers 79 births to untreated mothers	Same as above	Same as above & manual dexterity (bead threading, pegboard)	Better values in treated group for pegboard*, bead threading**
Pharoah et al. (1981) Papua New Guinea [67]	Same 5 villages Children aged 6–11 yr of women who had thyroid function measured *n* = 37 or 35 for some tests	Same as above	Same as above	Significant correlations between motor ability of child & maternal T4 level
Pharoah et al. (1984) Papua New Guinea [68]	Same 5 villages *n* = 20 children aged 10–12 yr whose mothers had thyroid function measured in pregnancy	Same as above	Same as above & Pacific Design Construction Test	Significant correlations between both intellectual & motor ability of child & maternal T4 level
Connolly et al. (1989) Papua New Guinea [69]	Same 5 villages *n* = 44 children aged 14–16 yr whose mothers had thyroid function measured during pregnancy	Same as above	Motor performance, card sorting	Significant correlations between all mental & motor scores & maternal T4 level

*$p < .05$, **$p < .01$, ***$p < .001$.

Abbreviations: DQ, developmental quotient; IQ, intelligence quotient.

Source: modified from ref. 47.

are less clear than those from maternal supplementation studies, probably because there are only a few studies and only one had a randomized design with pre- and post-treatment measures.

Conclusions about iodine deficiency and development

A substantial number of studies have examined iodine deficiency and its effect on child development. However, many of them have design problems. In spite of these problems, it is possible to conclude that supplementation is critically important pre-conception and in the first two trimesters of pregnancy for women who live in iodine-deficient areas. Few studies have looked at the effects of supplementation on children's cognitive function and school achievement, and the findings are inconsistent. However, supplementation for school-aged children in iodine-deficient areas remains important in order to reduce the incidence of goitre. Within supplementation programmes, girls should be targeted if possible because of the risk of pregnancy.

Policy implications

Clearly, iodine deficiency is a public health problem of global concern, and universal salt iodization is a priority [81]. Fortification of all salt for human and animal consumption is the easiest and most cost-effective method of iodization. However, the voluntary intake of salt is not always enough to protect the population from iodine deficiency. In Germany, for example, iodization of salt and of pig and cattle food was mandatory only in East Berlin. As a consequence, infants born in West Berlin were more likely to be iodine deficient, despite the availability of iodized salt [82]. Many factors hinder the progress of universal salt fortification, including poor storage, insufficient market control, insufficient monitoring, inattention to cost, limited programme integration, and governmental complacency [43]. Thus, the approach to salt iodization must be tailored to each particular country's needs.

Although salt is the most desirable option, other possible forms of fortification do exist. According to WHO [83], iodized oil should be used in situations in

TABLE 3. Iodine intervention studies with children

Source	Sample	Intervention	Outcome measures	Results
Wang & Yan (1985) China [76]	*n* = 150, 7–11 yr 120 from areas of severe I deficiency (30 from 4 different villages) 30 from non-endemic areas Excluded children with poor scholastic record, goitre or hearing impairment in all villages, similar SES, except for control	I prophylaxis for 3 yr	Mean hearing threshold Hearing at different frequencies	Lower hearing threshold in untreated groups*** improved with treatment
Dodge et al. (1969) Ecuador [77]	Children from 1 village (*n* = 51) aged 6–10 yr injected compared after 2 yr with those in control village	2 ml iodized oil	Goddard Test Goodenough, draw-a-man	Mean intelligence of treated > controls, girls***
Bleichrodt et al. (1989) Spain [78]	*n* = 287, 6–12 yr from several different villages 103 children from I-deficient areas who had been treated 32 mo earlier 102 children from I-deficient areas 82 control children from non-I-deficient areas Areas matched for SES, degree of isolation, health care, quality of education	Single oral dose (2 ml) of Lipiodol	Manual dexterity Reaction time	No difference in mean values or distribution curves
Bautista et al. (1982) Bolivia [79]	*n* = 200, 5.5–12 yr Double-blind assessment 100 girls, 100 boys randomly assigned to treatment or placebo	Oral dose of 1.0 ml iodized poppyseed (Ethiodol) 475 mg I control received 1.0 ml uniodized oil 1 treatment	Bender-Gestalt School grades Thyroid size Stanford-Binet (IQ) Urinary I	IQ showed significant* dependency on goitre size change in both groups (especially in girls)
Shrestha (1994) Malawi [80]	*n* = 134, 6–8 yr from same area of endemic goitre Double-blind placebo-controlled study 72 children received I 72 children received placebo	Single oral dose (1 ml) of iodized oil	Fluid intelligence Crystallized intelligence Perceptual skill	Fluid intelligence*** Crystallized intelligence* Perceptual skill***

Abbreviations: IQ, intelligence quotient; SES, socio-economic status.

which the prevalence of iodine-deficiency disorders is moderate or severe, cretinism and neonatal hypothyroidism are present, or universal salt iodization programmes would not reach women of reproductive age in one to two years. Although it is certain that women of reproductive age should be given iodine at all costs, it is not yet clear if schoolchildren should also be given priority. Single oral doses of Lipiodol, 240 mg for 6 months or 480 mg for 12 months, have been shown to prevent the worst iodine-deficiency disorders, such as hypothyroidism and cretinism, and doses much higher than 400 mg are usually not recommended [59, 84–87].

Eighty-eight of the 97 developing countries iodize salt. However, problems with the marketing and production of adequately iodized salt still prevail. Several countries face the challenge of achieving universal salt iodization by assisting and encouraging many small producers to iodize salt. The next step towards the successful achievement of universal salt iodization will require ongoing monitoring of salt iodization through its various stages of production and distribution, including monitoring urinary iodine excretion.

Iron deficiency

In 1985, the estimated prevalence of anaemia (haemoglobin <110 g/L) in children under five years of age was 46% to 51% in developing countries and 7% to 12% in developed countries [88]. It is difficult to be certain of current prevalence levels, because the Opportunities for Micronutrient Interventions (OMNI) still cite a 51% prevalence in young children [89]. Anaemia has many different causes, but by far the most common is iron deficiency. Therefore, it is reasonable to assume that most anaemic children are iron deficient. Anaemia is most prevalent in children between 6 and 24 months of age, and the major causes are inadequate dietary intake of bioavailable iron, malaria, and parasitic infections.

In adults, iron deficiency affects work capacity and work productivity [90]. In one study, anaemic Indian children five to six years of age had lower work capacity than non-anaemic children [91]. For some years there has been concern that iron deficiency affects children's cognitive, motor, and behavioural development, and a substantial number of studies have been conducted to investigate this. Unfortunately, many of the studies have failed to use a randomized design.

Iron-deficiency anaemia and concurrent development

It is well established that iron-deficient anaemic children usually have poorer levels of development than non-anaemic children. Many correlational studies have linked iron status with current development [92–96]. Associations have been found between iron-deficiency anaemia and poor concurrent development in pre-intervention measures of infants who were subjects in treatment trials. Infants with iron-deficiency anaemia scored lower on the Bayley Test of Mental Development in Indonesia [97], Guatemala [98], Chile [99], and Costa Rica [100, 101] and on the Bayley Test of Motor Development [97, 98, 100, 101]. Only a few studies have failed to find associations with iron-deficiency anaemia and development [102, 103].

Lozoff examined the level of anaemia that was associated with a decline in development and found that infants with haemoglobin below 150 g/L had significantly lower motor development scores than infants with higher haemoglobin levels, whereas infants with haemoglobin levels below 100 g/L had lower mental and motor development scores [100]. Walter and colleagues reported that infants who had anaemia for long periods of time had poorer development than those who had anaemia for only a short period [104].

Longitudinal studies of development of children who had iron-deficiency anaemia in infancy

Not only is anaemia associated with concurrent poor development, but in several studies it has also been shown to predict future poor development. In a longitudinal study of growth and development of children in the first two years of life in Yugoslavia [105], children's haemoglobin level at 18 months predicted their developmental levels at 24 months.

In five longer-term studies (table 4) [106–109; Hurtado E, personal communication 1998], children who were anaemic in infancy continued to have poor levels of mental development several years later, even when their iron deficiency had been treated successfully [106–108, 110]. Costa Rican children who were anaemic between 12 and 23 months of age and were treated successfully with iron were followed up at five years of age and given a comprehensive battery of tests. Those who had been anaemic were normal in all measures of nutritional status, but they scored lower than control children on most of the cognitive and motor tests. They also came from less stimulating homes, but after a large number of confounding variables had been controlled for, the formerly anaemic children still scored lower than the controls on tests of visual motor integration, gross and fine motor skills, and subtests of the Woodcock-Johnson pre-school battery and performance IQ [106].

In a similar study in Chile, five-year-olds who were anaemic at 12 months and had been treated scored worse on a test battery including fine motor proficiency, psycholinguistic ability, and pre-school abilities [104, 107, 111].

In a third longitudinal study, middle-class Israeli children had their haemoglobin levels examined at 9 to 10 months of age, and their developmental levels or IQs were assessed at 2, 3, and 5 years of age. Children

TABLE 4. Longitudinal studies of infants with iron-deficiency anaemia

Study	Sample	Measurements	Results
Lozoff et al. (1991) Costa Rica [106]	163 of 191 lower-middle-class children from a study between 12 & 24 mo of age retested at 5–6 yr Group 1: 30 with Hb ≤100 g/L in 1st study Group 2: 133 children with ≥100 g/L	Battery of tests: WPPSI, Bruininks-Oseretsky motor test, Woodcock-Johnson psychoeducational battery, VMI, Goodenough draw-a-man, neurological examination	After several confounding variables had been controlled for, group 1 had significantly lower scores in WPPSI performance scales, gross & fine motor skills, VMI, psychoeducational battery
De Andraca et al. (1990) Chile [107]	Lower- & middle-class participants in a previous study of Fe fortification from 3 to 12 mo; from an original 196 chose 41 formerly anaemic & 29 non-anaemic	Battery of tests: Stanford-Binet, Illinois psycholinguistic abilities test, psychoeducational battery, Bruininks-Oseretsky motor test, VMI, neurological examination	Anaemic group had significantly lower scores in all tests except tests of gross motor ability & more neurological immaturity
E. Hurtado et al. (1998) USA [personal communication]	3,322 participants in the WIC programme, Florida Hb measured on enrolment	School records at age 10 (5th grade)	Hb ≤ 90 g/L had small increased risk of learning disability, after many confounders had been controlled for
Palti et al. (1985) Israel [108]	Middle-class children had Hb screened at 9 mo *n* = 873 at 2 yr *n* = 388 at 3 yr *n* = 239 at 5 yr	2 yr Brunet-Lezine 3 yr 5 yr WPPSI IQ	Anaemic children had significantly lower scores at 2, 3, & 5 yr After maternal education & birthweight had been controlled for, significantly lower only at 5 yr
Palti et al. (1985) Israel [108]	Same study as above 20 children with Hb ≤ 105 g/L 56 controls > 115 g/L	2nd grade children teacher rating behaviour & school achievement	Anaemic children had significantly lower school achievement & behaviour rating after confounders had been controlled for
Cantwell (1974) USA [109]	61 infants studied from birth to 7 yr 32 infants became anaemic (Hb < 100 g/L) 29 received Fe & were not anaemic Assignment method not given	Neurological examination at 6–7 yr Stanford-Binet	Anaemic children's IQ = 92 Non-anaemic children's IQ = 98 (no statistics given) More neurological soft signs in anaemic children

Abbreviations: Hb, haemoglobin; IQ, intelligence quotient; VMI, visual motor integration; WPPSI, Weschler Pre-school & Primary Scale of Intelligence.

who had haemoglobin < 100 g/L scored lower than control children at each age level. However, when maternal education and birthweight were controlled, the difference was only significant at five years [110]. These children were examined again in the second grade [108], when the formerly anaemic children had poorer school achievement ratings than children who had haemoglobin levels above 115 g/L. The authors pointed out that maternal education made a much larger contribution to the ratings than a history of anaemia.

In a study published only in abstract, Cantwell reported an increased incidence of neurological delay in seven-year-old children who were anaemic in infancy [109].

Hurtado and colleagues (personal communication, 1998) took an epidemiological approach to the problem. They used records from Dade County, Florida, of birthweight, enrolment in WIC programmes (a national programme of nutritional supplementation), and achievement in elementary school. Based on the 3,771 records with complete data, 10-year-old children who had been anaemic on enrolment in the WIC programme in the first four years of life were more likely to be receiving special education. This finding remained after several variables had been controlled for (birthweight, ethnicity, maternal education, etc.).

Conclusions from longitudinal studies

The depressing implication of these studies is that iron-deficiency anaemia leads to irreversible changes to children's development. However, as with most other nutritional deficiencies, iron deficiency is associated with many environmental disadvantages [106, 112], which themselves may detrimentally affect children's development. Most of the studies discussed above attempted to control statistically for social factors that could contribute to the differences between groups, such as home stimulation and maternal IQ and education. It could still be possible that differences in home environments accounted for the differences between the two groups. Some measures of the environment may not have been sensitive, or there may have been other unmeasured variables that influenced children's development. Thus, to demonstrate a causal relationship, randomized controlled trials are essential.

Treatment trials in children under two years of age

Short-term treatment trials

The first treatment trials were short, usually lasting less than two months, and produced no convincing evidence of benefit to children's developmental levels. Children who received short-term treatment showed improvements in scores on the Bayley Test of Mental Development [99], although there were no placebo anaemic groups, so that test practice could have accounted for the improvement. Four short-term treatment trials with placebo groups in the United States [113], Guatemala [98], Costa Rica [100], and Chile [104] failed to find significant treatment effects, although the sample sizes were extremely small in most of the studies.

Treatment trials longer than two months

Studies with longer-term supplementation for two to six months yielded inconsistent although more positive results (table 5) [97, 100, 101, 104, 114]. Unfortunately, few of them had randomized designs. Three studies had no placebo group, and all anaemic children were treated and compared with non-anaemic children. In two of the studies, anaemic children were treated for three months [100, 104], and in the other they were treated for six months [101]. In these three studies, the anaemic children initially had lower scores on the Bayley mental scales than the non-anaemic children, and in two of the studies they had lower scores on the motor scale as well [100, 104]. The treated anaemic children did not improve more than the non-anaemic ones in either scale in any of the studies. In one study [100], the group of children achieving complete haematological normality significantly improved relative to the non-anaemic group. However, Walter and colleagues [104] found no improvement with supplementation in a similar subgroup.

Randomized controlled trials

Only two of the treatment trials were randomized. In England 97 anaemic children were randomly assigned to a vitamin C and iron supplement or vitamin C alone. There were no significant differences on the Denver Mental Development Test after two months of treatment. However, more iron-treated children than placebo-treated children had a normal rate of development. Also, the Denver Test was not designed to be sensitive to small differences, which may account for the failure to find an effect.

In the second randomized control trial, 50 anaemic children aged 12 to 18 months were assigned to iron treatment or placebo. The treated group showed a dramatic overall improvement in both mental test scores (18.8 points higher in the treated group than in the placebo group) and motor test scores (18.4 points higher in the treated group than in the placebo group) after four months of treatment (fig. 1) [97].

Conclusions from treatment trials

When assessing the results of treatment trials of children of this age, there is no consistent evidence that short-term treatment improves development. The three longer-term trials, which had no anaemic placebo group [100, 101, 104], as well as the longitudinal studies discussed previously, all suggest that treatment does not improve development in anaemic children. The failure of six months of treatment to produce even a hint of reduction of the deficit in anaemic children in the Costa Rican study [101] is particularly worrisome. However, without a placebo group, we do not know how untreated anaemic children would have developed, and we cannot assume that they would develop at the same pace as non-anaemic children. Therefore, the study design prohibits making any firm conclusions.

The Indonesian study [97] stands alone in having a randomized design and showing a large treatment effect in anaemic infants following longer-term treatment. The design was robust, but the study had only 25 treated

TABLE 5. Trials of iron treatment given to anaemic children under two years of age for at least two months

Study	Sample	Treatment	Test	Results
Aukett et al. (1986) UK [114]	*n* = 97 IDA 17–19 mo Random assignment to treatment or placebo	Fe & vitamin C for 2 mo; placebo was vitamin C	Denver Test	No significant treatment effect on Denver scores; significantly more treated children achieved normal rate of development
Lozoff et al. (1987) Costa Rica [100]	1) 12–24 mo, *n* = 52 IDA, *n* = 35 non-IDA Random assignment to treatment or placebo 2) Children from group 1 after the 1-wk Bayley Test; all IDA group treated, non-IDA group given placebo	Oral or intramuscular Fe for 1 wk	Oral Fe for 12 wk	Bayley Test Initially anaemic group had lower MDI & PDI scores; no treatment effect after 7 days IDA children who had complete Fe status recovery after 3 mo, not significantly different from non-anaemic MDI & PDI at 15 mo; anaemic group with partial recovery still had significantly lower scores
Walter et al. (1989) Chile [104]	1) *n* = 196, 3 mo stratified by BF, randomly assigned to treatment or placebo; no baseline measures 2) *n* = 39 IDA, *n* = 30 not IDA, from pooled group at 12 mo randomly assigned to treatment or placebo 3) All children from group 2 given Fe treatment	1) Fe-fortified food from 3 to 12 mo; tested at 12 mo 2) Oral Fe for 10 days 3) Oral Fe for 3 mo	Bayley Test	1) Groups pooled, anaemic children had lower MDI & PDI at 12 mo 2) No treatment effect on MDI or PDI 3) No difference in change in MDI or PDI between anaemic & control groups
Idjradinata & Pollitt (1993) Indonesia [97]	12–18 mo 50 anaemic (IDA) 29 non-anaemic Fe-deficient 47 Fe-sufficient Each randomly assigned to treatment or placebo	4 mo Fe treatment	Bayley Test	Initially IDA significantly lower MDI & PDI than other 2 groups, IDA significantly improved & caught up to the other 2 groups
Lozoff et al. (1996) Costa Rica [101]	12–23 mo *n* = 32 IDA *n* = 54 non-IDA All IDA treated & non-anaemic randomly assigned to treatment or placebo	6 mo Fe treatment	Bayley Test	IDA significantly lower MDI on enrolment & showed no improvement, PDI lower (non-significant) & remained so throughout

Abbreviations: BF, breastfeeding; IDA, iron-deficiency anaemia; MDI, mental development index of the Bayley Test; NS, not significant; PDI, psychomotor development index of the Bayley Test.

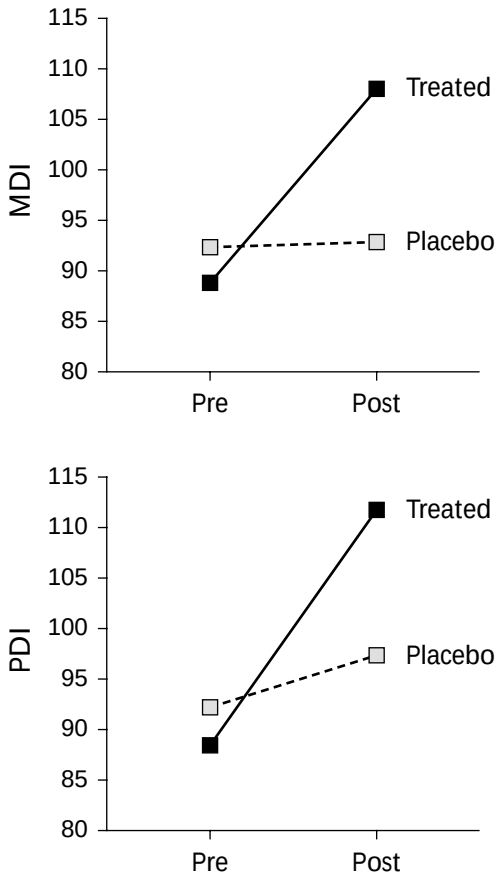

FIG. 1. Graphs of (a) mental (MDI) and (b) psychomotor (PDI) development in treated and placebo iron-deficient anaemic children [97]

children and clearly needs replicating before it can be extrapolated to all populations.

Prophylactic treatment trials

Six prophylactic randomized controlled trials (table 6) [Williams J, personal communication, 1998; 104; 115–118] involved giving iron supplementation in the first year, usually before any degree of anaemia developed. Their aim was to prevent anaemia from developing in one group of children. Two recent large studies, one in England [118] and the other in Chile [117], reported no difference in development between the treated and placebo groups at the end of the supplementation period. In the Chilean study, 944 non-anaemic six-month-old children were randomly assigned to iron supplementation or placebo; the children were tested on the Bayley Test at 12 months of age. In the English study, 9-month-old children were enrolled and supplemented until they were 18 months old, when no difference was found on the Bayley Test between supplemented and non-supplemented children. These two studies were published only in abstract form, so the full details cannot yet be evaluated.

Two other studies are difficult to interpret [104, 115]. In a randomized trial in Papua New Guinea, two-month-old children were given intramuscular iron or a placebo [115]. At 12 months they were given tests of habituation. Unfortunately, the high prevalence of malaria parasitaemia confused the results, and there was no clear treatment effect. Those children without parasitaemia and treated with iron had longer fixation times than the children receiving placebo, indicating better attentional abilities; habituation was not affected. In another randomized trial [104], children were given fortified formula or food from three months of age. We were unable to find results reported by the original randomization groups, because the anaemic children from both groups were pooled and said to have lower scores than non-anaemic children.

Two studies showed clear benefits from iron prophylaxis. In a Canadian study [116], 283 infants between birth and two months of age, mostly from poor Amerindian families, were randomly assigned to iron-fortified formula or regular formula. The difference in the incidence of anaemia between the two groups reached a maximum of 19.9% (28.0 vs 8.1) at six months of age and declined to 7.8% at 15 months. The motor scores of the iron-fortified group on the Bayley Test were not different at 6 months but were significantly higher at 9 and 12 months of age (maximum difference, 1/2 standard score). However, the benefit was transient and no longer significant at 15 months. There was no treatment effect on the mental scale. Although this was a well-designed study, the loss of 129 children by 15 months raises doubt as to the validity of the findings at this age.

A second important study was recently reported from England [Williams J, personal communication, 1998]. One hundred poor inner-city children were randomly assigned at 7 months of age to iron-fortified formula or unfortified cow's milk until 18 months of age. On enrolment, some children were already anaemic (16% in the non-supplemented and 13% in the supplemented group). By 12 months the proportions were 31% and 3%, and by 18 months they were 33% and 2%, respectively. The groups had similar scores on the Griffiths Test on enrolment at 18 months, but at 24 months their developmental quotients and scores in every subscale except the locomotor were significantly higher than those of the group receiving cow's milk (fig. 2). The latter group showed a marked decline in scores between 18 and 24 months of age, which did not occur in the fortified group. A decline around this age is well established in deprived children. The main problem with this study is that the ingredients of formula differed from cow's milk in several ways other than the iron content, and these other ingredients may have played

TABLE 6. Prophylactic iron treatment trials in infancy (in chronological order)

Study	Sample	Treatment	Test	Results
Heywood et al. (1989) Papua New Guinea [115]	*n* = 96, 2 mo Longitudinal cohort Matched sex & BW Random assignment to treatment or placebo All checked for malaria parasites	Injection of Fe or placebo at 2 mo	12 mo: habituation test, examination for malaria parasites	Malaria confused the results; in parasite-free children only, treated children had higher fixation times No effect on habituation
Walter et al. (1989) Chile [104]	*n* = 196, 3 mo Stratified by BF Randomly assigned to treatment or placebo	Fe-fortified or non-fortified food from 3 to 12 mo	12 mo: Bayley, no baseline measures	No significant benefit on Bayley scores Anaemic children in pooled groups had lower MDI & PDI scores
Moffatt & Longstaffe (1994) Canada [116]	*n* = 283, 6 mo Bottle-fed infants, randomly assigned to treatment or placebo at birth (*n* = 154 at 15 mo)	Fe-fortified or regular formula	6, 9, 12, 15 mo: Bayley	PDI not significantly different at 6 & 15 mo, significantly better in Fe-treated group at 9 & 12 mo MDI not different
Lozoff (1996) Chile (abstract only) [117]	*n* = 944, 6 mo Randomly assigned to treatment or control	Fe or no Fe, 6–12 mo	12 mo: Bayley	No treatment effect on Bayley scores 4% IDA in control group, 15% in treated
Williams et al. (1998) England [personal communication]	*n* = 100 inner-city infants on cow's milk Randomly assigned to treatment or control at 7 mo	Fe-fortified formula or cow's milk from 7 to 18 mo	7, 18, 24 mo: Griffiths	18 mo: no treatment effect 24 mo: significant treatment effect on DQ & all subscales except locomotor

Abbreviations: BW, birthweight; DQ, developmental quotient; IDA, iron-deficiency anaemia; MDI, mental development index of the Bayley Test; PDI, psychomotor development index of the Bayley Test.

a role. This study illustrates the importance of conducting longitudinal studies when concerned with child development outcomes, because if the study had stopped at 18 months when the supplement was stopped, no effect would have been evident. It is possible that the developmental deficit takes time to develop, which may explain the failure of other preventive trials to show a benefit [101, 118].

Conclusions from preventive trials

It appears that preventive trials benefit some populations. The two later studies were both randomized controlled trials, although one had a large loss and the other did not give only iron. The difference in proportion of anaemic children between the groups in the English trial [Williams J, personal communication, 1998] was considerable (30%), and the follow-up continued for 17 months, which may explain why benefits were found. In contrast, in most of the other studies, the duration was shorter and the difference between the groups in anaemia was not so great.

Iron-supplementation studies of anaemic school-aged children

Studies with schoolchildren will not be discussed in detail, since our focus is on younger children. However, when interpreting findings from studies in younger children, it is useful to be cognizant of findings from

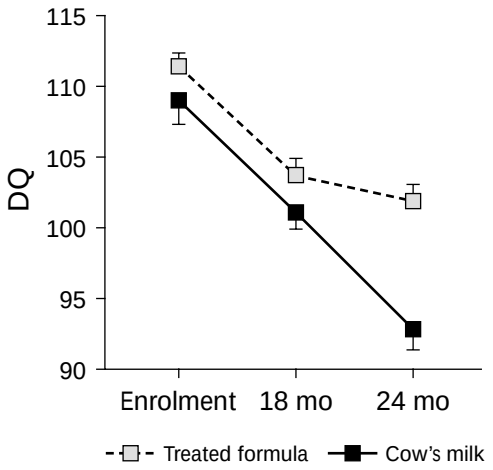

FIG. 2. Griffiths developmental quotients of children given iron-fortified formula (n = 50) or unmodified cow's milk (n = 50) [Williams J, personal communication, 1998]

older children. Unlike studies in the first two years of life, studies in older children have had reasonably consistent results. Benefits to children's performance on tests of cognitive function or school achievement were reported in India [119], Indonesia [120–122], and Egypt [123]. It is unclear why one well-designed study in Thailand failed to find an improvement in school achievement when anaemic children were given iron [124].

Mechanisms

Lozoff reviewed the possible mechanisms whereby iron deficiency might affect behaviour and mental development [125]. Research in animals suggested that the brain is directly affected. Total brain iron is reduced in iron deficiency, and if it occurs early in life, there is a permanent reduction despite correction of anaemia [126, 127]. Iron is essential for myelination, and iron-deficient rats show hypomyelination. In addition iron plays a role in neurotransmitter function, and dopamine function is decreased [126–128].

Another possible mechanism is through the children's behaviour itself, which could lead to poor development. Anaemic children have been reported to be inhibited [129], and recently systematic observations showed that they stay nearer their mothers, are wary and hesitant, and interact less with family members [125, 130]. This behaviour is similar to that of malnourished children [131]. It has been hypothesized that the children are isolated from their environments and thus fail to explore and acquire skills at a normal rate, a phenomenon known as "functional isolation" [132].

Recent work in children may explain the link between central nervous system changes and behaviour [125]. Infants with iron-deficiency anaemia had prolonged latency in auditory brain stem responses, which remained after correction, providing evidence that the central nervous system is affected in iron-deficiency anaemia. Iron-deficient infants also have reduced vagal tone, which remains after correction of iron deficiency. Reduced vagal tone has been linked to behaviour changes, including poorer developmental outcome, extreme inhibition, and reduced ability to cope with stress [133, 134]. These changes could explain some of the behaviours of iron-deficient children.

Summary of findings and conclusions on iron deficiency and child development

Association between iron-deficiency anaemia and development

The association between iron-deficiency anaemia in the first two years and concurrent and future poor developmental levels is well established. It is also well established that iron-deficiency anaemia is associated with many sociocultural disadvantages.

Iron-deficiency anaemia causes poor development

School-aged anaemic children benefit from iron treatment in terms of cognition and school achievement, indicating that there is likely to be a causal association between iron treatment and improved cognition. It is extremely unlikely that older children are more sensitive to iron-deficiency anaemia than younger children.

There is evidence from two preventive randomized controlled trials that iron deficiency detrimentally affects child development [116; Williams J, personal communication, 1998], although the benefit is transient in one study. However, as two recent trials failed to find a benefit [101, 118], we need to carefully examine the data when they become available in order to determine why these studies have inconsistent findings. Possible reasons are the duration of the treatment, the age of the child at testing, and the difference in the prevalence of anaemia between the treated and the placebo groups. No trials have been reported in countries with extremely high levels of anaemia. No consistent evidence suggests that mental development is affected differently from motor development.

Response of children with iron-deficiency anaemia to treatment

Short-term treatment does not benefit children's development during the period of treatment. In children under two years of age, the evidence for an improvement in development in response to longer-term treatment of iron-deficiency anaemia rests on one small randomized trial [97], and these findings need to be replicated. Several studies failed to show an improvement with treatment, but they had less robust designs.

Policy implications

Many developed countries have reduced pre-school anaemia through the use of iron-fortified formula, complementary foods, and iron supplements. For example, in the United States the prevalence of anaemia has seen a steady decline of 5% among low-income children who received iron-fortified foods through the federal food supplement programme for women, infants, and children [135]. However, among similar low-income populations in Canada and Britain, the prevalence of iron-deficiency anaemia among low-income children remains around 25% or even higher [136].

At the 1990 World Summit for Children, goals were set to reduce iron-deficiency anaemia by a third of the 1990 levels by the year 2000 [20]. However, large-scale interventions in developing countries to reduce anaemia have had little success; most approaches have been limited to providing supplements [137]. Although governments have adopted policies to reduce iron-deficiency anaemia among pregnant women and pre-school children, often these are not enforced or implemented. Recent research has demonstrated that approaches such as the control of malaria and other parasitic infections, long-term supplementation, and food fortification can successfully reduce the prevalence of iron-deficiency anaemia [138, 139]. These approaches need to be considered by policy makers and governments as possible means to reduce the prevalence of iron-deficiency anaemia. Furthermore, anaemic children usually have other risk factors for poor development; if these children are to attain optimal development, an integrated approach, which includes child-development activities, is needed.

Zinc deficiency

Zinc deficiency is now recognized as a public health problem [140]. Zinc deficiency is associated with complications of pregnancy and birth outcomes [141], impaired immune function [142], and increased duration and severity of diarrhoea in children [143]. It also causes growth retardation, and several studies have shown that zinc supplementation can produce a significant growth response in height and weight-for-height [144–146].

Zinc deficiency occurs in many countries, but the actual number of people affected is unknown because of difficulties in diagnosis. The quality of the diet, the incidence of infection, and the physiological stage of development all determine the prevalence of zinc deficiency. It is common where diets contain little meat and high levels of phytate or fibre, which reduce zinc bioavailability. These characteristics are common in the diets of many developing countries. Cow's milk also inhibits zinc bioavailability, whereas breastmilk does not. In addition, competitive interactions between zinc and copper and between zinc and iron may further limit availability [147].

Requirements for zinc are increased during periods of rapid growth, such as infancy and pregnancy, and in addition, increased loss in the stool occurs in diarrhoea. Zinc deficiency is therefore likely to be common in young undernourished children who have frequent diarrhoea.

There is concern that zinc deficiency may detrimentally affect children's mental development and behaviour. Several studies in primates have shown that zinc deficiency affects behaviour [148]. A few studies conducted in children are summarized in table 7 [143, 147, 149–152]. Children's behaviour in their homes was the outcome of interest in two randomized, controlled trials of zinc supplementation. In a study of Indian children aged 12 to 24 months, their activity was divided into five groups according to intensity, and the supplemented group spent more time in the highest-intensity category; ratings of their overall activity level were also significantly increased [143]. In a study in Guatemala [150], the supplemented children were observed to sit and play more often and lie down less often than unsupplemented children. However, the definition of play was unclear, and no difference in the age of attainment of motor milestones was found. Neither study analyzed the results by change in scores.

One study examined the effect of supplementation on infant's psychomotor development. In a randomized trial of 52 very-low-birthweight children in Canada [152], the group that received zinc and copper supplements had significantly higher scores on the locomotor subscale of the Griffiths Test than the unsupplemented group after approximately six months. The other subscales were not affected.

In two randomized, controlled trials of the effects of zinc supplementation on the cognitive function of schoolchildren, no differences were found. However, an extremely limited range of cognitive functions were tested [147, 151]. In a recent Chinese study [149], schoolchildren showed benefits to their scores on a wide range of cognitive tests after 10 weeks of zinc supplementation as compared with a group receiving a micronutrient mixture. The groups were randomized by class, and the analysis was done by child. The evidence suggests that zinc deficiency affects behaviour and cognition, but more studies are required to determine a causal relationship with confidence.

Other nutritional deficiencies

Vitamin A deficiency

Vitamin A deficiency is associated with blindness and increased severity of infections such as measles and di-

TABLE 7. Studies of the effect of zinc treatment on children's behavioural and cognitive functions

Source	Sample and study design	Treatment	Outcome	Results
Penland et al. (1997) China [149]	*n* = 372 6–9 yr Double-blind randomized controlled treatment trial; 3 groups	A. 20 mg Zn daily B. 20 mg Zn daily plus micronutrients C. Micronutrients only 10 wk duration	Growth: knee height Neuropsychological functions: visual motor tracking, continuous performance, visual perception, short-term visual memory, concept formation, abstract reasoning, finger tapping	Knee height: B > C > A Neuropsychological findings: significant treatment effect after A or B compared with C for continuous performance, visual perception, visual memory, tracking, concept formation, finger tapping
Bentley (1997) Guatemala [150]	*n* = 108 6–9 mo Double-blind randomized controlled trial	10 mg Zn or placebo 7 mo duration	Behaviour observed at baseline & 3 & 7 mo later	No difference at baseline or 3 mo 7 mo: supplemented group sat & played more, cried less Major milestones not different
Sazawal et al. (1996) India [143]	*n* = 93 children 12–23 mo Double-blind randomized controlled treatment trial	10 mg elemental Zn given daily for 6 mo to treatment group	Behaviour observation for 2 consecutive days, 5 h/day	Significant increase with treatment in high-movement activities Significant treatment effect on children's activity rating score & on energy expenditure score
Cavan et al. (1993) Guatemala [151]	*n* = 162, ~81.5 mo Double-blind randomized controlled treatment trial	Before study all were given multivitamin & mineral supplement without Zn Treatment: 10 mg Zn daily or placebo 25 wk duration	Anthropometry Biochemistry Functional assessments Taste acuity, cell-mediated immunity, cognition (letter sequences, oral directions, design reproduction)	Significant treatment effect for mid-arm circumference & triceps skinfold only, not significant for height & weight No significant treatment effect for functional physiological & cognitive measurements
Friel et al. (1993) Canada [152]	*n* = 52 VLBW infants, mean gestational age 29 wk Randomized controlled treatment trial	Supplemented 6 mo: 11 mg/L Zn, 0.9 mg/L Cu Unsupplemented: 6.7 mg/L Zn, 0.6 mg/L Cu Assessed at 3, 6, 9, 12 mo	Biochemistry: blood & hair samples Anthropometry Cognition: Griffiths developmental assessment	Significant difference in growth velocities & Griffiths motor subscale between supplemented & unsupplemented group No significant difference in Griffiths global score between supplemented & unsupplemented group

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child health and nutrition programmes that encompasses improving the psychosocial environment. In order to do this, we need good indicators of both the child's environment and his or her development. We need to pilot and evaluate different approaches and learn from the few projects that are already in progress.

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A developmental function of motor activity among nutritionally at-risk children

Ernesto Pollitt, Jia-Fen Huang, and Abas Jahari

Abstract

Learning about the dynamics of early childhood development in the context of poverty and malnutrition is an effective way to identify the periods of highest psychosocial vulnerability and the role of timing in the differential responsivity of young children to interventions. Motor activity under natural conditions is one area of development that requires further study because of its biological and psychological developmental importance. This paper presents an estimate of the development function of motor activity among poorly nourished children whose ages ranged from 12 to 30 months. It also focuses on the longitudinal relationship between the nature, level of motor development, and intensity of motor actions, on the one hand, and physical growth, dietary intake, and motor activity, on the other.

Two cohorts (12 and 18 months old) of rural West Javanese children were studied. Motor activity, energy intake, physical growth, and motor development were measured every two months. A motor activity score was calculated based on the estimated energy cost and intensity of each activity and their frequency and duration during each of the periods of observation. Intensity was classified according to a three-point scale (high = 1.25, moderate = 1.0, low = 0.75). The Bayley Scale of Motor Development and a scale of motor milestones were used to assess motor development (e.g., crawling, creeping, walking, and running).

The developmental function of activity was curvilinear. It showed a moderately fast acceleration from 12 to about 18 to 20 months; at that point the curve reached a plateau. The functions of growth and energy intake were linear. The average motor behaviour of these children was characterized by its low level of intensity. Although the relationship between motor activity and motor development was relatively close up to about 20 months, thereafter the motor activity and motor development scores were independent of each other. The changes in activity level were primarily determined by a significant decline of involvement in activities having a low energy cost and an increase in activities having moderate or high energy cost. The decline of motor activity observed at 18 months is reminiscent of the decline in growth velocity observed during the first six months of life among malnourished children. It is plausible that the pattern of activity observed could be explained by either contextual or cultural factors.

Introduction

Early childhood development programmes aim to prevent and ameliorate the psychosocial developmental delays observed among children from economically impoverished populations. In low-income countries, large-scale (national) programmes are justified because they allegedly foster a child's competence to meet the demands of primary education. In many of those countries, the governments face heavy economic losses associated with the failure of children to meet formal educational demands by dropping out of school early or having to repeat grades. For example, children finish primary school in 8 to 10 years instead of 6 years as it is programmed. These disappointing outcomes often follow early childhood malnutrition, poor health, and limited educational opportunities.

The recent attention that international organizations and interested governments have given to early developmental delays calls for a comprehensive understanding of the patterns of development among children who are developmentally at risk in low-income countries to identify sensitive points for intervention. Good intentions, by themselves, will not bring about salutary developmental changes. Little is known about child-care practices and the social, emotional, motivational, motor, and mental development of such children. Learn-

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ing about the course of their development and its environmental determinants in the context of poverty and malnutrition will help identify the periods of highest vulnerability and the differential responsivity to interventions as a function of timing.

Physical growth among low-income populations in low-income countries illustrates the importance of drawing the trajectory of a particular growth or developmental outcome. The linear growth of such populations is close to the median of the reference standards of the World Health Organization (WHO) up to about four months of age. This period is followed by a period of growth faltering up to about 36 months [1–3]. The most timely period of intervention to prevent, in part, growth faltering is during the periods when growth deficits are steep [4].

The reduction of energy intake leads to a reduction of energy expenditure, including lowering motor activity [5, 6]. It is theoretically plausible that this adaptation [6] places a heavy toll on development, since motor activity is an important antecedent of cognitive function and social-emotional regulation [7–10]. In the context of developmental psychology, motor activity is also recognized as a key indicator of infant temperament. Interindividual differences in activity have been associated with differences in the intensity with which children respond to environmental stimuli [11, 12].

The theoretical recognition of the biological and psychological importance of motor activity has not been accompanied by strong field studies on the motor activity of nutritionally at-risk children under natural conditions [13]. There is a large body of knowledge and normative data on the timing and characteristics of physical growth of well-nourished and poorly nourished children, but this is not so for motor activity. For example, it is not known whether the deceleration in growth that starts at about four months among poorly nourished children is associated with a similar shift of motor activity. Likewise, we know little about the behavioural mechanisms that mediate the reduction of motor activity under conditions of deficient diets or increased morbidity. Moreover, only recently has it been recognized that besides energy deficiency, deficiencies of zinc and iron also reduce motor activity [14, 15].

Field studies of the motor activity of young children from different populations will help us understand the nature and causes of intra-individual, interindividual, and intergroup variability of activity levels. The enormously complex task of standardization of methods to collect normative data may be prohibitively expensive and is not likely to generate interpretable information if the ecocultural context is not accounted for.

This paper addresses the following questions: What is the developmental function of motor activity among poorly nourished children whose age ranges from 12 to 30 months? How does this developmental function compare with the weight gain and linear growth curves of the same children? Is there an association between changes in the shape of the curve for the developmental function of motor activity and changes in energy intake? What is the longitudinal relationship between the nature, level of motor development, and intensity of motor behaviour, on the one hand, and motor activity, on the other hand?

Methods

Research design

This study is part of a larger project on early supplementary feeding, motor development, behaviour, and cognition in West Java, which included two cohorts of children (12 and 18 months old) enrolled in 24 day-care centres in six tea plantations. There were three different dietary interventions: energy plus micronutrients (E), micronutrients (M), and skim milk (SM). The dietary interventions were randomly assigned to the day-care centres. For the present study, the effects of treatment were statistically controlled, and within each cohort the subjects from the three groups were pooled together.

Location

The six tea plantations were located in the subdistrict of Pangalengan, 50 km south of Bandung, the capital of West Java. Pangalengan is at an elevation of 1,500 to 1,800 m above sea level and has a temperature that ranges from 12° to 17°C. The six plantations encompassed 32 communities of workers and their families, with little in- or out-migration. In 1992 the average wage for picking tea leaves was approximately Rp 72,000 per month (Rp 2000 = US$1.00). The population of each community ranged from 272 to 2,399 (average, 1,047), with an average household size of 4.2 members.

Communities and day-care centres

Twenty-four communities in the six tea plantations met two inclusion criteria: presence of a day-care centre and at least two infants or toddlers classified as wasted and stunted. All houses had electricity and potable water. Public bathrooms with toilets were available in separate quarters. Primary schools and medical services were available in all communities.

The day-care centres were usually located in the residential area of each community and were open from 6 a.m. until 2 p.m. Most had one multipurpose room for playing and napping, a kitchen, a restroom, and a small vegetable garden. The children enrolled in the day-care centres ranged in age from 1 to 72 months,

and the number of children per day-care centre ranged from 5 to 35.

Subjects

All children 12 (±15 days) and 18 (±15 days) months of age living in the communities and enrolled in the day-care centres were potential participants. Among these children, we selected and invited to enroll those children who met two anthropometric criteria: wasting and stunting. Wasting was defined as a weight-for-length between one and two standard deviations below WHO standards. Stunting was defined as a length-for-age below one standard deviation of the respective median of the same reference. There were 53 children in the 12-month cohort and 61 children in the 18-month cohort.

Variables and measurements

Motor activity

Every two months, three fieldworkers carried out four hours of observation of motor activity when the children were awake: two hours in the morning at the day-care centres and two hours in the afternoon at home. The second session usually took place after the mother returned home from working in the field.

The list of activities used is a modification of the lists used by others [13, 16] in studies on malnutrition and motor activity (table 1). Continuous observations were conducted with the aid of computer notebooks (Acer Model No. K386S) and custom-tailored software. Observation and recording of the data were done simultaneously.

TABLE 1. Motor development scale, observed activities, and activity cost

Motor development			Motor activity		
			1	Lying	1.20
1	Sit 1	Sits with support	2	Sitting still	1.20
2	Sit 2	Sits without support and the body is not upright			
3	Sit 3	Sits without support and the body is upright			
4	Crawl 1	Lying on abdomen, can raise himself or herself up by the hands	3	Crawling	2.50
5	Crawl 2	Lying flat on the abdomen, can raise the body bearing the weight on the hands and the tips of the toes alone			
6	Creep 1	Crawls and starts by going backwards	4	Creeping	2.00
7	Creep 2	Creeps on all fours (on hands and knees)			
			5	Kneeling	1.40
			6	Carried	1.20
			7	Sitting with movement	1.40
			8	Squatting	2.00
			9	All fours	1.20
8	Walk 0	Walks with assistance of other; feet are not steady yet	10	Walks with assistance	2.50
9	Walk 1	Walks with assistance of other; feet flat on the floor			
10	Walk 2	Walks by self with support			
11	Stand 0	Learning to stand	11	Stands with assistance	1.30
12	Stand 1	Stands with support			
13	Stand 2	Stands without support	12	Stands without support	2.30
14	Walk 3	Walks a few steps without support	13	Walks without assistance	3.00
15	Walk 4	Walks alone with small steps			
16	Walk 5	Walks with large steps			
17	Run	Running	14	Running	5.00
			15	Climbing	3.00
			16	Pushing	2.00
			17	Jumping	3.50

A total motor activity (TMA) score was calculated as follows:

$$TMA = E \times I \times F \times D$$

where

E = estimated energy cost of an activity,
I = estimated level of intensity (vigour) of an activity,
F = frequency of an activity during four-hour period of observation,
D = duration of each episode of each activity.

The energy cost of each activity was estimated based on the existing literature [Durnin J, personal communication, 1996]. Intensity was classified in a three-point scale (low = 0.75, middle = 1.0, high = 1.25). Because the activities were exclusive of each other, the computer calculated the duration in minutes of each activity coded (table 1).

Of particular interest were the processes involved in the variability of activity within or between children. We investigated three particular changes: changes in intensity; changes in the frequency and duration of activities having low, moderate, or high energy cost; and acquisition of new motor skills.

Dietary intake

The total energy intake of the children at the day-care centres and at home was measured for a 24-hour period at the beginning of the study and every 2 months thereafter for 12 months. These measurements included the energy from the supplements given to the children from the two cohorts and as part of the larger study. However, as noted, the effects of the nutritional intervention were controlled for in the assessment of the growth and developmental outcomes reported here.

Anthropometry

According to the same schedule as the dietary-intake assessments, a series of anthropometric measurements was obtained, including weight, recumbent length, head circumference, skinfolds, and arm circumference. This paper is concerned with only the first two of the anthropometric measurements.

Motor milestones

The main objective was to assess the sequential changes in gross motor skills (e.g., crawling and standing) leading to bipedal locomotion. To assess these changes, we developed an ordinal scale based on the classical work of Myrtle McGraw [17] on the neuromuscular maturation of the human infant and on over 100 hours of observation of infants and toddlers who attended the day-care centres. McGraw had proposed a timely sequence in the development of different phases of motor skills involved in movement, ranging from incipient propulsion in the superior region of the body to erect locomotion. A motor milestone score was obtained based on the child's most advanced skill. These data were collected weekly.

Bayley Scale of Motor Development

This scale includes items that test both fine and gross motor movements. Palmar prehension, thumb opposition, and partial finger prehension of a pellet are examples of items that test fine motor movements. Gross motor movements are assessed by items such as sits with support, pulls to sitting position, stepping movements, and walks with help.

Results

Developmental function of motor activity (12 to 30 months)

Figure 1 presents the mean scores of motor activity obtained every 2 months for 12 months from the two cohorts. It also includes an exponential regression estimate for the 12-month cohort (R^2 = .98). After reaching a motor activity score of about 450, the curve turns flat in both the 12- and the 18-month cohort (see also table 2). This pronounced change in motor activity was unexpected, because on average children in this population are first able to walk without assistance, which is a comparatively high-energy expenditure activity, at about 14 months [18].

Energy intake and anthropometry

Figure 2 presents the curve estimated from the means of the total energy intake at each time point for the two cohorts. It also includes the results from the respective regression equations. For both cohorts, the best fit to the data were linear regressions; for the 12-month

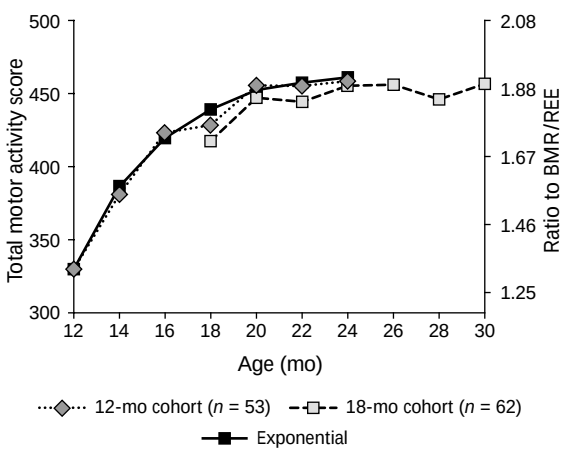

FIG. 1. Total motor activity score (mean) changes with age (including exponential regression estimates)

cohort, $R^2 = .34$ ($p < .0001$), whereas for the older cohort, $R^2 = .32$ ($p < .0001$). The differences in the shape of the curves that best fit the intake (linear) and activity (curvilinear) data show that the precipitous change in activity level at about 18 to 20 months was not preceded or accompanied by a change in the intake of energy.

Figures 3 and 4 present the weight and the recumbent length curves and the results from the regression equations. Here again these functions do not resemble the curve of activity level.

Processes involved in the regulation of motor actions

Intensity (vigour)

The Count growth model [19] was also used to estimate the developmental function of activity with and without the intensity factor. We have shown previously that the Count model provides a close fit to growth data [2, 20]. The three model parameters represent three components: initial departure point (i.e., not time dependent) *a*, linear increase in activity *b*, and deceleration *c*.

TABLE 2. Exponential least squares summary statistics (12-month cohort)

Source	DF	Sum of squares	Mean square	r^2
Regression	3	66,321,101	22,107,033.6	
Residual	368	1,275,591.3	3,466.28	
Uncorrected total	371	67,596,692		0.98

Exponential regression equation:
Estimated TMAS = –3074.6 + 3541.2 *[1 – exp (–0.271 * age)]
Estimated asymptote of TMAS is 466.

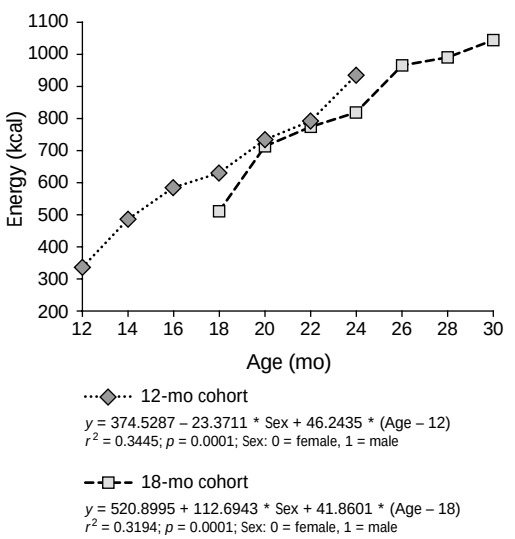

FIG. 2. Mean total energy intake according to cohort and age

The mathematical expression is written as follows:

$$y = a + bx + c \log (x + 1)$$

Figures 5 and 6 present the curves of the motor activity scores, with and without intensity, for the 12- and 18-month cohorts, respectively. Figure 5 shows that the Count model provides a moderate fit to the data from the 12-month cohort, with ($R^2 = 0.35$; $p < .0001$) and without ($R^2 = 0.36$; $p < .0001$) intensity. Both curves show a modest incremental change in motor activity up to about 18 to 20 months of life, followed by significant deceleration. The equations for the 18-month cohort (fig. 6) were also statistically significant, but the

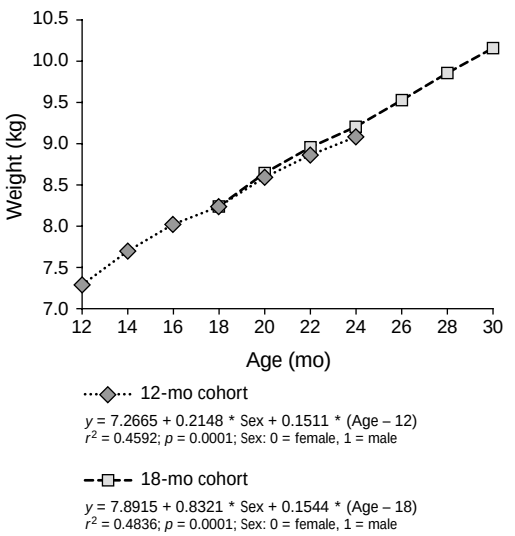

FIG. 3. Mean weight according to cohort and age

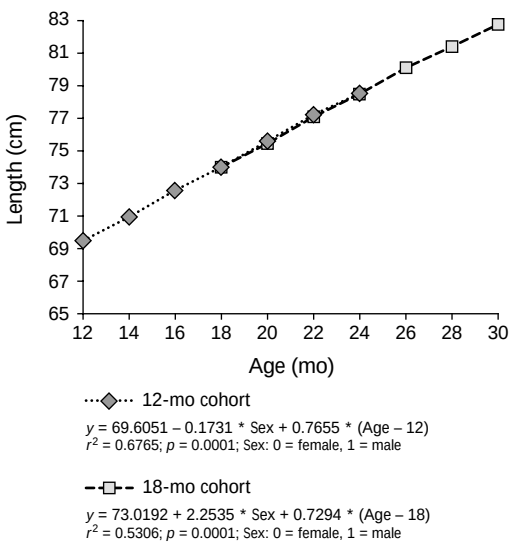

FIG. 4. Mean recumbent length according to cohort and age

R^2 in both equations was very modest (0.10). Both lines show a very slow increase of activity throughout the 12 months of observation.

Changes in motor development

In the 12-month cohort, the non-parametric (Spearman) coefficients of correlation among the three motor variables (activity score, motor milestones, and Bayley Motor score) up to about 18 months are moderate to large in size. The coefficients range from 0.35 (motor activity and Bayley Motor score) to 0.82 (motor activity and motor milestone scores). However, after 18 months there is a large drop in the size of the two coefficients, so that by 24 months these correlations are not different from zero. Such a statistical pattern in the association of motor development and motor activity should not be surprising, because by about 20 months the variability of motor development was significantly reduced, as most children were able to walk with or without assistance.

Changes in motor behavioural profile

Children can change their motor behavioural profiles by changing the frequency and duration of activities with low or high energy cost. Figure 7 presents the longitudinal curves based on the mean values of the three sets of activities having different energy costs at each of the assessment periods of the 12- and 18-month cohorts. These curves show that during the first 6 months of observation, there was a change in the behavioural profile of the children of the 12-month cohort. Simultaneously, their involvement in low-cost activities decreased and their involvement in moderate- and high-cost activities rose. This is not obvious for either the second 6 months of the 12-month cohort or for the entire 12-month period of observation

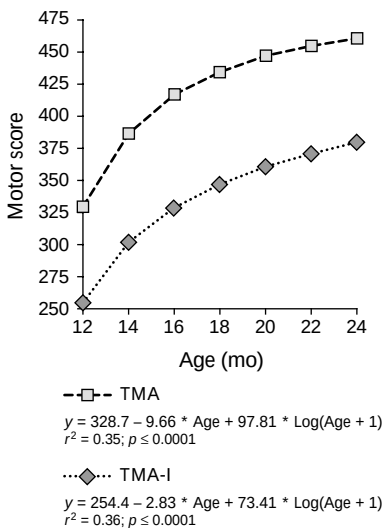

FIG. 5. Fitted regression line for total motor activity score according to age (12-month cohort)

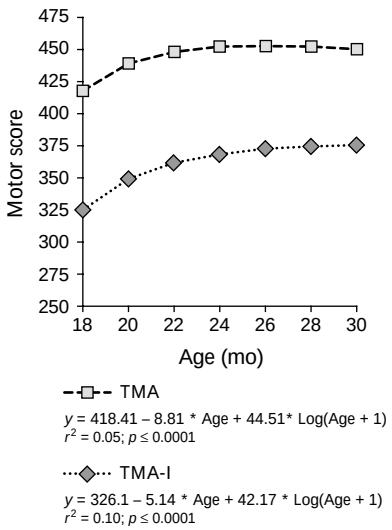

FIG. 6. Fitted regression line for total motor activity score according to age (18-month cohort)

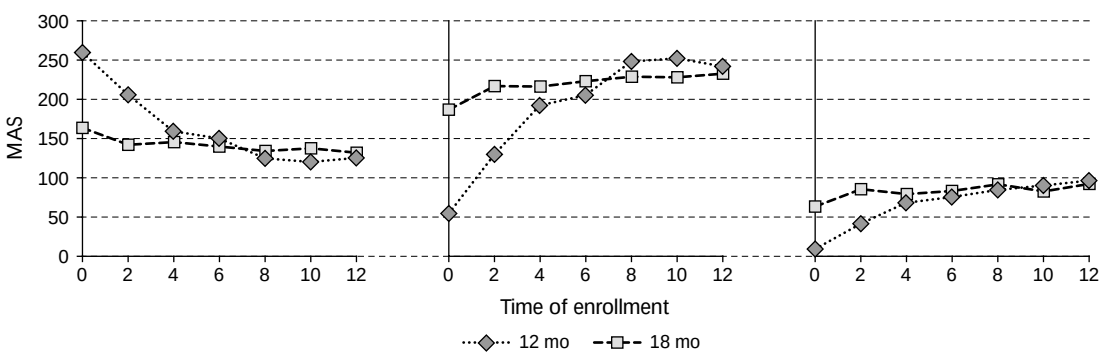

FIG. 7. Mean motor activity scores (MAS) according to time, cohort, and energy cost of activity

of the children of the 18-month cohort. In this older group there was a modest change in the pattern of behaviour involving the three categories of activity.

Discussion

There was a downward shift in motor activity at about 18 months. This developmental function is reminiscent of the deceleration of weight and linear growth observed at about 4 to 6 months among many nutritionally at-risk infants in low-income countries. However, because the study started when the youngest children were 12 months of age, no conclusions can be drawn from this sample regarding the shape of the activity function at that earlier age. We can conclude, however, that the steep decrement in motor activity observed at 18 months was not associated with a similar decrement in the velocity of physical growth. Likewise, the change in activity was not associated with any major change in the caloric intake of the children.

Other research sources have shown that motor development is not spared in the presence of malnutrition during the first 18 months of life. Several studies have shown that early supplementary feeding of poorly nourished children improves their performance in motor development scales [21]. It would be adaptive if malnutrition were to have a larger effect on physical growth before it affected motor development, because, as we have already noted, skills such as creeping, crawling, and walking are milestones of substantive value for cognitive and social-emotional development. In particular, this type of delay of motor development can delay visual perceptual development.

The intra- and inter-individual variability of motor activity depends on the intensity of the actions and the nature and use of the motor skills that are part of the behavioural profile of children. In our sample, the children were neither vigorous nor energetic, and their behaviour was characterized primarily by involvement in activities having a moderate or low energy cost. This was true even for children whose ages ranged from 24 to 30 months.

It is plausible that the pattern of motor activity that we observed among the infants and toddlers in Pangalengan is explained by contextual and cultural factors [22]. For example, the caretakers in the day-care centres where the children spent over six hours a day were generally concerned with pooling children into a group and placing them in particular areas of a multipurpose room. This informal policy must constrain somewhat the mobility of the children who are walking. Moreover, the children were free to move about the yard only during a relatively short recess period. In addition, in the communities the caretakers often carry infants and toddlers on their hips. Such a practice could certainly be an additional limiting factor.

Acknowledgements

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Overview of early child-care and education programmes and Jamaican case studies

Christine Powell

Abstract

The extent to which early childhood programmes can produce long-term benefits to children's cognitive and social-emotional development continues to be a major concern of policy makers. This paper examines some of the model intervention programmes for children under four years of age that have been carried out in the United States and some developing countries, with emphasis on our experience in Jamaica. In general, programme participants have shown concurrent gains in IQ during the intervention. These have been sustained into the early school years, after which there is a tendency for the gains to decline. However, some programmes have reported persistence of IQ gains to the age of 12 years. Long-term gains in educational progress include fewer placements in special education classes and less grade retention. Programmes of greater duration and intensity were more likely to be successful.

Introduction

Over the last four decades, there have been several studies designed to evaluate the impact of early child-care and education programmes on the cognitive and social-emotional development of children from poor circumstances. Although these programmes have been instituted in many countries, the United States provides the largest number of evaluations carried out under experimental conditions, which can give some estimate of the benefits to be derived. I will give a brief overview of some of the more well-designed programmes from the United States for children under four years of age, followed by some programmes from developing countries. I will conclude with some Jamaican case studies.

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In general, programmes may be categorized according to who was targeted—the parent, the child, or both—or whether the intervention was home or centre based. Centre-based programmes are usually conducted outside the home in day-care centres or specially designed pre-school centres. These programmes are concerned mainly with directly affecting the child rather than the family, although in some cases instructions are also provided for the mothers in centres. A few have been entirely parent focused, in that parents attend regular meetings at a centre.

Home-based programmes are usually aimed at improving the child's developmental status by enhancing the child-rearing and child-care environment in the home. This is generally done through home visits intended to influence the child's primary caregiver. The target is therefore one or both parents and the child. It was expected that working with parents would help to combat post-programme erosion effects by providing a mechanism for stimulation to continue after the programme ended. There was also the possibility that benefits would spread to other children within the family and possibly also to neighbours. It was also expected that mothers would derive benefits for themselves, and many programmes included activities to help them develop a more positive self-concept, feelings of competence, and skills training.

Some of the better-evaluated programmes from the United States, which had either an experimental or a quasi-experimental design, are summarized in tables 1 to 3. They were also chosen to reflect the variety of approaches that have been tried.

Intervention programmes in the United States

Programmes for children under two years of age: Predominantly centre based

Some of the centre-based programmes involved intensive interventions for the children that required costly

personnel and material resources; for example, the Milwaukee study [1] involved extensive provisions for the child and family for six years. The children were enrolled as early as six weeks to three months of age and were randomly assigned to experimental or control groups. They spent full days in the centre, where the staff-to-child ratios were as low as 1:2 for the babies and increased as the children got older. Family intervention that provided job training and social and remedial education for the mothers was also included. Some of the largest gains in IQ have been reported from this programme; for example, differences as high as 32 IQ points between the children in the experimental and control groups were reported at three years of age. At 10 years of age, the children in the experimental group had superior school achievement and a mean IQ 20 points higher than that of the control children. There has been some controversy over the persistence of these gains, and the programme has been criticized as unrealistic, impractical, and not reproducible on a large scale.

A similar intensive centre-based programme, the Carolina Abecedarian Project [2], was followed by a school-age intervention in which a resource teacher visited the homes and provided the parents with individualized sets of educational activities for the children. There were four groups: centre alone, centre plus three years home instructions, home instruction alone, and no intervention. At follow-up at 12 years of age, the children who had participated in the centre-based preschool programme, alone or in combination with the school-age programme, had significantly higher IQ and school achievement scores than the controls. The advantage of the additional home intervention was small. Project CARE [3] extended the Abecedarian Project concept to include a family educational intervention. This was influenced by the thinking that a family-support intervention would be effective in changing the home environment and possibly have a larger impact than the more child-focused centre-based programme. Three groups were compared: centre-based programme plus family education delivered through home visits, family education alone, and no intervention. The centre plus family-education group had significantly higher scores than the other two groups on the Bayley Mental Development Index up to age 18 months and on the Stanford-Binet test up to 36 months. At 48 months the centre group had higher scores than the family-education group but not the controls. Thus, family education alone did not have any benefit on the children's cognitive development.

The Parent Child Development Centers [4] in three states (Louisiana, Texas, and Alabama) focused predominantly on the mothers, who met in groups at a centre to discuss activities related to the children's development. Sessions on family relationships were also included to help the mothers function more effectively within the family. The expectation was that mothers would retain benefits and help to sustain those seen in the children. There were variations among the three programmes in time spent in the centre (table 1). The Houston, Texas, programme included home visits in the first year, complemented by four weekend family workshops. In the second year, mothers and children attended the centre four times a week. In the Birmingham, Alabama, group the mothers assisted with the care of their own children in the centre and gradually took over responsibility as the children got older. Participants in all three programmes were randomly assigned to intervention or control. Benefits to the children during the intervention ranged from 6 to 8 developmental quotient (DQ) points, and significant benefits were detected one year after the intervention in the groups in Birmingham and New Orleans, Louisiana. In Houston advantages in the achievement levels in grades 2 to 5 were reported, but no benefit was found to IQ at 36 months of age.

Instructions that were meant to improve the cognition and verbal development of the child were sometimes given directly to the mother in the absence of the child. Karnes and colleagues [5] combined such activities with home visits to observe how the mothers were implementing the programme. A difference of 16 IQ points on the Stanford-Binet test between index children and controls was observed after 15 months. This improvement is comparable to that seen in other studies in which trained professionals were used. Although the inputs were considerable, including the availability of play materials and monthly home visits as well as weekly meetings, it is impressive that these gains were made with such limited contact with the child. However, the children were not randomized to groups, and therefore caution must be used in interpreting the results. The economic advantage of using mothers to carry out the intervention could have far-reaching implications in the extension of such services.

High-risk children who were also socio-economically disadvantaged have also shown significant gains from early intervention. The Infant Health Department Program [6] was a multisite intervention for low-birthweight children ($\leq$ 2,500 g). The programme, which lasted from birth to three years of age, included weekly home visits in the first year and fortnightly thereafter, educational centre-based care from 12 months, and parent support groups. By three years of age, children who weighed between 2,000 and 2,500 g at birth had an average IQ 13.2 points higher than the controls; the gains among children with lower birthweights were more modest.

Programmes for children under two years of age: Predominantly home based

Summaries of four predominantly home-based programmes that were initiated in children under 24

TABLE 1. Intervention studies in the United States with children from birth to two years of age: predominantly centre based

Program & ref.	Initial age	Sample & assignment	Intervention	Child outcome
Milwaukee Project [1]	3 mo	Low-SES mothers with low IQs Random assignment to experimental or control group until age 6 yr	Child spent 5 da/wk in centre	Experimental group significantly better than controls on Gesell at 18 mo, WISC up to 10 yr, & school achievement at 10 yr
Carolina Abecedarian [2]	6 wk–3 mo	Low SES Random assignment to experimental or control group	1. Control 2. Centre-based programme to age 5 yr 3. Centre-based programme to age 5 yr + home instruction to age 8 yr 4. Home instruction to age 5–8 yr	Experimental pre-school group significantly better than controls on Bayley to 18 mo, Stanford-Binet to 48 mo, & WPPSI at age 5 yr Experimental pre-school with or without school-age intervention significantly better than school-age intervention alone or no intervention on IQ tests at age 12 yr
Project CARE [3]	6 wk–3 mo	Low SES Random assignment to 2 experimental groups or control group for 5 yr	1. Child attended centre + family education through home visits 2. Family education only 3. Control	Centre + family education group significantly better than other 2 groups on Bayley at 12 & 18 mo & on Stanford-Binet at 24 & 36 mo Better than family education only group but not controls at 48 mo
PCDC, New Orleans, LA, USA [4]	2 mo	Low SES Random assignment to experimental or control group for 3 yr	Parent meetings 2 mornings/wk & monthly group meetings	No significant difference between experimental & control groups on Bayley & Uzgiris & Hunt at 22 mo Stanford-Binet scores significantly higher in experimental group at 36 mo & 1 yr later
PCDC, Houston, TX,USA [4]	12 mo–3 yr	Low SES Random assignment to experimental or control group for 2 yr	Weekly home visits in yr 1 Child spent 12 h/wk in centre in yr 2	Experimental group significantly better than controls on Bayley at 24 mo No difference on Stanford-Binet at 36 mo or school achievement in grades 2–5

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TABLE 1. Intervention studies in the United States with children from birth to two years of age: predominantly centre based *(continued)*

Program & ref.	Initial age	Sample & assignment	Intervention	Child outcome
PCDC, Birmingham, AL, USA [4]	3–5 mo	Low SES Random assignment to experimental or control group for 3 yr	Child attended centre with mother 3.5 da/wk in yr 1, 4.5 da/wk in yr 2, 5 da/wk in yr 3	No difference between experimental & control groups on Bayley at 22 mo Stanford-Binet scores significantly higher in experimental group at 36 mo & 1 yr later
Multisite IHDP group [6]	Birth	Low-birthweight & premature (<2,500 g & 37 wk) Random assignment to experimental or control group for 3 yr	Weekly home visits in yr 1, bi-weekly in yr 2 & 3 Child attended centre from 12 mo to 3 yr	Experimental group significantly better than controls on Stanford-Binet at 36 mo Children weighing 2,000– 2,500 g at birth had greatest gains
Educational Intervention at Home [5]	12–24 mo	Low SES Matched controls Duration 7 mo in yr 1 & 8 mo in yr 2	Weekly group meetings for mothers + monthly home visits	Experimental group significantly better than controls on Stanford-Binet & ITPA at end No follow-up reported

Abbreviations: IQ, intelligence quotient; IHDP, Infant Health and Development Program; ITPA, Illinois Test of Psycholinguistic Abilities; PCDC, Parent Child Development Center; SES, socio-economic status; WISC, Wechsler Intelligence Scale for Children; WPPSI, Wechsler Preschool and Primary Scales of Intelligence.

months of age are shown in table 2. Home visits were conducted on a weekly or fortnightly basis but did not necessarily involve activities with the child. Home visitors ranged from professional teachers [7] to peers of the mothers [8]. The Florida Parent Education Programme [8] is an example in which paraprofessionals or peers of the mothers were used to carry out the intervention. This programme had several groups, for which the length of intervention varied from one to three years. In addition to home visits, the children also spent two mornings per week in a centre during the third year of the programme. Starting at the age of 3 years, the children who had received two or three consecutive years of intervention had significantly higher scores on IQ tests, and the differences were still significant at 10 years of age. Benefits in school achievement and a reduction in placement in special-education classes were also related to the intervention.

Professional teachers conducted weekly home visits of 60 to 90 minutes duration over 16 months in the Ypsilanti-Carnegie Infant Education Project [7]. Although some differences were reported during the intervention period in favour of the experimental children, no significant differences were found in the IQs of the children at the end or one and five years later. In the Nashville Programme, children were randomly assigned to extensive home visiting, materials only, or controls for nine months [9]. The only difference found among the groups was a significant increase in receptive language scores, a test of language interaction between mother and child in the extensive home-visiting group. Gutelius and colleagues [10] conducted an intervention provided to the family by paediatricians and nurses who used a mobile unit to provide prenatal counselling and well-baby care, supplemented by home visits from the nurses for cognitive stimulation. The programme was started while the mothers were pregnant. They were counselled on how to provide appropriate sensory, motor, and language stimulation for the child. An average of 21 health and 24 stimulation visits were carried out over the three-year period. By 12 months, significant differences had emerged, and by 36 months, the difference of 8 points on the Stanford-Binet test was highly significant. These benefits are important, considering the small amount of input that was spread over three years. This is an example of in-

TABLE 2. Intervention studies in the United States with children from birth to two years of age: predominantly home based

Program & ref.	Initial age	Sample & assignment	Intervention	Child outcome
Florida Parent Education [8]	3 mo	"Indigent" on obstetric records Random assignment to experimental or control group for 3 yr	Weekly home visits for 3 yr & 2 mornings in centre during 3rd yr	Experimental group not different from controls at 12 & 24 mo Experimental group significantly better than controls on Stanford-Binet at 3– 6 yr, WISC at 10 yr, & school achievement at 10 yr
Ypsilanti-Carnegie Infant Education [7]	3, 7, & 11 mo	Low SES Random assignment to experimental or control group for 16 mo	Weekly home visits	Experimental group not different from controls on Bayley or Stanford-Binet at end or 1 yr later
Family-Oriented Home Visiting [9]	17–24 mo	Low SES Random assignment to experimental or control group for 9 mo	Weekly home visits	Experimental group not different from controls on Stanford-Binet at end or 2 yr later, but receptive language significantly different at end
Mobile Unit for Child Health Supervision [10]	7th mo of pregnancy	Unmarried teen-aged mothers Low SES Random assignment to experimental or control group for 3 yr	21 health-care visits & 24 stimulation visits	Experimental group significantly better than controls on Bayley at 12 & 24 mo & Stanford-Binet at 36 mo

Abbreviations: SES, socio-economic status; WISC, Weschler Intelligence Scale for Children.

tegrating a stimulation programme through the health services.

The results from these programmes were mixed, in that benefits to the children's cognitive development were seen in only two of the programmes, with the largest improvements coming from the Florida Parent Education Programme, which was conducted over a three-year period. The benefits were generally smaller than those seen in the predominantly centre-based programmes and raised questions concerning the efficacy of home-based programmes in that setting.

Programmes for children over two years of age: centre based, home based, or both

Summaries of three programmes that began after two years of age are shown in table 3. The Early Training Project [11, 12] consisted of an intensive 10-week centre-based programme during the summer, followed by weekly home visits for the remaining nine months of the year. One group of children received three years of intervention, another received two years, and a third served as a control. There was an increase in the children's IQ scores during the intervention, but these benefits gradually declined once the intervention had ceased.

In the Perry Preschool Project [13, 14], children from low-income families with IQs ranging from 70 to 85 were recruited in cohorts over a four-year period. They were randomly assigned to experimental or control groups after stratification for IQ, sex, and socio-economic status. Children in the experimental group were taught from a cognitively oriented curriculum in a preschool centre for 12.5 hours per week and were visited at home with their mothers for 90 minutes each week. The first cohort spent 30 weeks in the programme, and subsequent cohorts spent 60 weeks.

This project provided one of the longest and most intensive follow-ups of such programmes and gives insight into not only cognitive benefits but also socialization and adult economic success. The programme

TABLE 3. Intervention studies in the United States with children two to four years of age: centre based, home based, or both

Program & ref.	Initial age	Sample & assignment	Intervention	Child outcome
Early Training Project [11, 12]	3.5–4.5 yr	Low SES Random assignment to experimental or control group for 1 or 2 yr	Summer pre-school for 10 wk Weekly home visits for rest of year	Experimental group significantly better than controls on WISC at end 3 yr later no difference between groups
High/Scope Perry Preschool Project [13, 14]	3 or 4 yr	Low SES Random assignment to experimental or control group, stratified by IQ Duration 30 or 60 wk	Weekly home visits Child attended centre for 12.5 h/wk	Experimental group significantly better than controls on Stanford-Binet after 1 & 2 yr & after 2 yr follow-up School achievement better at age 14 yr
Verbal Interaction Project [15-17]	2 or 3 yr	Low SES 1. Matched 3 groups for 1 yr, 3 groups for 2 yr, 3 control groups 2. Pairs of experimental & control groups	Bi-weekly home visits	Marked IQ difference at end of study between experimental & control groups School achievement & Stanford-Binet significantly better in experimental groups in grade 3

Abbreviations: IQ, intelligence quotient; SES, socio-economic status; WISC, Weschler Intelligence Scale for Children.

effects have also been analysed in terms of the costs and benefits. The programme resulted in benefits to the children's IQs during the intervention, and although they declined somewhat after intervention, they were still significantly higher than those of controls up to 2 years later. Significant differences were found in school achievement at 9 and 14 years of age. In addition to better school adjustment, as reflected by fewer placements in special education and grade retention, the experimental group also had fewer episodes of delinquency and adult criminality and greater adult economic success.

Levenstein and colleagues [15, 16] conducted a series of home-based interventions for children aged two to three years. Mothers and children were visited by toy demonstrators twice a week for half-hour sessions. The toy demonstrators worked from a structured curriculum and involved mother and child together in play. Children who received two years of visiting had larger benefits than those receiving one year. The mean difference in IQ between the two-year group and the controls was 13 points. At eight and nine years of age, the children who had received intervention showed benefits in school achievement and in expected grade placement. However, the differences in IQ were no longer significant [17].

Long-term follow-up after intervention

One of the major concerns regarding the effectiveness of pre-school intervention programmes is whether their benefits persist. The Consortium for Longitudinal Studies [18] provided some evidence of long-term effects of early education programmes in a follow-up study of children who had participated in 11 projects that provided special educational programmes for children from families of low socio-economic status. The children were 8 to 18 years of age and were assessed by psychological and educational measures. Their school records were collected, and they and their parents were interviewed. The studies varied in a number of characteristics, such as the age of the child at the start of the project, the extent of parental involvement, curriculum models, types of programme delivery, and length and intensity of the intervention. The studies were analysed separately and together.

The pooled results showed that children who had participated in pre-school programmes had better school adjustment as indicated by lower rates of grade retention and referral to special-education classes. The programme participants also had a more positive self-concept, more achievement-related reasons for being proud of themselves, and higher rates of school comple-

tion and employment. The impact on the families was also important. Programme parents showed higher aspirations and expectations for their children and indicated more satisfaction with their children's school progress than the parents of control children.

The results of school achievement testing were somewhat disappointing, in that only modest gains were seen. It might have been expected that the improved school adjustment would have been reflected in school achievement. The IQs of the programme children were significantly higher than those of the control children during the period of intervention, with an overall difference of 7.4 points at the end after background variables were controlled for. After this there was a gradual decline, although the effect was still significant up to three or four years later.

The mechanism proposed was that children who had participated in pre-school programmes had gained skills such as the ability to follow instructions, task perseverance, and sustained, focused attention, and that these, together with the cognitive gains, had helped them to adjust to the demands of the school system. These positive attitudes and behaviours had in turn elicited positive responses and reinforcement from teachers and parents, thereby helping the children to develop a greater sense of competence and higher aspirations for success. Although the participants in the interventions did better than the control children, it is important to note that they were still not functioning at the level of middle-class children.

Barnett [19] reviewed 36 early childhood programmes in the United States, including 15 model demonstration programmes and 21 large-scale public programmes. He confirmed the earlier findings of the Consortium, in that the programmes resulted in improved performance on IQ tests and that these remained at least until they entered school, after which there was a tendency for these gains to decline. Other types of long-term impacts on subsequent school progress, such as lower rates of grade retention and placement in special classes, were also seen. The studies with the more rigorous study designs found the greatest effects, which suggests that design flaws and measurement errors diminished some of the actual programme effects. Ramey and Ramey [20] concurred that well-designed programmes with intensive interventions could produce long-term benefits. Boocock [21] reviewed studies from other developed countries and also found similar positive outcomes.

Intervention programmes in developing countries

Studies in various countries

Although pre-school programmes and child-care services have been offered in many developing countries, relatively few have been rigorously evaluated. Two experimental studies that were carried out in response to the growing concern over the effects of malnutrition on mental development in Cali [22] and Bogota [23] in Colombia showed long-term benefits. They included nutritional supplementation and health care, alone or in combination with educational intervention. In the Cali study, which was centre based, the combined interventions had substantial benefits to the children's development that were proportional to the duration of the intervention. The children receiving intervention made more progress in the first three grades in school and had higher IQ scores at nine years of age [24]. The Bogota study was conducted with high-risk families. The intervention began with pregnant women, who received nutritional supplementation. The children received supplementation for three years, either alone or in combination with maternal education. All interventions benefited the children, and the combined interventions produced the largest gains. No detailed follow-up of the children's development has been reported. A brief report indicated that the supplemented group performed better on tests of school readiness at seven years of age [Mora JO, Super CH, Herrera MG, personal communication, 1991]. The main conclusions from these studies are that some of the deficits in intellectual functioning that accompany poverty and malnutrition can be prevented or ameliorated through improvements in diet, learning experiences, and health surveillance.

There are also evaluations of existing service programmes that have been reviewed by Halpern and Myers [25] and Myers [26]. These include programmes from Brazil, Chile, Colombia, and Peru that have used a variety of approaches, such as parent education and day-care centres for the children. In general, modest gains in children's cognitive development and in mothers' knowledge were reported. However, few studies had comparison populations, and there was little attempt at long-term follow-up.

The Turkish Comprehensive Early Enrichment Programme [27, 28] evaluated the impact of three different types of pre-school care: educational pre-school centres, custodial day-care centres, and home-based day care. Half of the mothers in each group received an additional training component on children's development, and the results were compared with those without maternal training.

The children in the educational centre performed better on tests of IQ and cognitive functions and achievement in mathematics and Turkish, and had higher school grades up to grade 3, than children in the other groups. Maternal training also increased the children's IQ scores, but there was a tendency for maternal training to benefit the children in the custodial and home programmes more than those in educational centres. The problem with interpreting these results is that children from educational centres came from better homes. However,

there appears to have been a clear effect of the maternal training programme.

The programme of Integrated Child Development Services (ICDS) [29] in India was designed to provide supplementary nutrition, immunization, health care, health and nutrition education, and non-formal preschool education to children under six years of age and education to women of child-bearing age, especially pregnant and lactating women. These extensive services, covering several million children and mothers, are delivered by paraprofessionals in group settings.

Chaturvedi looked at the psychological and social development of the children in one of the original experimental areas [29]. A group of 214 project children was compared with 208 children matched for parental education and occupation, socio-economic status, and household education. The children had been exposed to the ICDS for a continuous six-year period and were six to eight years old at the time of evaluation. They were significantly better than non-ICDS children in school attendance, academic performance in school examinations, and general behaviour in school, as rated by the teachers. At ages six and seven, they had significantly higher IQs. No long-term follow-up was reported.

Jamaican studies

We carried out five studies with various groups of deprived children in Jamaica. The typical pattern of development of children is precocity in the first year of life as compared with test norms and then a gradual decline thereafter [30]. By four years of age, they could be up to 18 months behind their more advantaged peers [31] whose development is comparable to, or above, the test norms [32].

Four of the studies used the home-visiting approach in which a trained visitor worked with the mother and child in the home. The approach was based on the assumption that by working with mothers and children we could bring about changes in the mothers' child-rearing practices that would make them more effective teachers of their children. The visits were aimed at enhancing mother–child interactions and improving the self-esteem of both. In working with the mothers, we also hoped that the benefits would last longer and spread to other children in the home and possibly to neighbourhood children as well. This model may be less expensive than centre-based programmes and therefore more feasible, particularly for developing countries.

The home visits were carried out by trained community health aides, except in the first study, in which trained nurses were used. A visit would last for approximately one hour, during which the visitor would explain activities to the mother and demonstrate play techniques by playing with the child. We developed a curriculum based on Piagetian concepts, such as search for hidden objects, in children under 24 months of age. For those older than two years, concepts such as colour, shape, size, quantity, position, and motion were used. In addition, activities that facilitated language development, fine and gross motor skills, and problem solving were included. Simple instructions were written for each toy and activity. Toys were taken and left until the next visit, when they were exchanged for new ones [33]. Mothers were encouraged to play with their children between visits, praise them, and give them positive reinforcement. A strong emphasis was placed on verbal interaction. The relationship between the visitor and the mother was friendly rather than authoritarian.

To maintain the quality of the visits and to ensure that the activities conducted were appropriate for the child's ability, the visitors attended regular workshops with a supervisor. The visitors kept records of the visits, which were discussed and used to plan the next visit. Four to five visits were done per day, and the supervisor accompanied the visitor at least twice per month and completed an evaluation checklist [34].

Intervention with community children

In the first intervention project, 22 children aged 34 to 40 months were visited at home weekly for one hour. This project was fairly expensive, since the visitors were nurses and the toys were bought. After eight months, the visited group showed an increase of 13 DQ points as compared with a group of children from a neighbouring community who were not visited [34]. In subsequent programmes, we developed a range of toys made from materials commonly available in the homes, such as plastic bottles, margarine containers, and scraps of cloth. This helped to reduce costs and had the additional benefit of demonstrating to the mothers toys they could make from materials available to them.

The next community intervention was run from a government health clinic, and the intervention was started at a much younger age, as the focus was to prevent the decline in development that is frequently seen in young children from poor homes. The aim was to determine whether the programme could be delivered through the existing primary health-care services supervised by a midwife and using community health aides as visitors. We also wanted to determine the relative effectiveness of different frequencies of visiting schedules. The study had two phases.

In the first phase, three groups of children aged 6 to 30 months assigned by neighbourhood were chosen. One group of 49 children was visited fortnightly, and another group of 45 children was visited monthly for two years. The third group of 45 children served as controls. The group visited fortnightly showed a modest but significant improvement in development as compared with the group visited monthly and the controls. The DQs of children in the group visited monthly were not significantly different from those of controls. How-

ever, they had significantly higher scores on the Peabody Picture Vocabulary Test than the controls, as did the group visited fortnightly. This was the only benefit to the group visited monthly.

The effect of fortnightly visiting was less than anticipated on the basis of previous experience with weekly visiting. It was not clear whether this was due to less skilled visitors or to the reduced frequency of visits. A weekly visited group was therefore introduced. Fifty-eight children aged 16 to 30 months from the same neighbourhoods were randomly assigned to intervention or control. After one year of intervention, the mean DQ of the group receiving intervention was 11 points higher than that of the controls. The DQs of the children in the group visited weekly were significantly higher than those of children of similar age in the groups visited fortnightly and monthly during the first phase [35]. The benefits therefore increased as the frequency of visiting increased, giving a dose-response relationship (fig. 1).

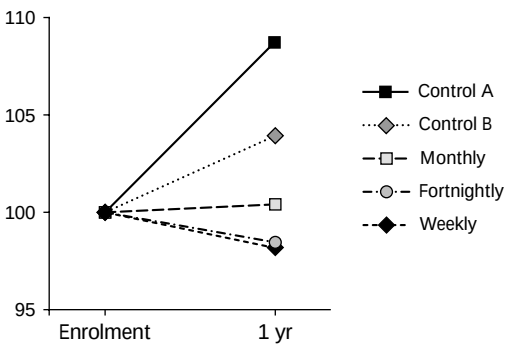

FIG. 1. Mean developmental quotients (DQ) of children aged 16-30 months in experiments 1 and 2 [35]

These results showed that the development of poor urban children could be improved with psychosocial stimulation. Improvements varied in proportion to the frequency of visiting, and weekly visiting made the most substantial improvements to the children's development. It was also shown that this type of intervention could be delivered from a health centre. However, the level of supervision was much higher than might be possible on a day-to-day basis.

Intervention with severely malnourished children

A similar home-visiting approach was successfully used with malnourished children. In one study, severely malnourished children aged 6 to 24 months were played with daily while in the hospital and then visited weekly at home for two years and fortnightly for a third year. They were compared with a group of severely malnourished children who were admitted to the same hospital the previous year and received standard care without a play intervention, and with a group of adequately nourished children who had been hospitalized for other reasons [36]. They were followed for 14 years after leaving the hospital. Both malnourished groups had similar low levels of development on admission to the hospital. The malnourished children who received intervention showed marked improvement and actually caught up to the controls during the intervention. However, the malnourished children who did not receive intervention continued to show a large deficit relative to the controls throughout the study (fig. 2). At the 14-year follow-up, the group receiving intervention showed benefits in the Weschler Intelligence Scale for Children full and verbal scales and in school achievement scores as compared with the control group [37].

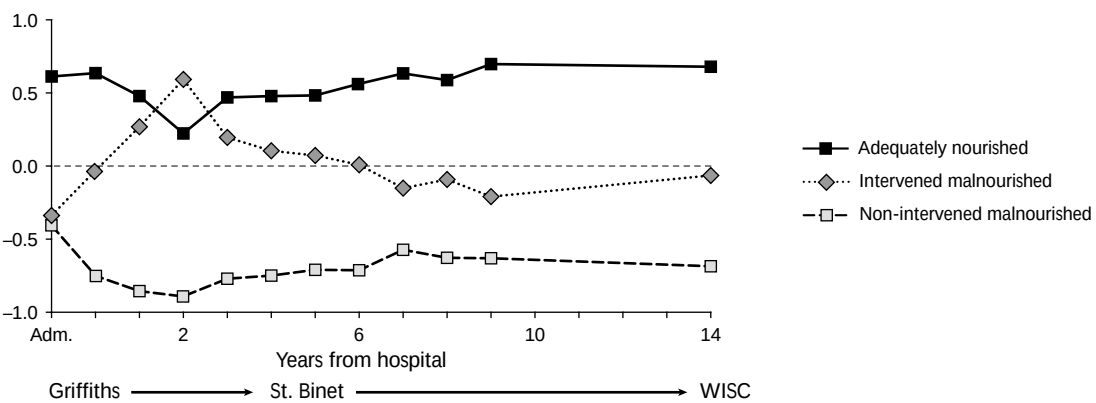

FIG. 2. Mean standard IQ scores of severely malnourished children who received intervention compared with scores of malnourished and adequately nourished children who did not receive intervention followed up 14 years after leaving the hospital [38]. Children were assessed first by the Griffiths Test up to 4 years after leaving the hospital, then by the Stanford-Binet Test, and at 14 years by the Weschler Intelligence Scale for Children

Combined intervention with nutritional supplementation and psychosocial stimulation

After our studies of the effects of providing child development activities to severely malnourished and poor community children, it was important to determine whether additional benefits would be gained by providing nutritional supplementation as well as child development activities and whether the benefits would be interactive or additive. In a fourth study [38], we worked with stunted children, since up to 40% of children under five years of age in developing countries are stunted. One hundred twenty-nine stunted children (height-for-age < –2 SD of the National Center for Health Statistics references) aged 9 to 24 months were randomly assigned to one of four groups: control, stimulation, supplementation, or both treatments combined. A fifth group of non-stunted children from the same neighbourhoods was also included. The treatments were delivered weekly for two years. The child development activity programme was similar to that used previously, and the supplement was 1 kg of full-cream powdered milk. The control group was visited every week to control for any benefit of the extra attention given to the supplemented children.

The developmental levels of all the treatment groups improved relative to the controls. The group that received both treatments showed the greatest improvements and was the only one to catch up to the non-stunted children (fig. 3). The benefits of the combined interventions were additive and not interactive. The children were evaluated four years after the intervention ended. A small global benefit remained from supplementation and/or child development activities, since these groups had higher scores than the controls in 13 or 14 of the 15 tests, more than would have been expected by chance, although the differences in the individual tests were not statistically significant. Factor analysis of the tests yielded three factors. The scores on one of them, the perceptual-motor factor, were significantly higher in children who had participated in child development activities [39]. Unfortunately, the benefits from child development activities and supplementation were no longer additive.

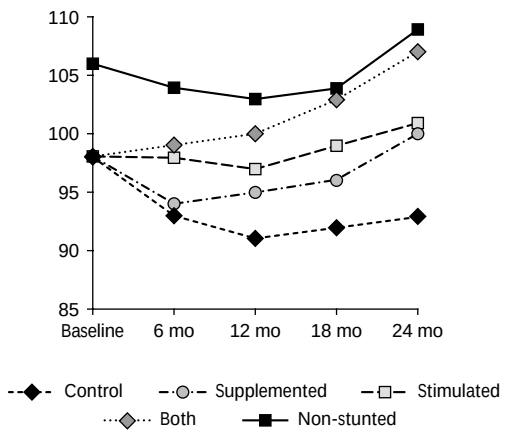

FIG. 3. Mean developmental quotient (DQ) scores of five groups of children over two years. The groups are non-stunted children, and stunted children who received both stimulation and supplementation, supplementation alone, stimulation alone, and no intervention (control) [38]

Comments on the home-visiting strategy

The main function of the home visitors was to encourage the mothers to engage in activities that would help their children's development. Such skills as questioning, conversation, problem solving, creativity, and explanation were encouraged. In order to do this, the visitors provided the parents with information about the intellectual development of children and teaching strategies that would help promote learning. In addition, guidelines were given as to the content of what could be taught.

During the home visits, activities and concepts that were appropriate for the developmental levels of the child were introduced. The home visitor demonstrated these activities in such a way that they could be clearly understood by both mother and child and would enable the mother to carry out the activities on her own once the visitor had left. The relationship between the community health aide and the mothers was critical, and it was important that both mother and child enjoy the visits.

The choice of the visitor was therefore important to the success of the programme. Some studies elsewhere have used professionals, whereas others have opted for volunteers or paraprofessionals or previous programme graduates. Professionals were usually graduates with training in child development. The use of professionals makes the programme less generalizable, since not only are they scarce but few developing countries could afford to pay them. Paraprofessionals are less costly than graduates, and they are now being used more often in home-based programmes. A certain level of literacy is required, since the programmes often involve structured curricula that demand reading as well as record keeping. Some of the less able community health aides had difficulty in grasping the theoretical concepts behind the programme or in appreciating the developmental stage of the child. We found that it was quite possible for a community health aide to miss the point of an activity or to forget to link the appropriate concept with the activity. These problems were overcome only by constant supervision, training, and reinforcement.

The use of paraprofessionals had the advantages that they were readily available and the cost was low. In addition, they were comfortable working in poor neighbourhoods and could readily understand the family's problems and relate to them easily.

Child-to-child model

In addition to the home-visiting approach, we developed a child-to-child model that was targeted at children from remote rural areas where home visiting was thought to be less feasible. The aim was to work at school with the target children's older siblings, who would then take the intervention home. Older children traditionally help with the care of their younger siblings, so this was culturally appropriate and feasible if the children attended school. A pilot study was conducted to improve stimulation in the home and introduce some health practices. The schoolchildren made toys for their younger siblings and were taught how to play with them at home. After one year in the programme, the schoolchildren's knowledge of child development had improved and the mothers reported that they brought the toys home and played with their siblings. However, there was no improvement in the siblings' development [40, 41]. We concluded that the inputs were too small to affect the younger children's development. The schoolchildren themselves were the main beneficiaries of the programme, and the Ministry of Education has modified the ideas generated by the programme and included them in the primary school curriculum.

Summary and conclusions

Developed countries

A large number of studies on the effects of early intervention on the development of poor children have been carried out. Some of those with good study designs and evaluations have been reviewed above. They were also chosen to reflect a variety of programme models that have been tried. Although problems such as attrition of the sample can make interpretation difficult, some conclusions can be drawn.

Well-designed early childhood care and education programmes can produce significant benefits to the participants' development that can influence later school performance and social outcomes that prepare them for adulthood. The benefits varied with the type of intervention. Centre-based programmes were more consistent in showing improvements in the IQs of the children than home-based programmes. There was some suggestion that the more intensive programmes that involved a greater amount of time spent with the children produced larger IQ benefits to the children.

Few of the programmes that began in infancy reported benefits before two years of age. Presumably the scores of the control groups were still high, and the decline in development commonly seen in poor children had not yet started. By three years of age, more consistent differences began to emerge between programme children and controls. However, it is not possible to determine whether the first two years of intervention added to these benefits. Programmes with older children that were designed to investigate the effects of age of entry did not find any significant differences between the benefits to children entering at three years of age and the benefits to those entering at age four.

The results from programmes that included long-term follow-up showed that, in general, it was possible for benefits to IQ to remain up to three or four years after the end of the programme. The Carolina Abecedarian Programme reported persistence in IQ gains up to the age of 12 years. Benefits in other areas that could influence performance in school were also seen. There was less need for special education and less repetition of grades among programme participants.

Many studies also reported benefits to the mother that helped them to play a more supportive role in their children's development and also benefits to themselves, such as better self-esteem and a sense of self-worth.

Developing countries

The main problem with most of the studies from the United States was that they were expensive, particularly those which were centre based. These models would be neither feasible nor practical in developing countries without substantial modifications to reduce costs. Many innovative programmes in developing countries have been conducted, and benefits have usually been reported. However, evaluations have seldom been rigorous or long term. Tightly controlled research projects in developing countries have resulted in important concurrent benefits to the children's development, and some benefits have been sustained at least for a few years. However, the studies are few in number and generally too expensive to be copied on a large scale.

The Jamaican series of studies used a slightly less expensive model (although still probably only feasible for small, targeted populations). These studies showed that teaching child development activities to mothers in a home-visiting programme was successful in improving their children's development in the short term and had some sustained benefits. It was possible to use paraprofessionals, but a minimum frequency of visiting was required. A child-to-child approach working with schoolchildren was less likely to improve the development of younger siblings.

Another concern in developing countries is the poor quality of the primary schools. In many instances, these are likely to erode benefits gained in the early childhood programmes. Therefore, it is probably necessary to continue interventions at least through the first grade of primary school. The challenge is to find low-cost ways of doing this.

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The role of care in programmatic actions for nutrition: Designing programmes involving care

Patrice L. Engle and Lida Lhotska

Abstract

Incorporating care practices and resources for care into existing health, nutrition, and integrated programmes can have significant positive effects on children's growth and development. Correlational studies and a few efficacy trials suggest the promise of this approach for improving the survival, growth, and development of children, particularly those under three years of age. This paper defines the concept of care, clarifies characteristics of nutrition programmes that include care, and describes four intervention strategies for health and nutrition that incorporated care. It summarizes lessons learned from these and other experiences and current actions that UNICEF and others are taking regarding care, and suggests further steps.

Introduction

Care can have powerful effects on children's growth and development. In the 1950s and 1960s, John Bowlby [1]. described the significance of a child's attachment to a single caregiver for normal emotional, cognitive, and physical development. About the same time, Wayne Dennis [2] observed infants at two years of age in orphanages who could barely sit up and could not speak. They had little contact with the child-care workers in the facility. As an experiment, he selected a group of infants for special treatment; he assigned each child to one particular caregiver who was asked to pick up, hug, and talk to the child on a daily basis. Children with this treatment changed radically; they began to talk, developed rapidly in terms of their motor behaviour, and grew well. The treatment was care.

Since these early studies, much research has illustrated the importance of attachment between child and caregiver, a "unique and enduring bond," and of psychosocial care in general for all aspects of a child's development. Yet despite this knowledge, in 1991 the world witnessed the deprived conditions under which Romanian orphans were being raised [3].

Cruezinger [4] describes conditions in an orphanage in Russia that was probably similar to the Romanian institutions. Each caregiver was responsible for 20 children under three years of age and worked for 24 hours at a time. The caregivers felt overwhelmed by the work and the children's needs. They believed that they had to train the children to be able to survive in the institution that they would move into at age four (the Children's House), and had to make the children "tough." Also, caregivers and administrators felt that orphans or abandoned children were "different emotionally," since they came from a poor heritage. Children were rarely held, for fear that they would demand more than the caregivers could provide. If children cried from a fall, they were told to shut up and stop crying. They were continually hurried to the next activity of the day. As a result, the children soon became silent and non-verbal, and they grew up totally unprepared for life beyond the institution. One mother who traveled to Romania to adopt an 18-month-old child reported that he could not sit up and one side of his head was flattened from curling up next to the bottle that had been attached to his crib "as if he were a hamster" [5].

The opportunity to replicate some aspects of Dennis's classic experiment occurred as these infants, many of whom were at least moderately malnourished, were adopted into Canadian families. Could they show as much progress as Dennis's Iranian orphans? In this case, not only was care improved, but also health services and nutritional intake.

Morison et al. [3] asked adoptive parents to estimate the children's developmental levels before adoption, when they were first observed in the facility. Children were assessed a year after they had been adopted into Canadian homes. Two groups of children were identified: those who were adopted before they had spent 4

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months in the orphanage and those who had spent at least 8 months in the orphanage, usually closer to 18 months. In both groups, almost all of the children were rated as delayed in language, social development, and fine and gross motor development. Both groups improved dramatically in the subsequent year. At that assessment, over half of the children were reported as normal; their progress was marked.

The comparison between the early and later adoptees (approximately 45 per group) on the one-year assessment was revealing. Both groups had improved dramatically, but the children adopted before spending four months in the orphanage were indistinguishable from comparison children born in Canada. The children adopted later still lagged far behind their compatriots, particularly in language and social development. Moreover, these children as a group showed a series of behaviours that tested the patience of their caregivers; they had difficulty with food, often eating far more than needed. They formed only weak attachments to their new parents, and some were indiscriminately friendly to strangers. Their most difficult, but most common, characteristic was poor control over attention-seeking behaviours and frequent episodes of anger and irritability. The longer the children had been institutionalized, the more persistent the problems [3, 6]. It appears that care as well as health and food inputs during the first year of life were crucial for the children's development.

This paper describes four intervention strategies for health and nutrition that incorporated care. It discusses lessons learned from these and other experiences, reviews briefly current actions that UNICEF and others are taking regarding care, and suggests the next steps that we need to take. The first step is to define the concept of care and what characterizes a programme that "involves care."

Defining care

Care as it has been defined in the past 10 years refers to the behaviours and practices of caregivers (mothers, siblings, fathers, and child-care providers) to provide the food, health care, stimulation, and emotional support necessary for children's healthy growth and development. These practices translate food security and health-care resources into a child's well-being. Not only the practices themselves, but also the ways they are performed—with affection and with responsiveness to children—are critical to children's growth and development [7].

Food, health, and care are all necessary, but none alone is sufficient for healthy growth and development, according to the UNICEF conceptual framework [8]. All three elements must be satisfactory for good nutrition. Even when poverty causes food insecurity and limited health care, enhanced caregiving can optimize the use of existing resources to promote good health and nutrition in women and children. Breastfeeding is an example of a practice that provides food, health, and care simultaneously.

One way to categorize influences on children is to divide the environment into a continuum ranging from proximal (close) to distal (distant) aspects of the environment [9]. Aspects of the environment directly experienced by the child are labeled proximal and include both physical and social dimensions. Care practices or behaviours are proximal aspects of the environment that are primarily social and influence children's growth and their development. This is a wide net that captures many behaviours that have long been recognized as important for child nutrition, such as breastfeeding, home health care, and hygiene practices, and brings in less recognized behaviours, such as a family's care for women and psychosocial care. Using a single term to encompass these behaviours has the advantage of highlighting their interrelationship within the locus of the household. Using a single term has the possible disadvantage of including so many behaviours that the term becomes meaningless. In order to avoid the latter problem, care behaviours defined here are those relevant to nutrition and growth, and six kinds of behaviour have been specified as most important for child growth and development.

Distal aspects of the environment, such as the availability of a water source within the house, the amount of food available on a daily basis, or the energy and knowledge of a primary caregiver, affect child nutrition indirectly. The distal aspects of the environment of interest here provide resources for care, which may be human, economic, or organizational. Human resources at the family level include the caregiver's knowledge, beliefs, and education and enough physical health and mental health and confidence to put the knowledge into practice. Economic resources include the caregiver's control of resources and time in order to provide care. Organizational resources include alternative caregivers and community care arrangements,, and emotional support from family members and community networks [10]. These same three kinds of resources also occur at the community, district, national, and international levels.

Caring practices and resources vary tremendously by culture and perhaps even more among families within cultures. Children's basic needs for food, health care, protection, shelter, and love are the same in all cultures. Differences may be seen in how each culture and each family attempts to meet these needs. Widespread changes in families due to urbanization, the increased economic role of women, expansion of primary education, and population increase require changes and adaptations in care practices for which families may be ill prepared.

Care practices include care for women, including care for pregnant and lactating women; breastfeeding and complementary feeding; psychosocial care; food preparation and food hygiene; hygiene practices; and home health practices [7]. Some care practices, such as breastfeeding and hygiene practices, have been investigated extensively, whereas others, such as family support for young women to delay childbearing, have rarely been studied. This paper will focus on two care practices—care during complementary feeding and psychosocial care—since these are two areas that have received relatively less attention.

Care during complementary feeding

High-quality complementary food, which is provided from about the sixth month onward, is a key component of good nutrition. Previously food quantity and, to some extent, food quality were the major topics considered. However, behaviours or practices related to how food is provided to children and fed to them have been found to influence nutrient intake in studies such as those in Nepal [11].

Four aspects of the proximal behaviours of complementary feeding that affect intake can be defined: adapting the feeding method to the child's psychomotor abilities (e.g., spoon handling); feeding responsively, including encouraging a child to eat, attending to possible low appetite, balancing child versus caregiver control of eating, and using an affectionate or warm style of relating to the child during feeding; creating a satisfactory feeding situation by reducing distractions, developing a consistent feeding schedule, and supervising and protecting children during eating; and feeding frequently and when children are hungry.

Adaptation to psychomotor abilities for self-feeding

Adapting to children's changing motor skills can require close attention by the caregiver, since these abilities change rapidly during the first two years of life. For example, by seven months of age the gag reflex moves to the posterior third of the tongue, permitting the child to ingest solids more easily than earlier [12]. The time required for a child to eat a certain amount decreases with age for solid and viscous foods, but not for thinner purees. Children's abilities to hold a spoon, handle a cup, or grasp a piece of solid food increase with age and practice [13]. Self-feeding with a spoon requires a number of steps from putting the spoon in the plate, filling it with food, taking it to the mouth, and emptying it. Children practice these components separately at first, putting the spoon in the dish over and over, often banging the spoon and handling it to gain skills. Only several months later are the sequences concatenated [13].

Feeding responsively

Feeding responsively can be particularly important for young children. Caregivers encourage, cajole, offer more helpings, talk to children while eating, and monitor how much the child eats. Mothers and other caregivers who show or model for children how to eat healthful foods will encourage children's eating, especially when food quality is low. The amount of food that a child consumes may depend as much on the caregiver's active encouragement of eating as on the amount offered [11, 14, 15].

The caregiver's understanding of and response to the child's hunger cues may be critical for adequate food intake. For example, if the caregiver perceives a child's typical mouthing actions in response to new food sensations as a food refusal and ceases to feed, the child will receive less food.* When children are fed from a common pot, the amount eaten is not easy to determine. Having a separate bowl for each child can help determine quantities eaten and protect the slow eater, although the person with whom the food is shared makes a difference [16].

Cultures vary along a dimension of control of eating. At one extreme, the caregiver has all of the control and children are force-fed, whereas at the other extreme, control is given entirely to the child. Neither extreme is good for children. When too much control is in the hands of the caregiver, forced feeding or continued and even intrusive pressure on children to eat is seen, which may lead eventually to inability to monitor food intake and to obesity [17, 18]. Passive feeding, particularly if a child has anorexia or poor appetite, may result in inadequate intake [19]. Caregivers have been observed to encourage feeding only after seeing that the child is refusing to eat, which may simply result in fruitless battles [15].

The feeding situation

The feeding situation may also influence the food intake of young children. Some children are fed on a regular basis each day, sitting in a prescribed place with food easily accessible, whereas others are fed while wandering around or at the time the caregiver finds convenient [20]. If the main meal is prepared late at night, children may fall asleep before it is completed. Children can be easily distracted, particularly if food is difficult to eat (e.g., soup with a spoon the child is

* Kotchabhakdi NJ, Winichagoon P, Smitasiri S, Dhanamitta S, Valyasevi A. The integration of psychosocial components of early childhood development in a nutrition education programme of Northeast Thailand. Paper prepared for the Third Inter-Agency Meeting of the Consultative Group on Early Childhood Care and Development, Washington DC, January 1987.

unable to use) or not particularly tasty. If supervision of feeding is not adequate, other siblings or even animals may take advantage of a young child's vulnerability and take food away, or food may be spilled on the ground.

Psychosocial care

A second set of care practices that influence both growth and development of children consists of social, emotional, and cognitive interactions between caregivers and children. Four major kinds of practices have been defined [7, 21].

Responsiveness to developmental milestones and cues

Responsiveness to developmental milestones and cues affects children's growth and development. This includes the extent to which caregivers are aware of their children's signals and needs, interpret them accurately, and respond to them promptly, appropriately, and consistently [21]. Responsiveness may be illustrated by the caregiver's behaviour when a child cries or fusses. If the caregiver does not have time to respond or misinterprets the reason for the crying, the caregiver may miss an opportunity to feed the child when the child is hungry. Responsiveness is also important for developing language. Even before they can talk, children understand simple adult speech and can learn the give and take of conversation. Caregivers who talk to their children in simple language and respond to children's verbal play will help their children learn language earlier.

Responsivity also varies according to the age of the child; the most appropriate response changes with the child's developmental stage. For a very young child, the response to fussing may be touching and holding, whereas at an older age, it could involve talking or demonstrating appropriate behaviours.

Vygotsky's theory explains the importance of responsiveness for cognitive development and language [22]. Vygotsky suggests that learning is most likely to occur when information is appropriate to the child's developmental status or is in the child's "zone of proximal development." The extent to which a caregiver can adapt information and interaction to the child's emerging structures will determine the effectiveness of the learning [23]. This process has been labeled "scaffolding," since a scaffold is an extra structure or support needed to construct a building and is perfectly adapted to that particular building. As applied here, the caregiver provides the support or scaffold for the child's developing cognition. The caregiver's ability to be responsive or sensitive to the child's emerging abilities facilitates the child's development. Sensitivity is the "ability to accurately perceive and interpret the infant's attachment signals, and to respond to them promptly and adequately" [24].

Sensitivity or responsivity improves children's learning and cognitive development [25]. For example, maternal sensitivity coded during mother–child interactions at 9 months uniquely predicted the child's language comprehension at 13 months—more than the child's comprehension at 9 months [26]. The mother's excessive directiveness or intrusiveness was unrelated to language development, a result also found in other studies [25].

Meins [27] asked mothers to construct a box with their 36-month-old children. Mothers who had a close relationship with their children (securely attached) were more likely to use feedback from their children's performance in gauging the level of specificity of their succeeding instructions than mothers with a more distant relationship. Closely connected mothers may be more able to pitch their instructions at an appropriate level. Meins described these findings in terms of the zone of proximal development; mothers had the ability to tutor their children within the "region of sensitivity to instruction."

Parents' expectations of the age at which children learn important skills like walking or speaking their first word (developmental milestones) also affect their children's development; parents who expect earlier development are likely to have children who develop earlier. Helping parents to be aware of developmental stages can have positive effects on children's development and can help the parents identify slow development.

Attention, affection, and involvement

The attention, affection, and involvement that caregivers show to children influence their growth and development. The most important factor in a child's healthy development is to have at least one strong relationship (attachment) with a caring adult who values the well-being of the child. Lack of a consistent caregiver can create additional risks for children. The child needs frequent positive interactions. To the extent possible, valuable traditional practices should be identified and sustained. Examples are infant massage in India [28], postpartum rest of mother and child in many Muslim countries, and responsiveness to children's desires in Bali. These customs may be undermined by an encroachment of Western values and urbanization.

Encouragement of autonomy, exploration, and learning

Encouragement of autonomy, exploration, and learning by caregivers can improve children's intellectual development and nutritional status. Young children are born with the ability to learn, but they need the encouragement and freedom to be able to develop that ability. In developing countries, malnourished children

who have been given verbal and cognitive stimulation have higher growth rates that those who have not [29]. Caregivers need to provide safe conditions for play, encourage exploration, and provide learning opportunities in addition to good nutrition.

The research and development process for care

Occasionally a concept will be recognized as logically necessary and critical to understand long before the details of definition, conceptual mapping, indicators, and even evidence for effectiveness are well established. This is true for care; the concept was recognized by a number of researchers during the Iringa experiment of the 1980s [30], explored further in Zeitlin's positive deviance work [31], and reinforced by the success of using communication strategies for positive behaviour change via social marketing. It was also supported by new research indicating that factors other than income, such as maternal education, were important predictors of undernutrition. The process of defining care as an integrated construct and having it become part of our planning and programming has been the work of the 1990s.

Care is an overarching concept that includes a number of discrete care behaviours, such as breastfeeding or care seeking, that have been investigated intensively and that provide good models for the research and development process. As with breastfeeding, the process should follow a logical progression from literature review to research suggesting that care plays a significant role in child growth and nutrition, research delineating the kinds of problems that result in poor care, development of possible care interventions, efficacy trials to test the interventions, and finally scaling the interventions up to national or international levels and evaluating the results. The development of indicators occurs during this process.

The research efforts indicate quite clearly the importance of care for growth and development, and the kinds of problems that lead to poor care. Interventions have been developed and tested for some care behaviours, but not others, and we do not yet have universally accepted agreements on the measurement of care practices in all areas. The number of studies that address more than one care practice is limited. Because the concept is complex and behavioural, it may take some time and effort to move through these steps. The recent appearance of research examining behavioural factors related to growth and development suggests that the process is under way.

Evidence for the effectiveness of care in interventions

Although one can envision an investigation that would compare the effects of a distal intervention, such as household water taps, with and without an intervention to change care practices, such as hygiene, studies of that type were not located. However, there were a number of studies demonstrating that changed care practices resulted in improved child growth or child development. Incorporating care practices and resources for care into existing health, nutrition, and integrated programmes can have significant positive effects on children's growth and development.

Effects of care on child growth and development: Correlational studies

A number of studies found correlations between care practices and child growth and development, even with controls for household economic resources. For example, in a study in Barbados, feeding practices, such as breastfeeding preference and feeding intensity, predicted later growth [32]. Several recent reviews have summarized the correlational data showing effects of these variables on growth and development [21, 33, 34].

Effects of care on child development: Experimental studies or efficacy studies

Several recent reviews of the experimental literature on the effects of various forms of early intervention on children's cognitive development provide evidence that a psychosocial intervention can have significant effects on children's development. Small-scale experimental designs that manipulate parental behaviour have shown effects on children's language and cognitive development [35].

Programmes to improve psychosocial care through parent education about parent–child interaction have been effective. In the United States, programmes promoting improved parenting skills through home visits have shown modest effects on cognitive outcome [36]. Home visiting has been found to be an effective component of programmes targeting low-birthweight and premature infants [37], non-organic failure-to-thrive children [38], and undernourished children in developing countries [39, 40]. Olds and Kitzman [37] reviewed four randomized trials of home-visiting interventions that were designed to work with parents to improve the cognitive development of pre-term and low-birthweight newborns. All of the trials found consistent evidence of increased mental test performance. In programmes that are aimed at parents and children who are at social and economic risk, the results are more mixed than for those interventions directed to families of pre-term and low-birthweight infants.

A mother-training intervention was also found to be effective in Turkey [41]. A training programme for mothers that was designed to help them to foster cognitive development using the home-intervention

programme for pre-school children and to become sensitized to their children's needs was assessed in combination with three different child-care arrangements in a 2×3 research design. They compared the effects of attending pre-school programmes with educational aims versus custodial day-care programmes versus staying at home. Mothers' participation in the home-training programme was associated with higher scores on cognitive tests and school performance, particularly when combined with an educationally oriented programme.

Another approach to improving psychosocial care is through day-care centres or child-care programmes, with the care provided by child-care workers in a group environment. When high-quality child development activities in child-care centres are implemented with acceptable fidelity, they have consistently had a positive impact on cognitive function and IQ scores in the United States and in other developed [42, 43] and developing [39] countries.

Effects of care on child growth: Experimental studies or efficacy studies

There is considerable evidence that growth is affected by some care practices, such as exclusive breastfeeding and appropriate disposal of waste and excreta. More surprisingly, there is some evidence that changes in psychosocial care can have effects on physical growth. In an controlled efficacy trial in Bogota, Colombia, malnourished children who were provided with "maternal education" visits twice weekly from six months through three years of age were significantly taller at three years [40] and maintained that difference three years after completion of the programme [29]. The presumed mechanism was that the parents were more aware of their children's food needs and were more likely to direct food towards them. It is possible that parents who were alerted to children's cognitive needs were also more responsive to nutritional needs.

Relatively few programmes have investigated whether and how specific care practices have changed as a result of intervention. These assessments could be useful for process evaluation. For example, in two studies, changes in parental behaviour, such as responsiveness, teaching behaviour, and encouragement, were found even when the child outcomes did not change [36].

Incorporating care in the design of programmes

How does programming change if care is involved? Three changes can be identified, which reflect many recommendations currently being made to increase the effectiveness and sustainability of projects: assess and change care behaviours in addition to distal factors such as food or health care; evaluate care practices and resources from the household or integrated perspective; and plan for additive or combined effects on care practices and care resources through programming that considers multiple routes to change.

First, in addition to distal strategies such as increasing education or providing better services, actual care practices or behaviours should be assessed and targeted for change, if inappropriate, or reinforcement, if appropriate. The provision of care is a critical link between food and health resources and the child's physical and psychosocial development. For example, a new health-delivery system might not only provide a new strategy for diagnosing illnesses, but also adapt that information to the caregivers' beliefs and knowledge about illness and illness terms used in home treatment. A programme to improve complementary feeding should assess, analyse, and take action to improve not only foods but also feeding practices, such as frequency of feeding, responsiveness to children's cues of hunger, or the feeding situation.

Second, the "care" focus requires the programme planner to evaluate household practices in support of children as an integrated whole. The same individuals perform multiple tasks to support child health and development. An intervention might affect several care practices or resources for care, since it could result in multiple demands on time, energy, and knowledge. The costs of a programme should be evaluated in terms of care. For example, a programme that provides additional income-generation opportunities for women should evaluate consequences of changed behaviours for care practices, such as food preparation, home health care, or care for women. The benefits of a programme can also be evaluated in terms of care. A family-planning programme that results in longer birth spacing may provide mothers with increased available time. Teaching a caregiver to be more responsive to her child's indications of hunger may also increase her tendency to respond to a child's attempts to communicate and therefore increase the speed of language development. Increasing resources for care, such as increasing the help provided by fathers, may have positive effects on several aspects of care.

Third, there may be additive or interactive effects on child outcomes of changes in care practices that programmes can capitalize on. Improving several aspects of care at the same time will have greater effects on child growth and development than improving only one aspect of care. Interventions to improve child nutrition or child health as well as child development may have additional impacts on child development. A child who is healthy may be more responsive to improved environmental inputs and therefore may develop more rapidly. A more active and verbal child may also stimulate more care from busy caregivers. There is an intimate relationship between physical and psychological growth,

particularly in the first years of life [44, 45]. Programming that includes several of these care needs simultaneously may be more able to reach families and provide the impetus for significant change in child outcomes than single-focus programmes.

Examples of programmes that involve care

To illustrate how programmes change when care is taken into account, examples of four kinds of programmes for children under three years of age that involve care are presented: a nutrition education project, interventions for low-birthweight infants, a parent education programme including both early child development and nutrition, and a child-care/day-care programme. In each case, programme effectiveness and which component might be labeled "care" are described. These programme models and others are summarized in table 1.

Nutrition education project

The Nutrition Communication Project of the Academy for Educational Development used the principles of nutrition education and social marketing to create, implement, and evaluate strategies to improve maternal and child nutrition without increasing income [48]. Over an eight-year period, projects took place in Mali, Niger, Burkina Faso, and Honduras. In each country, the strategy involved a five-step process of assessment through formative evaluation and surveys, planning, preparation of materials, implementation of the intervention, and evaluation. These projects are defined as involving care, because specific feeding practices in the home and resources for care were included in assessment, intervention, and evaluation. Other components of the project focused on increasing the supply of vitamin A (e.g., by making sauces with green leafy vegetables), and these did not involve care.

The Mali project provides a good example of how care can be part of a nutrition education project [48]. The nutrition problems identified in the region were wasting (11%), stunting (25%), low birthweight (15%), and night blindness. Formative evaluation and surveys led to the identification of problems, some of which were caring practices: the introduction of complementary foods was delayed to nine months of age; 80% of young children's meals were not supervised; and 66% of children were given pre-lacteal feeds. Some problems identified fell under the category of care for women within the family. A family should be sure that women are allocated sufficient supplies of the family food and that they have the autonomy and decision-making power to obtain it. In Mali neither men nor women were aware of children's and women's dietary needs, and men were responsible for many food purchases.

Based on the assessment phase, behavioural messages and targets were defined. In addition to food messages, some messages involved the process of feeding, a care practice: "Promote more appropriate active feeding behaviours: specifically, three supervised meals a day; use a separate bowl for children 6 to 24 months of age; make sure the child finishes the bowl, and give more if the child is still hungry."

One involved resources for care and care for women: "Emphasize men's responsibility for women's and children's nutrition; men can keep children happy by buying healthful food at the market."

These messages were communicated through community mobilization. Some of the techniques were the use of story pictures showing local women succeeding at tasks, interpersonal communication (mother's card, counselling cards), placing stickers on the mother's card to reinforce the counselling message, and showing men in the pictures on the mother's card (health record card). An evaluation of the programme from 1991 through 1994 indicated significant changes from pre-test to post-test in the trial villages. The percentage of children with low weight-for-height dropped from 38% to 28% in trial villages, whereas in a comparison group of villages it increased by 1%. The percentage of stunted children was reduced from 46% to 31% without an increase in household income. Some behavioural changes were also noted. Fathers were more likely to bring food home to the families, and mothers were more likely to eat what the men brought.

In Burkina Faso, similar key target behaviours were defined. However, the results were less impressive in Burkina Faso than in Mali, probably because the intensity of the programme was lower. In Mali non-governmental organizations and local workers presented the message in the communities and the homes, whereas in Burkina Faso the health-care workers communicated the message during health-care visits.

Among the lessons learned were the following: one needs workers dedicated to the project in order for it to be effective; specific messages need to be given to specific audiences; social support for women needs to be strengthened; and different behaviour changes require different methods. The authors concluded that of the problems they identified, complementary feeding was the most difficult to change and required intensive interpersonal communication to change. On the other hand, increasing the intake of vitamin A required a media-based approach focused on increasing intake of specific foods.

High-risk infants: Low-birthweight children

A second type of programme that incorporates care into a medical facility is the treatment of low-birthweight infants. A number of carefully controlled efficacy studies showed that the care practice of tactile stimulation or gentle massage will result in greater weight gain in low-birthweight or very low-birthweight babies [60, 61]. The authors suggested that the mechanism for the observed effects may be that the massage increases cat-

TABLE 1. Incorporating care into health, nutrition, and integrated programmes: the care component and research evidence for its effectiveness according to type of programme

Type of programme	Care component (practice or resource)	Research evidence[a]
Primary health care	Curative: Encourage active feeding & stimulation of sick children Preventive & promotive: Screened for delays, provided information on care for development	Several studies under way
Maternity care	Provided social support during pregnancy to reduce stress Provided information on caregiving skills prenatally & immediately postnatally	Randomized controlled trial of prenatal home visits resulted in decreased incidence of abuse & more positive child-rearing attitudes [46] (+) Multicentric trial of social support during pregnancy showed no effects on birthweight or complications [47](0)
Nutrition	Education: Included messages on supervision of eating, need for a separate bowl, increased monitoring of child intake, offering additional foods Education: Increased resources for food by increasing the value of feeding of women & children by men Education: Combined teaching about parenting skills & interactions regarding food with food recommendations for toddlers in low-income families Growth monitoring & promotion: Taught caregivers about developmental norms as well as improved diets for young children in regular assessments & counselled parents with problems Breastfeeding promotion: Included information on specific aspects of development during the postnatal counselling visit & in support groups	AED project in Mali showed significant increases in child nutritional status & feeding behaviours as a result of the communication strategy [48](+) AED project in Mali increased fathers' role in food purchasing [48](+) Iringa project in Tanzania increased men's labour to free women's labour [30](+) Building blocks for toddlers programme (Cornell University Extension) combined home visits & small groups enrolled in WIC programmes Significant differences in nutrition knowledge, food variety, & self-reported parenting strategies were found [49](+) KKA project in Indonesia: mothers were given monthly developmental norms & techniques for working with their children No effects on nutritional status were seen (0), but feeding behaviours improved (+)[b]
At-risk children	LBW infants: Increased opportunities for tactile stimulation Provided opportunities for early skin-to-skin contact LBW: Home visiting for parent instruction	Early skin-to-skin contact & rooming: more rapid feeding initiation, higher cognitive development at 18 mo [50] Skin-to-skin contact: increased rates of breastfeeding [51](+) Infant health & development programme for LBW infants combined home-based activities for the 1st yr, then centre-based activities: significant increase in IQ [52]

continued on next page

TABLE 1. Incorporating care into health, nutrition, and integrated programmes: the care component and research evidence for its effectiveness according to type of programme *(continued)*

Type of programme	Care component (practice or resource)	Research evidence[a]
At-risk children *(continued)*	HIV-infected children: Increased cognitive stimulation & caregivers' awareness of feeding problems	Behavioural consequences of HIV may affect care. Correlational studies reported language deficit [53] & feeding difficulties [54]
	Malnutrition: Increased maternal motivation to change feeding practices by seeing change in children over the 2-wk period	Hearth Model of 2-wk feeding & group sessions resulted in significant changes in proportion of moderately & severely malnourished children in Viet Nam & Haiti [55] (+)
Integrated programmes	Home-visiting programmes for low- income families: Included direct services for children, help for parents with literacy, jobs, etc.	Results of randomized trials in US showed only short-term effects on cognitive development, few effects on parents [56] (0) Programmes in Turkey [41] & Jamaica [39] showed long-term significant effects on cognitive development (+)
	Community development &/or income-generation projects: Day-care programmes or feeding centres may be included; community mobilization for improved growth & development of children	
	Parenting programmes with health & nutrition component: Provided information on growth & development of children as well as role plays & materials on responsible parenting (husband–wife relationship, rights, & obligations)	Participants in the Parent Effectiveness System Programme in the Philippines who met weekly in groups to learn & role play on 13 topics, including child growth & development, health & nutrition, & husband–wife relationships, reported significant changes in their & their children's behaviour [57][c] (+? – no other impact data)
	Child-care programmes for working mothers: Strong components of both nutrition & early child stimulation are needed Models include pre-school centres & family-based care	Some of the centres reviewed by the International Center for Research on Women also showed positive effects on growth [58](+) Colombia home day care programme (ICBF) has shown some positive effects, particularly on psychosocial development, less on nutrition [59](+)

Abbreviations: AED, Academy for Educational Development; HIV, human immunodeficiency virus; LBW, low-birthweight.

a. + indicates that the intervention had a positive effect; 0 indicates that no effect was found.

b. Satoto. Care and child feeding, growth, and development. Paper prepared for the Indonesian Conference on Complementary Feeding, Surabaya, Indonesia, January 1996.

c. Early Childhood Enrichment Program–Parent Effectiveness Service Evaluation Study. Final Report, Manila, 1989.

echolamine and vagal activity, which leads to increased food absorption. More rapid initiation of breastfeeding when combined with rooming-in was also found for low-birthweight babies who received tactile stimulation [51]. One study even reported higher levels of cognitive functioning at 18 months as a result of tactile stimulation postnatally [50]. Infant massage is a traditional care practice in a number of societies and has been shown to have positive effects on growth by observational studies [28].

In the United States, a large effectiveness trial to assess the possibility of avoiding long-term deficits among low-birthweight and very low-birthweight infants was conducted. This programme, the Infant Health and Development Program for low-birthweight infants, combined home-based activities for the first year, then

intensive centre-based activities for the next two years, plus parent support groups. In a randomized trial, children receiving the home visits and centre-based programme showed a significant increase in IQ [52]. The intervention was conducted to improve the quality of psychosocial care that parents could provide and enhance their human resources for care through home visits and support groups. The greatest impact was observed with families who were most involved, although this relationship was not necessarily causal.

Among the lessons learned from this and other programmes was that these home-visiting programmes were most effective when the families perceived the need for the visits, which tended to be the case for families with low-birthweight infants. Visits to low-income families with term infants had more mixed results, perhaps because the families felt less need for the intervention.

Integrated programmes: Increasing parental knowledge and skills in health, nutrition, and early childhood development

The previous two examples illustrate how specific care practices either can be the main focus of a project or can complement other interventions. The third example combines interventions to improve several care practices into an integrated programme for increased effectiveness.

In the Philippines, the parent effectiveness service provides low-income and disadvantaged families with an opportunity to increase their knowledge and skills in 13 areas, including health and nutrition, child growth and development, and responsible parenthood [57]. Families are recommended to the neighbourhood parent effectiveness assembly for the sessions. The members of about 10 families (almost entirely women) meet weekly with a social worker, the implementer, or a parent volunteer to discuss the material and use role playing and activities to learn the concepts.

Two evaluations were reported in 1989 and 1993 [57].* Both were one-time surveys of parents in the programme and the programme leaders (post-test only, no control groups). These evaluations suggested that parents were generally pleased with the programme. They reported positive changes in their own behaviour and in their interactions with their children. Parents felt that the sessions on husband–wife relationships and responsible parenthood were most useful. There was slightly less interest in the sessions on child development and very little interest in games and children with disabilities. In both evaluations, most parents did not attend all of the sessions. No objective measure of impact was taken.

A number of lessons were learned. When the evaluation sample of parents were asked to identify their child-care activities, 81% mentioned feeding and 56% mentioned grooming. Very few mentioned psychosocial care for child development. Evidently psychosocial care was a less salient care practice than feeding and cleaning. Not surprisingly, parents found the sessions on child development less useful than those on health and nutrition. The most valuable sessions from the perspective of the parents and the social workers were those on husband–wife relationships and the responsibilities and duties of parents, including rules of the household and child management techniques. As in the previous programme model, perception of the need for the programme seemed to be an important component of success.

The group leaders, who were social workers and volunteers, had only five days of training on the methods and no follow-up training. Some felt that they had not mastered the technical information in the health and family-planning sessions; they recommended asking representatives from the Ministry of Health or Family Planning to present these sessions. Lessons learned included a need for a reduced workload for the implementers and increased training.

Day-care centres, crèches, and alternative child-care strategies

Child care for working mothers, particularly for children under three years of age, is an increasing need in many parts of the world, particularly in the growing megacities of the South. A variety of alternative care systems are used: institutional day care, home day care (care of several children in her home by a non-relative for pay), informal arrangements with family members, and paid workers in the home. Each of these arrangements involves food, health, and care of several types.

Mehra et al. [58] evaluated nine well-known day-care centre projects for children under three in developing countries. They examined the effects of these child-care programmes on children's nutritional status. The programmes reviewed included mobile crèches in India, seasonal day-care centres in Senegal, and the Accra Market Women's Association in Ghana. All programmes were closely connected to the women's workplace.

According to the reports from these institutions, significant increases in nutritional status as a function of the interventions were found in over half of the projects. Children in home day care or pre-schools had lower rates of mortality and morbidity than those not receiving intervention. The authors concluded that these effects were due to the amount of food served, the cleanliness of the locations, and the protection of the space.

The psychoeducational component of these programmes was not specifically evaluated in the report. However, Mehra et al. concluded that this component of the institutional programmes was not nearly as strong as the health and nutrition component. The

* Early Childhood Enrichment Program—Parent Effectiveness Service Evaluation Study. Final Report, Manila 1989.

ratio of caregiver to child was about 1 to 15 or 20 in both institutional and home day care. This ratio contrasts with the recommendation in the United States of 1 to 3 for children under three years of age. Kits for educational instruction were sometimes available but were not always used because of lack of knowledge of how to use them or fear that the children would damage the materials.

The lessons from this review were that easy access to these centres was a key determinant in the use of the day-care programme; there is a need for quality control and training of caregivers in child development, nutrition, health, and hygiene; and nutrition can be improved with these programmes. Finally, since less is known about providing psychosocial care to children, there is a need for research on the best models or techniques for care.

Perhaps this work can be informed by work in the West. An extensive investigation of the quality of day care for children under three years of age in the United States concluded that only three factors consistently influenced children's development: the ratio of caregivers to children, small group size, and absence of authoritarian or rule-based attitudes among the child-care providers [62].

The number of children in these care programmes was very small compared with those in informal alternative care. These alternative care arrangements may be less than optimal, and the caregivers may be too young or untrained to be capable of providing care. To help clarify the extent of the problem, an assessment of where children are cared for when the primary caregiver is out of the home for an extended period and who is providing the care should be an essential part of demographic and census reports. This question has been included in several of the Demographic and Health Surveys, such as that in Zimbabwe [63]

Current work on care

Interest in combined nutrition, health, and child development or psychosocial care programmes has increased dramatically recently. Several major efforts by the Child Health and Development Division of the World Health Organization (WHO)[44], the Pan American Health Organization [64], and the World Bank [65] to compile research and define "best practices" provide a basis for building programmes for care.

UNICEF has made considerable efforts to incorporate care into its programming. In a review of the annual reports from 1996, 40 countries mentioned projects involving care, most of which involved psychosocial care to improve early child development. Many mentioned training materials and courses. Collecting and evaluating these materials could be an important role for UNICEF. The Nutrition Section provided training and workshops for policy makers and planners in a number of countries and regions during the 1997–1998 period: India, Pakistan, Viet Nam, Lesotho Regional office, Brazil, Central and Eastern Europe, Jamaica and Latin America, West Africa, and the Philippines. In each country, efforts are being made to incorporate care into programs, using models such as those described in table 1. The Care Initiative [7] has been translated into a number of languages.

Because the interest in the integrated approach to care has been relatively recent, programming has had to rely on accumulated wisdom rather than research findings. Experts with long experience, such as Myers [66], have written on the costs and benefits of integrated programs, although without using the term care.

Within the next five years, we should have much more information on the effectiveness of incorporating care into health and nutrition programmes, particularly psychosocial care. In Bangladesh a large nutrition programme is under way that was designed to include care in two ways: focusing on feeding behaviours and practices and increasing resources for care. The latter included a women's support group and specific counselling for couples when they get married. In Bolivia, Uganda, the Philippines, and Indonesia, the World Bank and the Asian Development Bank are sponsoring integrated programmes that include nutrition, health, and psychosocial development. Programmes are also being designed by non-governmental organizations such as Save the Children in Nicaragua.

These efforts should help us move from research studies to programmatic efforts. At this point, however, there is a need for more research to provide specific guidelines for programmes, particularly those that focus on psychosocial care and active complementary feeding behaviours. Do we have the appropriate materials to guide these efforts? How can the psychosocial component be most effectively integrated? Who has the resources to present this information? What should the delivery mechanism be? Currently a highly controlled efficacy study is being planned to test the hypothesis that increasing active feeding will result in greater nutrient intake, apart from increasing food availability.

Four different approaches to improving psychosocial care for young children have been developed but have not been systematically compared:

» the milestones approach: providing caregivers with milestones of development and assessing their progress using a growth monitoring and promotion model, as occurred in Indonesia with the developmental milestones card known as the KKA (Kartu Kembang Anak)[67];
» the information approach: providing information on the stages of child development and factors that influence that development, as in UNICEF's Better Parenting initiative and materials [68];

» the parenting skills approach: teaching caregivers skills for interacting with their children, such as the parent effectiveness service in the Philippines or the Eight Guidelines for Interaction of the WHO Programme on Mental Health [56];
» the parental resources approach: strengthening the resources for care through improving parents' abilities to provide economic and human resources to their children (e.g., two-generation programmes [56]).

Probably each of these approaches is effective in a particular context, and each has its limitations. The first may help parents identify and focus on their children's achievement of norms. However, it may also result in anxiety over the children's failure if the children are not able to reach the norms and if counselling is not provided. If the tests are administered in a group session, as in Indonesia, parents and children may feel ashamed or unwilling to attend future sessions, as described by Coletta et al. [67]. A key aspect of a milestones approach is to have relevant information and recommendations for improving psychosocial care. Otherwise, the child is assessed but there is no counselling for improvement, as in a growth-monitoring programme without promotion.

The second approach may be of most interest to parents who understand and value child development; it has been well accepted in the Middle East and Northern Africa region and in the United States but has not been as widely used in other areas. If many parents think of "care" as feeding and cleaning their children rather than psychosocial care, as was reported in the Philippines sample [57], parents may need additional orientation and awareness to understand and value child development before this "educational" approach becomes more popular.

The third model appeared to be of interest in the Philippines, where the concept of psychosocial care was still new. It is consistent with current psychological theory, which stresses the importance of the quality of the interaction between child and caregiver for learning and development, particularly the sensitivity or responsivity of the caregiver to the child (e.g., in Valenzuela [69]). A pilot programme in South Africa is using the Eight Guidelines for Interaction developed by the WHO Programme on Mental Health as a family support programme [56]. Feeding behaviours could also be taught using this skill-based approach. This model seems to be promising but requires considerable training for the trainers.

The fourth model of resource enhancement was effective in the nutrition communication projects of the Academy for Educational Development [48] and probably should be a part of all studies. However, research suggests that resource enhancement will be more effective for child outcomes when combined with direct services for children [70].

The delivery mechanism was also a concern in a number of programmes. Projects that relied on health-care workers incorporating care messages into their daily work were much less effective than those that took the message into the homes through home visits, community actions such as dramas, or parent support groups. Frequency of contact seems to be a key element in programme effectiveness [69]. As we move towards integrated programmes, there is a concern that training a single person to be capable in child development and family functioning as well as health and nutrition issues may be difficult. In the Philippines Parent Effectiveness Service, the social workers felt that they could not handle all of the information [71]. The Indian Child Development Services workers found it difficult to provide home visits for the younger children, both because of time constraints and because of their perception of limitations in their knowledge regarding health and nutrition [72].

Resolving these delivery issues will require carefully evaluated studies. In the World Bank project in the Philippines, a new position of child development worker is being created. A similar approach was followed in the community-based nutrition centres in Indonesia. The Philippines Parent Effectiveness Service programme trained parents to be group facilitators who were as effective as the paid implementers. As experience with the integrated projects grows, strategies to maximize the benefits of this approach will be developed.

Conclusions and recommendations

The importance of care practices and resources, particularly the linkages among health, nutrition, psychosocial care, and psychosocial development, seems to justify its inclusion into programming. The following conclusions are now evident from the literature:

» Programmes that include care are likely to be effective in increasing nutrient intake and improving growth and development of children from birth to three years of age.
» A key element in psychosocial care is the sensitivity or responsivity of the caregiver to the child's emerging abilities.
» Effects on children are most likely to be seen from high-intensity interventions directly with children or with both parents and children, rather than solely with parents.
» Effective delivery of messages or support for care may be more likely to occur in a home setting than a health-care setting.
» In order for families to provide effective care, resources for care must be available and under the control of the caregivers.
» The potential contribution of men in families to the well-being of their children needs to be developed.

Other issues are much less clear. What contextual

factors should be taken into account to determine which of the four methods (testing milestones, providing knowledge about child growth and development, facilitating skill development, or strengthening resources in these programmes) would be most effective in improving growth or development? To what extent will changes in one care practice have effects on other practices? For example, will training mothers to be more responsive to children's cues in feeding result in improvements in caring for sick children or providing responsive stimulation? Will an integrated approach to care be more effective than single-focus programmes?

There is much work yet to be done. Particular concern should be accorded to the urban context and the special caregiving challenges that occur under those conditions, including day-care and informal care arrangements. Delivery mechanisms also will require further investigation. Training of workers for care in general, and for psychosocial care and complementary feeding practices in particular, is urgently needed. The training should be based on efficacy research and programme evaluation. Using ongoing programmes to build a research base will be an essential element of this process. The definition of indicators for evaluating care has been discussed elsewhere [73] and is the next challenge.

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World Bank support for early childhood development: Case studies from Kenya, India, and the Philippines

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Abstract

The World Bank's portfolio of early childhood development projects is large (more than US$600 million) and is rapidly growing as a result of a recognition that early childhood is a crucial phase of human development, and that integrated health, nutrition, and stimulation of young children can have substantial economic benefit. The current conceptual framework underlying the World Bank's support for early childhood development is loosely defined as including all interventions directed at children or their caregivers to promote child development, preferably integrated as a package of health, nutrition, and early education services and targeted (but not exclusively) to the poorest households and including partnerships with other providers of such services. This paper analyses three World Bank-financed early childhood development projects in Kenya, India, and the Philippines and the issues arising from the design and approach to early childhood development in the projects. The key challenges for World Bank support to early childhood development are the following processes: developing a strong conceptual framework, delivering properly sequenced and truly integrated services at the level of the beneficiary, assuring that the poorest families are reached, providing adequate support to community-based workers, designing optimal, cost-effective interventions, measuring effectiveness, ensuring sustainability, and making partnerships work.

Introduction

Since the 1980s, World Bank lending for health, education, nutrition, and other social services has increased dramatically and now averages about US$3 billion a year. About a third of the investment in the social sectors has been estimated to benefit children directly. In the 1990s, the Bank began focusing more particularly on human development [1]. This shift, together with demand from client countries, has led to a rapid expansion of Bank funding for projects promoting early childhood development. So far the Bank has lent about US$600 million for freestanding early childhood development projects, with the largest share (about 60%) going to four projects in India. Other early childhood development projects cover the Latin American Region (Bolivia, Colombia, and Mexico) and Africa (Kenya, Uganda, and Nigeria).

Early childhood development projects are recognized as a powerful economic investment. First, this period in the life cycle provides a window of opportunity to break the vicious intergenerational cycle of malnutrition and impaired educability for children from poor families. Second, research has established that the impact of insults suffered in early childhood (resulting in growth failure, for example) is often irreversible or is far more expensive to cure than to prevent. Third, the synergistic effects of health, nutrition, and early stimulation suggest that returns from investments in health, nutrition, and stimulation, as a package, will exceed returns from investments in any of the individual interventions.

The broad conceptual framework currently underlying the Bank's support for early childhood development [2] may be summarized as follows:

» Differences in cultural and economic environments make it impossible to prescribe any single programme model for early childhood development. Instead, the following types of intervention have been identified as appropriate in early childhood development programmes: direct provision of health, nutrition, and pre-school services for children; parenting education; training of caregivers; downward extension and reform of lower primary education; and advocacy for policy or legislative reform or information, education, and communication action (IEC) in favour of children

» Although standard definitions of early childhood cover the period from birth to six years of age, Bank programmes have emphasized the importance of foetal development and the transition to primary

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school, effectively extending the appropriate age of intervention to before birth and beyond six years (usually up to eight years). Some programmes include interventions (e.g., iron supplementation) for adolescent girls as a more efficient means of affecting maternal health and nutrition.

» Programmes should provide an integrated package of services addressing health, nutrition, and psychosocial needs for the holistic development of the child. However, the delivery of these services could be as a horizontally integrated package or organized vertically to reach the same target group, depending on the nature of the existing delivery mechanisms.

» Children from poor households need and benefit the most from early childhood development services. Direct provision of services needs to be targeted to the most vulnerable sections of the population. Advocacy and education efforts may be directed more broadly to the population at large.

» Partnerships among governments, non-governmental organizations, the private sector, and donor organizations are considered particularly important in promoting early childhood development, given the wide appeal, broad experience, and inherent interest of diverse groups in the subject.

The application of the conceptual framework to three early childhood development projects in the Bank's portfolio in Kenya, India, and the Philippines is discussed below. A brief description of each project, drawn from World Bank project documents [3–5], is provided, followed by an analysis of their application to the conceptual framework. Implications are then drawn for the conceptual framework itself and for future projects.

Situation analysis of the development status of children

Kenya

The situation was assessed to be unsatisfactory in terms of the status and trends in the health, nutrition, and educability of children from birth to six years of age. About 34% of children in this age group were underweight, and the trend of decreasing malnutrition rates seen in the 1980s appeared to be reversing. Morbidity levels were extremely high, with an 80% prevalence of infection with worms and a 50% prevalence of anaemia (UNICEF, personal communication, 1995). The failure rate in primary education was high, with grade repetition rates of 13% in primary school and drop-out rates of 57% by grade 8.

India

Malnutrition was identified as the fundamental issue and a major constraint to child growth, health, and educability. About 30% of children were born with low birthweight and 50% were underweight by two years of age. At least 50% of pregnant women were anaemic.

Philippines

Progress in the reduction of mortality and malnutrition, and in the improvement of primary school performance was unsatisfactory, particularly in comparison to the Philippines' East Asian neighbours. Child mortality in the Philippines, for example, is twice as high as that in Thailand and is higher than in China, a low-income country. Around 30% of children are underweight, and primary school failure is high, with 32% of children dropping out of grade 4.

Situation analysis of existing programmes

Kenya

The demand for early child development services in Kenya resulted in the establishment of a large network of child development centres, mostly in rural areas, by parents of children who did not have access to privately owned nursery schools. About 19,000 centres covering approximately 1 million children (mostly in the three- to six-year age group) have been set up. The community was the most important partner in the development of the centres, taking responsibility for the provision of physical facilities, payment of salaries, organization of feeding programmes, and provision of learning and play materials. Some communities received financial and supervisory support from non-governmental organizations and the local government. In the 1970s the Government of Kenya stepped in to provide training support and supervision for the centres. In 1984 the National Center for Early Childhood Education (NACECE) was established at the Kenya Institute of Education. NACECE was responsible for the training of trainers, curriculum development, research, and coordination. District Centres (DICECE) were responsible for training teachers at the district level, inspection, community mobilization, and the evaluation of local programmes.

Despite some significant gains in enrolment and community initiative, there is wide variation in the type and quality of services provided by these centres. The government evaluated the centres, and the key issues were identified as follows: (1) Access to services was poor, particularly for the lowest-income groups. (2) Wide variations existed between centres in the level of physical facilities, trained personnel, supporting services, and activities. (3) There was a lack of both a policy and services for children up to three years of age, although children in this age group are increasingly using these centres and much developmental damage occurs dur-

ing this period. (4) There was low public awareness of the importance of early childhood development. (5) The level of caregiver wages varied widely, and payments were irregular. (6) Monitoring and supervision were inadequate. (7) There were no linkages between pre-schools and primary schools. (8) The levels of funding were too low to allow efficient and effective programme implementation.

The ability and willingness of communities to finance and manage their pre-schools was identified as the critical factor affecting quality and sustainability. This is significant because child care costs households, on average, about US$10 per child per year. Studies of child-care costs in Kenya estimate that a minimum adequate package of child development services will cost US$20 per child per year. The Government of Kenya expenditure (based on a centre enrolment of 1 million children) works out to only US$0.50 per child. Corresponding investments at the primary, secondary, and university levels are US$17, US$168, and US$418 for households and US$38, US$107, and US$1,400 for the government [Meyers, personal communication]. Teacher qualifications, motivation, and supervision were other important factors.

India

The Government of India began implementing the Integrated Child Development Services Programme (ICDS) in 1974. This programme provides an integrated package of health, nutrition, and early education services to children up to six years of age from disadvantaged households. It currently covers 4,214 blocks or 37% of primary development units in the country, providing services to about 100 million individuals.

The services include monthly growth monitoring for children up to six years of age, supplementary feeding for children up to six years of age and pregnant or lactating women, immunization, health referral, pre-school education for children three to six years of age, and nutrition and health education for women 15 to 45 years of age.

The main shortcomings of the existing programme are identified below. First. overall government investment in the programme has been inadequate. In addition, ICDS has focused on quantity rather than quality, expanding rapidly in terms of geographical coverage while underfunding inputs, in particular the training of front-line service providers. The targeting of children up to three years of age has been particularly poor, and the coverage of the most vulnerable households in communities covered by the project has been inadequate. The programme is intended to actively involve beneficiaries and integrate the delivery of services. However, in practice, it has tended to be almost exclusively government owned and managed, with limited involvement of the public and the health and education bureaucracies. Finally, the programme has failed to replicate the successes of other early childhood development programmes of both the government and non-governmental organizations in the country, mainly because of rigidities in personnel and programming approaches.

Philippines

A number of vertical programmes of the health, social welfare, and education departments provide services to promote early childhood development. These include child survival programmes of the Department of Health (immunization, diarrhoeal disease and respiratory infection control, and nutrition programmes), day-care and parent education programmes of the Department of Social Welfare and Development, and early education programmes of the Department of Education, Culture, and Sports.

The coverage of the child survival programmes, particularly immunization and micronutrient supplementation, is good. However, respiratory infections and diarrhoeal diseases are still leading causes of mortality and morbidity among children under five years of age. Nutrition programmes tend to focus on food distribution rather than growth promotion, and their coverage is inadequate. Moreover, these programmes face funding constraints for equipment and operating expenses.

The programmes of the Department of Social Welfare and Development have limited coverage. The Day-Care Centre programme mandates, by law, the establishment of at least one day-care centre in every barangay (village) to serve 60 children three to six years of age through two daily half-day classes of 30 children each. Not more than half of the country's barangays currently have a day-care centre. Funds for training and equipment are limited. The Parent Effectiveness Service is intended to provide training for effective parenting to promote the cognitive development of children. The coverage of the programme is extremely low at present, and its impact is uncertain.

Project objectives

Kenya

The objectives of the project are to improve child cognitive and psychosocial development, improve child health and nutrition, increase school entry and enrolment at the appropriate ages, and reduce repetition and drop-out rates in lower primary school.

The processes by which these are to be achieved include improving the quality of early childhood development services, mainly through the activities of front-line workers who are fully trained and supported, and by providing additional inputs such as health and nutrition; increasing the access and participation of the

poor; improving family capacity for child care; and increasing community capacity to organize, manage, and finance early childhood development activities.

India

The overall objective of the project is to increase the quality, impact, and cost-effectiveness of the ICDS programme in five project states. The project seeks to achieve the following development objectives: to improve the nutrition, health, and psychosocial status of children up to six years of age, with particular emphasis on preventing malnutrition in children up to three years of age; and to improve the nutrition and health of women, particularly pregnant and lactating mothers.

The processes by which these objectives are to be achieved include improving child-care practices, i.e., meeting the nutritional, health, and psychosocial needs of children; empowering women and adolescent girls through increased awareness and improved social and economic status that will enable them to take better care of their own and their household's health and nutrition needs; strengthening community capacity to participate in and monitor the progress of the ICDS programme; and strengthening the capacity at the central, state, and block levels to provide high-quality support and training to functionaries of the ICDS programme.

Philippines

The project's overall goal is to ensure survival and promote the physical and mental development of children, particularly from the most disadvantaged socio-economic groups. The core impact objectives include reducing child mortality and malnutrition and improving school readiness, including motor and cognitive skills. The process objectives include increasing the number of municipalities that implement early childhood development services, increasing the amount of investment in early childhood development by such municipalities, increasing access to early childhood development services, and establishing nutrition improvement programmes in 50% of the targeted municipalities.

Project components, coverage, and costs

Kenya

The project covers about 1.5 million pre-school children in selected districts throughout Kenya. Districts were selected on the basis of a composite indicator that took into account the availability of early childhood development services, health and nutrition status, school enrolment, drop-out rates, and income. The project initially focused on upgrading the performance and management of about 20,000 existing early childhood development centres through teacher training and community capacity building. The second stage involved implementation of pilot interventions to improve the scope and coverage of early childhood development services.

The core components of the project are an improved Teacher Performance component (US$5 million) to provide initial, orientation, and refresher training for teachers, as well as mechanisms for support, and a Community Capacity Building and Mobilization component (US$3.5 million) to improve parenting skills and strengthen the organization, management, supervision, and quality control of early childhood development services and develop the communities' capacity to mobilize and manage local resources, as well as monitor their utilization. The pilot components will include the following:

» community grants ($5 million) to assist community-managed early childhood development centres (constrained by low levels of funding) to pay for the salaries of pre-school teachers, school materials, and health and nutrition services; to subsidize fees for the poorest children; and to improve school facilities;
» health and nutrition services ($4.5 million), which would develop a replicable model, emphasizing prevention and promotion, to optimize the health and nutrition status of pre-school children at the community level;
» pre-school to primary school ($1 million) transition pilot programme, in those primary schools which have pre-schools attached, to provide continuity in both the curriculum and in teaching methodologies between pre-school and primary schools.

A regular monitoring system as well as a mid-term and a final evaluation will be set up to evaluate the impact of early childhood development services and to assess the differential effects of diverse early childhood development packages and delivery systems on child outcomes. The total project cost (including contributions from the government, the World Bank, and other donors) is US$35 million.

India

The project will cover 18 million children in the five states of Ultar Praden, Rajasthan, Maharashtra, Kerala, and Tamilnadu. The project will focus on improving the quality of services in 100,000 existing centres in the five states and in expanding ICDS into new blocks in each state. The project will also provide state-wide programme support for quality improvement; planning, training; management strengthening; information, education, and communication (IEC); monitoring; evaluation; and operations research. The total project cost, including the government's contribution, is US$290 million.

The components of the project are described below.

Service delivery strengthening (US$199.4 million)

Service quality improvement (US$46.4 million). Four specific areas are to receive emphasis:

» *Nutrition*. Activities will include regular monitoring to detect malnutrition and promote growth; supplementary feeding to children up to six years of age (with particular emphasis on those up to three years of age) and pregnant and lactating women; semi-annual vitamin A supplement to children aged nine months to six years and an iron folic acid supplement for at least 100 days to pregnant women and adolescent girls.
» *Health*. Activities will include immunization against six childhood diseases to reduce infant and child mortality; provision of appropriate and timely health care to beneficiaries (including early registration and regular check-ups for pregnant women); use of disposable delivery kits for safe delivery; deworming and oral rehydration therapy; and referral of ill and at-risk pregnant women and children up to six years of age.
» *Early childhood care and education* to promote the overall psychosocial development of the child. Activities will include pre-school education for children three to six years of age, early childhood stimulation for those up to three years of age, promotion of awareness of the importance of early childhood stimulation for all care providers, and opening of public nurseries in selected locations.
» *Community mobilization* for the involvement of the community in programme implementation and monitoring for long-term sustainability. Activities will include village social mapping and mobilizing resources and monitoring the child-care (Anganwadi) centres.

Convergence of services (US$4.0 million) provided by different ministries and agencies on a sustained and predictable basis to increase the impact of early childhood development investments.

Women's empowerment (US$12.5 million): economic empowerment of women and activities for adolescent girls, integrated with ICDS. Activities aimed at building self-reliance and awareness under this component include forming women's groups, training and building capacities in thrift and credit activities, increasing access to institutional finance, income-generating activities, and convergence of different women's empowerment activities sponsored by various departments.

Staffing and infrastructure development (US$136.5), including the staffing requirements of all components and construction of new facilities. Staffing activities will incorporate rationalization of the workload for the workers of the Anganwadi centres and better supervisor-worker ratios. Infrastructure development will involve construction of Anganwadi centres and offices and district offices.

Programme support (US$78.7 million)

Management and institutional development (US$13.4 million) to fund additional specialist staff in the areas of nutrition, training, communications, monitoring, and evaluation, who will be key to long-term quality improvement. Quality improvement teams are to be formed at the state, district, and block level with ICDS programme management.

Training (US$49.5 million). This would involve training of functionaries of both the new and old blocks, strengthening or establishing training centres and training teams at the state and district levels for the different categories of functionaries, developing training material, distance education for professional upgrading of ICDS functionaries, and networking with other departments and institutions for requisite training in additional areas.

Information, education, and communication (IEC) (US$10.4 million). IEC resource centres are to be established at the state and district levels for the development of communication strategies and IEC materials (with input from communities and ICDS functionaries).

Monitoring, evaluation, and operational research (US$5.4 million). Activities will include design of a Management Information System by the Government of India with flexibility for state-level innovations, streamlined to reduce the workload of the Anganwadi centres, and with data to be analysed and used as far as possible at the level at which it is generated. Baselines, mid-term reviews, and final surveys will be undertaken by pre-selected institutions with technical guidance, supervision, and quality control provided by a technical panel of experts. In addition, continuous social assessments will emphasize qualitative data collection on community perceptions, needs, and priorities for rapid assessment, analysis, and feedback to the community.

Central component (US$3.9 million)

A *Central Project Management Unit* (CPMU) will be established at the existing ICDS office at the centre and funding, will provide for overall project management, monitoring, and evaluation.

Philippines

The project focuses on upgrading and extending existing early childhood development services (such as the child survival, day-care centre, and parent effectiveness programmes) and on piloting new initiatives (such as the new national protein-energy nutrition programme and the day-care mother programme). The project will cover about 2.7 million children in three regions of the Philippines and 169 targeted municipalities that include the greatest number of children at risk. The project consists of the following components:

Component 1: Early childhood development service delivery (US$34.9 million)

Subcomponent 1.A: Programme Support for Provincial Local Government Units (LGUs).

This subcomponent consists of five packages, comprising support for five programmes in all provinces in the three project regions. These are the Expanded Programme of Immunization (EPI), the Integrated Management of Child Illness (IMCI) Programme, the Micronutrient Malnutrition Control Programme, the Parent Effectiveness Service (PES) Programme, and the Grade 1 Early Child Experience/Early Child Development (ECE/ECD) Programme.

Subcomponent 1.B: Financing Facility for Municipal/City Local Government Unit (LGU) early childhood development sub-projects.

This financing facility, which will operate through the Municipal Development Fund (MDF), will provide matching funds on a flexible cost-sharing basis geared to LGU income levels for LGUs who wish to invest in upgrading their early childhood development services. With technical support from the project, LGUs will submit proposals for three-year investment packages for appraisal and implement them once approved.

The investment packages will need to supplement or upgrade barangay-level early childhood development service providers, including rural health midwives (RHMs), day-care workers (DCWs), day-care mothers (DCMs), barangay health workers (BHWs), and child development workers (CDWs). Facilities, equipment, and supplies such as drugs, food supplements, teaching materials, and IEC materials will also be provided to achieve specified service norms. The team will provide a set of integrated early childhood development services, consisting of child health services (including micronutrient supplementation), a programme to control protein-energy malnutrition, parent effectiveness services to promote psychosocial stimulation for children under three years of age, day-care centre early education, and day care for children of working mothers.

Component 2: Support to service delivery (US$12.3 million)

This component will provide support to LGUs in implementing their investment packages in the areas of communication (advocacy, information, education, and communication for LGU executives, opinion leaders, decision makers, early childhood development providers, and parents), planning, management information systems (MISs), training and human resource development, and institutional development. Support will be provided at the central, regional, provincial, and municipal levels. This subcomponent will be managed by the Department of Social Welfare and Development (DSWD) in coordination with a mix of agencies, including non-governmental organizations, as appropriate.

Component 3: Research and development (base cost US$3.6 million)

This component will finance research and development activities needed to support effective implementation of early childhood development programmes and projects, including initial piloting of new field-level technical interventions proposed under the project. There will be three subcomponents: piloting of project interventions, unprogrammed financing for research and testing of new and innovative approaches to early childhood development services, and monitoring and evaluation of the effectiveness and impact of the project, including baseline and end-project evaluation surveys.

Monitoring and evaluation

It is too soon to assess the performance of these projects. However, each project operates in an environment of identified strengths, recognized weaknesses (proposed to be addressed by the project), and inherent risks.

In Kenya community ownership of early childhood development centres, an effective teacher training methodology, and institutional capacity nurtured for decades by the Van Leer and Aga Khan Foundations and UNICEF were valuable pre-project strengths. The project was intended to expand the teacher training programme, empower poor communities and households, and add new dimensions such as health and nutrition to the existing cognitive development programme.

In India the government has clearly articulated a vision of an integrated early childhood development programme and had succeeded in creating a large infrastructure for the delivery of services. The project seeks to renew emphasis on the nutrition component, promote the convergence of health and stimulation services, and improve women's capacity and community participation. The risks include overly ambitious workloads for poorly paid front-line workers and bureaucratization of social services.

The Philippines has the advantage of being a middle-income country with heightened literacy and a social-service infrastructure largely in place. However, the quality and coverage of the services are still far from adequate, particularly in the least well-off areas. The project seeks to fill this gap. The risks include a poor record in the implementation of projects in the social sectors and limited strategies for integrated service delivery at the level of the beneficiary.

Table 1 summarizes the core monitoring indicators identified by each of the projects. Each project includes a baseline, mid-term, and end-of-project evaluation to measure project impact.

Cross-cutting issues and implications for future programmes

Building on home-grown early childhood development models

All three projects focus on improving the efficiency and effectiveness of existing early childhood development programmes rather than creating new ones. In Kenya the National Center for Early Childhood Education has, with external assistance, promoted community-owned pre-schools for over 20 years. In India the ICDS, conceived as an integrated early childhood development model, has been in operation since 1973. The health and other programmes selected for strengthening in the Philippines have likewise existed for several years. Although the projects have focused on improving basic delivery systems, innovation has been important. In Kenya the delivery of health and nutrition services, the transfer of funds to community-managed schools for early childhood development services, and efforts to smooth the transition from pre-school to primary school by reorienting first-grade teachers are three new pilot initiatives. In India promoting convergence and introducing activities for the empowerment of women and adolescent girls are new dimensions to the existing programme. In the Philippines a home-based day-care programme is being introduced for the first time. World Bank support is intended to increase the levels of investment in what are largely underfunded initiatives, promote the holistic model for early childhood development, and transfer technology from successful experiences in other parts of the world.

An issue that arises for future donor involvement is what would be an appropriate approach in countries that have no community-based delivery systems on which to build such projects. In many cases, the delivery systems that do exist (e.g., for health services) may be so weak and overburdened already that it would be unrealistic or counterproductive to add responsibilities to existing staff.

A second issue that arises from this approach is whether the projects promote an optimal mix of services. Within the three technical areas of child health, nutrition, and stimulation, there is growing consensus in the research findings about appropriate intervention packages. For example, IMCI is a major effort to define this package for child health and to move beyond a facility-based to a community-based intervention. Promoting maternal nutritional status, breastfeeding, growth promotion up to 24 months of age, and micronutrient supplementation up to six years of age are recognized as a standard package of nutrition services. Stimulation techniques for children up to three

TABLE 1. Outcome and process indicators

Country	Outcome indicators	Process indicators
Kenya	Motor & cognitive skills Weight & height Age at school entry Repetition Drop-out rates, grades 1–5 Enrolment in ECD services	Enrolment for poorest-income quartile No. of caregivers trained Proportion of children 0–3 yr & 3–6 yr covered by health & nutrition services Parent committees strengthened Parent committees trained
India	Malnutrition rates, 0–3 yr Incidence of LBW	Coverage of children 0–6 yr & women by health & nutrition services, e.g.: » pregnant women receiving supplementary food & iron tablets » adolescent girls receiving iron folate » children weighed » underweight children receiving food » children exclusively breastfed » women & girls covered by awareness programme » ICDS workers trained
Philippines	Under-5 mortality Malnutrition rates 0–6 yr Incidence of anaemia 0–6 yr Motor & cognitive skills Grade 1 completion rates	» children fully immunized » children attending day-care centres Establishment of PEM programmes Establishment of CDWs Implementation of ECD projects

Abbreviations: CDW, child development worker; ECD, early child development; ICDS, Integrated Child Development Services; LBW, low-birthweight; PEM, protein-energy malnutrition.

years of age, particularly as part of traditional caring and feeding practices, and scaffolding techniques for stimulating cognitive development are well developed.

All the projects provide key health, nutrition, and stimulation inputs (see table 2). However, in practice, projects place different levels of emphasis on each of these areas. The emphasis is usually driven by perceived priority needs or the absorptive capacity of existing delivery mechanisms. For example, in Kenya the major investment is in psychosocial and cognitive development, because parents have already identified this as a priority, and the existing delivery system exists solely for that purpose. In India the investment is largely geared towards improving the nutrition component, primarily because it is considered a high priority in the Indian context, but also because the ICDS delivery mechanism was primarily intended for nutrition services and separate health and delivery networks are in place. In the Philippines most of the allocated expenditures are for health services, although local governments could skew investments in favour of nutrition or day care through the LGU packages. It would be useful to develop a conceptual framework identifying the relative weights required for the different types of interventions and reasonable unit costs of each.

Targeting the poorest

Poverty alleviation is one of the objectives of World Bank involvement in early childhood development, and early childhood development services have been shown in much of the research to have the greatest impact on children from the poorest households.

The Kenya and Philippines projects adopted geographical targeting, selecting, on the basis of composite income and other criteria, the most backward districts for project implementation. For some components, such as nutrition supplementation, growth monitoring is used as a screening mechanism. Beneficiaries are also thought to self-select, largely because the poor quality of publicly funded facilities meant that anyone who could afford to pay for private services did so.

TABLE 2. Early child development projects: Key inputs

Project	Kenya	India	Philippines
Maternal health & nutrition	None	Supplementary feeding for pregnant & lactating women, iron folic acid tablets, antenatal care	None
Children 0–3 yr			
Health	Immunization Prevention & treatment of common childhood illnesses Deworming	Immunization Deworming Oral rehydration therapy	Integrated management of childhood illnesses (immunization, control of acute respiratory & diarrhoeal diseases)
Nutrition	Breastfeeding promotion Growth monitoring Supplementary feeding Micronutrient supplementation	Monthly growth monitoring Supplementary feeding Micronutrient supplementation	Monthly growth monitoring Supplementary feeding Micronutrient supplementation
Psychosocial/ stimulation	Training of parents & care providers	Training of care providers	Training of parents & care providers
Children 3–6 yr	Pre-school Periodic health check-up & treatment of illnesses Micronutrient supplementation snack	Pre-school Treatment of illnesses Micronutrient supplementation	Pre-school Micronutrient supplementation Integrated management of childhood illnesses
Other features	Community owned & managed early child development centres Primary school transition programme	Convergence improvement strategies Empowerment of women & adolescent girls	Day-care mothers (home) Food-fortification programme

However, there is considerable anecdotal evidence to suggest that public services do not always reach the poorest. In India, for example, the most backward castes are often excluded from ICDS because the centres are located in the middle of upper-caste neighbourhoods or the workers are from the upper caste. Co-payment for services in Kenya excludes some of the poorest families from participation. A poverty study in the Philippines showed that although the poorest relied heavily on publicly provided services, they benefited less from them than did those who were better off. They also had the highest opportunity costs for participating in such programmes.

The Kenya project attempted to target the poorest by providing scholarships through community-managed schools. In India several targeting strategies, such as locating schools in hamlets dominated by the weaker castes, selecting workers from these castes, and identifying families at risk during household surveys and targeting services to them, have been proposed. Overall, however, it is not clear that the projects will effectively reach the poorest. In developing-country situations, where income can rarely be used as a screening criterion for participation in public services, it is necessary to develop effective targeting strategies to ensure the participation of the most vulnerable households.

Delivery of an integrated package of services

All three projects work within an integrated package framework, in that they recognize the need for interventions covering nutrition and psychosocial and cognitive development. The Kenyan and Indian models attempt to achieve integration through the early childhood development centre, which becomes the focal point for the delivery of all three services. Both projects also have a primary early childhood development worker who receives training in all three areas, although she is dependent on the health worker to deliver certain health inputs, such as immunization. In the Philippines project, separate workers are responsible for health, nutrition, and stimulation activities, although there is an attempt to achieve coordination in the context of a decentralized management of social services.

In practice, integration has been an area of identified weaknesses in these projects. The Kenya project has tried to ensure the successful integration of health and nutrition services by involving non-governmental organizations in service delivery. Non-governmental organizations are given the option of using any service delivery mechanism that works, including collaboration with the public health service delivery system, and of purchasing necessary supplies. In most countries, however, non-governmental organization coverage is not extensive. The India project has spelled out a variety of mechanisms to promote the convergence of services at the early childhood development centre, including joint planning, training, and supervision by health and ICDS workers. These measures are likely to have some positive impact, but the inertia of two large and strictly vertical bureaucratic delivery systems cannot be underestimated. The early childhood development centre as the focal point for service delivery still offers the greatest promise, but coverage of vulnerable children via centre-based programmes must first be improved through effective targeting mechanisms.

Partnerships

In the Kenya project, the World Bank collaborated effectively with non-governmental organizations and foundations, helping to maintain the non-bureaucratic approach that characterized early childhood development efforts in Kenya from the beginning. In the India and Philippines projects, the Bank collaborated extensively with UNICEF, particularly for technical assistance during project preparation. The Philippines project is also jointly funded by the Asian Development Bank.

The Human Development Department of the World Bank has initiated a global partnership effort in early childhood development. In April 1996, a conference entitled "Early Childhood Development: Investing in the Future" was held for early childhood development researchers and practitioners. Subsequently, the Bank organized two regional seminars, one in Africa and one in Latin America, to articulate region-specific issues and strategies. A similar meeting has been proposed for the Asian region. Early childhood development offers great promise as an area for cooperation among not only government donors and non-governmental organizations, but also with the private sector. There is obviously great scope for sharing of information and collaborating in the delivery of services.

Monitoring and evaluation

As the portfolio of early childhood development projects supported by the World Bank grows, extensive data are being collected on the effects of early childhood development interventions. The age of enrolment in primary school, indicators of school readiness (a combination of health, nutrition, and cognitive indicators), and grade progression and performance in early primary school are generally cited as key outcome indicators. The Bank's research department will be undertaking an evaluation of the impact and cost-effectiveness of a small sample of early childhood development projects in the portfolio. The proposal identifies several limitations in such a study (difficulty in randomly assigning individuals to treatments, unobserved family and community characteristics, etc.), and researchers have cautioned that outcomes from such evaluations

could exaggerate the role of early childhood development interventions and lead to simplistic models of child development. However, the results of such an evaluation, substantiated by other research findings, could help to define better the essential elements of cost-effective early childhood development programmes.

Key challenges

The key challenges for early childhood development programme design may be summarized as follows:

» developing a strong conceptual framework (what inputs are critical, at what stage, in what sequence, of what quality and intensity, for what outcomes?);
» delivering properly sequenced and truly integrated services at the level of the client (what integrating mechanisms? e.g., centre-based child development worker, joint training, fixed-day service, joint planning, supervision, monitoring, record keeping?);
» assuring that the poorest families who need the services the most are reached (what outreach or targeting strategies, demand-side mechanisms?);
» adequately supporting community-based workers to orchestrate a complex sequence of inputs for a large number of clients with limited measures (what skills, salary, training, and supervision?);
» designing optimal cost-effective interventions (what are the trade-offs among quality, cost, and impact?);
» measurement issues (what, how, and when?);
» sustainability (do governments sustain interventions? can interventions overcome serious environmental handicaps? what is needed to sustain impact over subsequent phases of human development?);
» making partnerships work (common framework, common jargon, same advice!).

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Economic considerations for analysis of early childhood development programmes

Jere Richard Behrman

Abstract

The first section of this paper presents analytical frameworks for considering the determinants of and the impact of human resources investments in childhood development. These are investments, because resources devoted to child development may have returns not only currently, but in the future. Emphasis is placed on the underlying behaviours that determine such investments by households, given their resources and the prices and programmes that they face. Important implications are that: (1) households have their own objectives and therefore may not make the decisions that policy makers anticipate; (2) households make such decisions together with many other decisions in light of all their resources and current and expected prices and programmes, so there may be important cross-programme effects; (3) for empirical analysis or casual observations, many of the determinants of childhood development investments and many of their impacts include not easily observed variables, so inferences that do not control for such variables may be wrong; and (4) the expected returns and costs may differ substantially, depending on a range of markets, programmes, and macro contexts. The second section considers estimation issues in ascertaining the determinants of and the impact of investments in childhood development: (1) random measurement error, which may bias towards zero the estimated effects of right-side variables; (2) omitted variable bias, which causes the estimated effects of observed variables to be misrepresented because these variables in part are representing the effects of the omitted variables; (3) simultaneity bias of a direction that depends on the model being considered if the right-side variables are determined simultaneously with the dependent variable; and (4) selectivity bias if data are available only on a selected sample. The third section presents a framework for policy choices related to childhood development. The two basic motives for policy interventions are discussed: (1) Efficiency to obtain the maximum output for given resources and technologies and (2) distribution of resources or products among members of society. Illustrations are given, with explicit reference to possible child development policies.

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Introduction

Early childhood development programmes are widely considered to be promising means through which society might improve the prospects of future generations of adults in low-income countries, as well as in other societies. This paper attempts to illuminate economic considerations related to analysis of early childhood development programmes and how they relate to what we think we know and to what we might be able to know, about the determinants and the impact of child development and about related policy choices.

Because these issues are inevitably empirical in nature, the tripartite foundations for good empirical analysis is considered, in the particular context of the determinants of and the impact of childhood development and related policy issues: theory, data, and estimation. These three dimensions of empirical social science analysis are critically interrelated. Theory provides frameworks for exploring systematically various dimensions of the determinants of and the impact of childhood development. Theory also points to what data are needed for such explorations, and to some of the probable estimation issues that should be addressed. Data, of course, are essential for empirical analysis, limit the extent to which analyses can be undertaken, and shape most of the estimation problems. Thus, the estimation problems reflect implications of theory and of the data that are available, and often more importantly, of the data that are not available—such as variables that are not observed or measured only imperfectly in the data but that may affect importantly childhood development and other human resource investments as well as subsequent adult productivity and other outcomes of interest.

The first section presents simple analytical frameworks for considering the determinants of and the impact of human resource investments in childhood development—production functions for representing the direct productivity impact of childhood development and reduced-form demand relations for family investments in childhood development and for related behaviours. Illustrations are given of the kinds of questions that can be answered about childhood development and related programmes within these frameworks, and about the difficulties in answering such questions. The second section discusses estimation issues in ascertaining the determinants of and impact of childhood development and related programmes. This section is important not only for analysts of the impact of childhood development, but for users of such analysis so that they can evaluate what we know and what we do not know from available empirical studies and from proposed future studies. The third section considers the basic framework for policy choices related to childhood development programmes, with emphasis on the two basic motives for policy changes—increasing efficiency (productivity with given resources) and changing distribution. Both of these motives are considered in some detail, with emphasis on information issues that are central to a number of possible policy interventions and to their evaluation, and on what policy changes are likely to have high priority.

Analytical frameworks for considering the determinants of and the impact of human resources investments in childhood development

Good theories about the determinants of and the impact of human resource investments, such as those in childhood development, abstract the essence of complex empirical phenomena in ways that lead to testable empirical propositions about behaviour and policy choices in the presence of imperfect information. This section begins with a production function that is central to these theories, and then turns to micro theories that underlie some dimensions of the behaviours determining investments in childhood development and other human resources, the returns to those investments, and policy considerations related to such investments.

Direct production function impact of childhood development

Childhood development, of course, is of interest in itself, perhaps because it increases child happiness. It also may be of interest because it has a "production function" impact on other outcomes later in the life cycle directly or indirectly of interest, such as education, health, wages, and productivity. The total impact of child development can be considered the present discounted value of all such effects, each weighted by its appropriate price.[1]

A firm production function, for example, can illustrate the (lagged) impact of childhood development (perhaps through its impact on subsequent learning capacities and health) and other characteristics of workers, together with other production inputs such as machinery and equipment, on firm production. A production function is a technological relation that gives the maximum output that can be produced with a given set of inputs by a firm (or by other production units). The production function in itself does not say anything about whether the inputs actually used are the best combination of inputs, given the firm's objectives. But it is an essential part of models of behaviours related to human resource investments within the larger contexts of objectives that a family has, markets that a family faces, and assets that a family has at the time that decisions related to child development are made.

The production function for firm f highlights the role of attributes of worker i in firm f—including the ability (A_{if}), education (S_{if}), health (H_{if}), and work effort (E_{if}) of worker i in the production of the firm's output (Q_f), given similar attributes of other workers in the firm (L_f), capital stock of the firm (K_f), firm management capabilities and organization (M_f), and knowledge (T_f) of technologies relevant to the firm's production:

Relation (1):

$$Q_f = Q(A_{if}, S_{if}, H_{if}, E_{if}, L_f, K_f, M_f, T_f)$$

This relation, of course, is the simplification of a complex production process, with all of the variables representing many dimensions. But this simplification points to some important aspects of production and how it might relate to earlier childhood development of current workers. It is important for a number of questions about childhood development to know what is the impact of earlier childhood development (C_{if}) of worker i on the production of firm f (or to evaluate the economic impact of resources devoted to child development, MQ_f/MC_{if}). For example, to evaluate the rate of return to increasing resources devoted to child development, it is necessary to have some notion of what long-run effects better child development has on economic productivity (and perhaps on other outcomes). It seems plausible that there is no direct impact of current worker's earlier child development on production, for which reason relation (1) does not include C_{if} explicitly. But that does *not* mean that the marginal product of childhood development on production is zero. To the contrary, it is thought to be positive through affecting direct production inputs such as education, health, and effort.

This has two important implications for the evaluation of the economic impact of resources devoted to child development. First, it may be necessary to have a

fairly long time horizon. Decades may pass before the returns to investments in these resources may be reaped. So such returns must be discounted to reflect the long lag between the investment and the returns. Second, it may be necessary to trace the impact through a number of channels—education, health, and effort in this example. Both of these factors mean that it is difficult to estimate empirically what is the magnitude of the economic impact of resources devoted to child development.

In part for these two reasons, all (or virtually all) of what might be considered production function estimates related to the impact of child development on economic productivity address one or the other of two stages: (1) The impact of child development on intermediate outcomes such as education or health, and (2) the impact of these intermediate outcomes on productivity. The second stage is just the estimation of relation (1). The first stage is the estimation of production functions similar in general form to relation (1), but with the intermediate outcome as the dependent variable that is being produced and resources devoted to child development among the right-side inputs. Relation (2) gives an illustration for education of the *i*th person (S_i), depending on previous child development (C_i), ability (A_i), health (H_i), nutrition (N_i), school quality (Q_i), and other factors:

Relation (2):

$$S_i = S(C_i, A_i, H_i, N_i, Q_i, \ldots)$$

There are a number of important questions about this production process pertaining to what is the impact of child development on education MS_i/MC_i), and the interactions between childhood development and other factors that enter into the production of education, or how the marginal product of childhood development affected by other individual, family, or school attributes (i.e., what is MS_i/MC_i MX_i where X_i refers to other individual, family, or school attributes that affect education). How much do resources devoted to child development improve education? Are resources devoted to childhood development more effective in their impact on education if the child has better health and nutrition? Greater abilities? Comes from a better family background? Attends a better school? Of course parallel questions are of interest for other intermediate outcomes affected by child development, as well as for the various intermediate outcomes through which child development may affect productivity in relation (1).

If analysts, whether they be sensible policy makers or high-powered econometricians, had good information on the inputs and outcomes of these production processes, considerable light could be shed on the answers to questions such as are raised in the previous paragraph by estimating the critical parameters in these basic production processes. But there are at least three basic data problems in undertaking such estimates.

First, some critical variables are not likely to be observed by analysts. Examples for relation (1) include individual worker's abilities A_{if}, individual worker's efforts E_{if}, and the firm's management capabilities M_i. Examples for relation (2) include abilities A_i and school quality Q_i. The lack of observations on such variables not only means that it is very difficult to assess their impact. It also means that it is difficult to assess the impact of observed variables. If children with more ability are likely to receive more childhood development resources and their abilities are not controlled in estimates of production relations such as (2), for example, the impact of childhood development on education is likely to be overestimated because it is in part proxying for unobserved abilities.

Second, some critical variables are likely to be observed only very poorly by analysts. Resources devoted to childhood development itself are a central example. Therefore most, although not all, empirical studies represent childhood development very crudely, by such measures as duration of participation in formal childhood development programmes, by imperfect test scores, or by family characteristics. If the observed indicator of childhood development that is used for analysis is a noisy representation of true childhood development with the noise random, this aspect of the data, if not controlled in the estimation, results in underestimates of the true effects of childhood development. If the observed indicator of childhood development is systematically related to other variables in the production function as, for example, might be the case with use of parental characteristics such as income and schooling that are likely to be systematically associated with health and nutrition in relation (2), the result is a multiplicity of biases in the estimates of the production technology in relation (2), depending on exactly what is the nature of relation between the observed indicator and the true extent of childhood development.

Third, though relations (1) and (2) are written without reference to time, production processes are dynamic, so longitudinal data on all the relevant variables may be required to understand the production processes, but often data are available only at a point in time or for very limited time periods. This may result in omitted variable biases that lead to misleading estimates of the nature of the production processes.

Household demands for human resource investments such as in child development

Resources devoted to childhood development may have current consumption benefits for the children and for their family and may have future investment effects through production processes such as those that are discussed above. Childhood development and other human resource investment determinants involve for-

going current consumption to increase future consumption. Becker's [1] Woytinsky Lecture provides a simple but very useful framework with which to think about investments in human capital. This framework is considered from the perspective of families making investments in childhood development, basic education, or other types of human capital.

Within this framework, human capital investment demands such as for childhood development reflect the equating of expected marginal private benefits and expected marginal private costs for human capital investments in a given child (fig. 1A).[2] The marginal private benefit curve depends importantly, *inter alia*, on the expected private gains in productivities (or perhaps in wages/salaries that may be related to productivities) due to human capital investments. These benefits depend on the marginal impact of the human capital investment on productivity in a production function such as in relation (1) (and perhaps indirectly through a production function as in relation 2) and on the marginal rewards that accrue to the investor because of that impact. The marginal private benefit curve is downward-sloping because of diminishing returns to human capital investments (given genetic and other endowments). The marginal private cost may increase with human capital investments because of increasing marginal private costs of borrowing on financial markets (if such markets do not permit borrowing for such purposes, at some point the marginal private cost curve may become very steep or vertical). The best human capital investment for this individual is H^*, where the two curves intersect, with both the marginal private benefit and the marginal private cost equal to R^*. For higher human resource investments than H^*, the marginal costs exceed the marginal benefits so there is pressure to reduce the investments to the H^* level. For lower human resource investments than H^*, the marginal costs are less than the marginal benefits so gains can be made by increasing investments to the H^* level. This equilibrium human capital investment at H^* is associated with an equilibrium rate of return, i^*, that equates the present discounted value of expected marginal private benefits with the present discounted value of expected marginal private costs. By comparing this rate of return with those on other investments the household can decide whether this investment should be undertaken.

If the marginal private benefit curve is higher for every level of human capital investment as for the dashed line in figure 1B, all else equal, the equilibrium human capital investment (H^{**}) and the equilibrium marginal private benefit (R^{**}) both are greater. The marginal private benefit curve may be higher for one of two otherwise identical individuals (children) except for the difference noted below because one individual (or whoever is investing in that individual, such as the individual's parents)[3,4] (1) has greater genetic endowments that are complementary with resources devoted to childhood development or other human capital investments; (2) has lower discount rates so that the future benefits of human capital investments have greater value at the time of the investment decision; (3) has human capital investment options of higher quality (e.g., access to higher quality public childhood development programmes or public schools) so that the marginal private benefits for a given level of private investments are higher, and the equilibrium investments greater;[5] (4) has better health and a longer expected life due to complementary investments, so that the post-investment period in which that individual reaps the returns to the investment in childhood development is greater

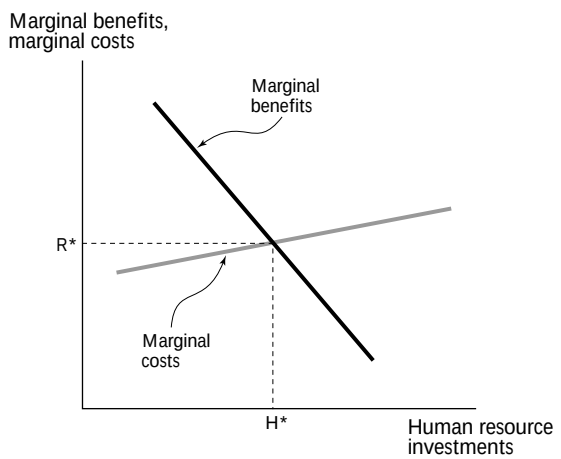

FIG. 1A. Private marginal benefits and private marginal costs of human resource investments including those in child development

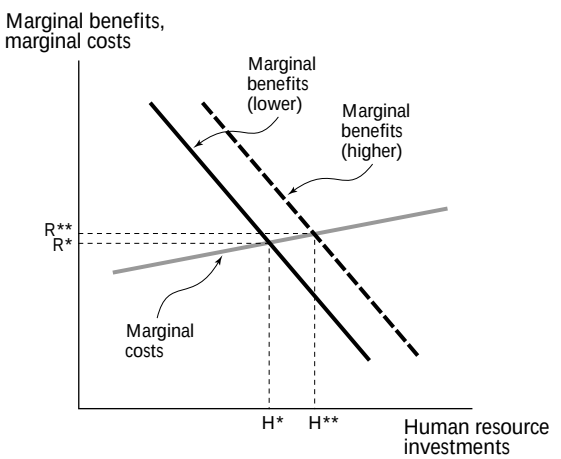

FIG. 1B. Private marginal benefits and private marginal costs of human resource investments, with higher(solid) and lower (dashed) marginal benefits

and therefore the expected returns greater; (5) has greater marginal private benefits to a given level of such investments because of schooling or labour market discrimination that favours that individual due to gender, race, language, family, village, or ethnic group; (6) has returns to human resources investments that are obtained more by the investor or the relevant decision maker (e.g., if traditional gender roles dictate that children of one sex, but not the other, provide old-age support for their parents, parental incentives may be greater to invest in children who are likely to provide such support[6]); (7) has greater marginal private benefits to a given level of investment because of being in a more dynamic economy in which the returns to such investments are greater; (8) has greater marginal private benefits to a given level of such investments because of greater externalities from the human capital investments of others in the same economy; or (9) lives in a more stable economy so that the discount rate for future returns is lower (because risk is less) and thus the marginal private benefit of future returns greater.

If the marginal private cost is lower for every level of human capital investment as for the dashed line in figure 1C, all else equal, the equilibrium human capital investment (H^{***}) is greater, with the marginal private benefit (R^{***}) lower at the higher investment level. The marginal private cost might be lower for numerous reasons. Compare two otherwise identical individuals except that one individual: (1) has lower private cost access to childhood development programmes related to such investments because of closer proximity to such services or lesser user charges; (2) has less opportunity costs for time used for such investments (e.g., such costs may have as an important component the costs of mothers' time in participatory programmes, and such costs may vary among women due to variance in their labour market wages); or (3) is from a household with greater access to credit (or less need for credit) for financing such investments because of greater wealth or status or better connections.

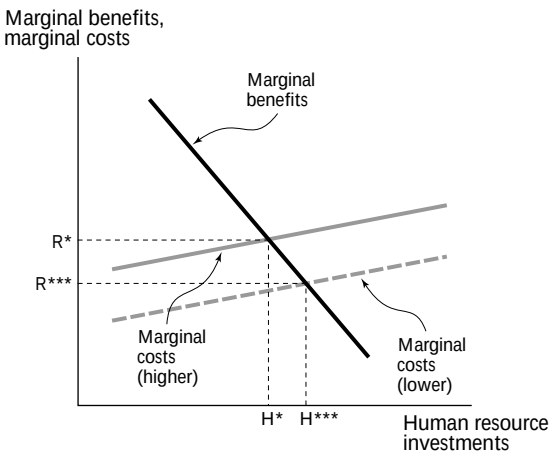

FIG. 1C. Private marginal benefits and private marginal costs of human resource investments, with higher(solid) and lower (dashed) marginal costs

This maximization process leads to demands for childhood development and other human capital investments in individual *i* that depend on all relevant prices P and on all relevant resources *R* and on all the parameters of the relevant production functions (including those for the production of human resources) and on preferences:

Relation (3):

$$H_i = H(P, R \mid \text{production parameter, preference parameters})$$

The prices include all prices that enter into the investing household's decision making process, including the prices paid by the households for childhood development programmes, basic education, and other consumption and investment purposes and for transferring resources over time (i.e., the interest rate) and for insuring against uncertainty. At the time that any human resource investment decision is made, these prices include all past and current prices for these goods and services (perhaps embodied in current stocks of human capital), as well as expected future prices (including expected future returns to human capital investments). The resources include all resources of the individual, household, educational institutions, and community that affect household decisions. These resources include human resources that reflect past investments, financial resources, physical resources, genetic endowments, and general learning environments.

This simple framework systematizes five critical, common sense, points for investigating dimensions of the determinants and the effects of childhood development investments and other human capital investments.

First, the marginal benefits and marginal costs of human capital investments in a particular individual differ depending upon the point of view from which they are evaluated: (i) There may be externalities (i.e., effects on others that are not transferred through markets, such as the knowledge externalities mentioned below) or capital/insurance market imperfections so that the social returns differ from the private returns; and (ii) There may be a difference between who makes the investment decision (e.g., parents) and in whom the investment is made (e.g., children) which may result in gender (or birth-order) differentials in incentives for investments in children given traditional gender (birth-order) roles in old-age care for parents. To evaluate the determinants of human capital investments and their impact it is essential to be clear about from whose perspective the investment decision is being made.

Second, human capital investments are determined by a number of individual, family, community, and (actual or potential) employer characteristics, only a subset of which are observed in social science data sets that are available to analyse childhood development determinants and effects. To identify the impact of the observed characteristics on human capital investments, it is important to control for the correlated unobserved characteristics. For example, households with greater income also may live in areas in which expected rates of returns from human capital investments tend to be greater and learning environments are better. If so and if only household incomes and not expected rates of return nor learning environments are observed in the data, the impact of household income on such investments is likely to be overestimated with usual procedures.

Third, to identify the impact of human capital investments including those directed towards childhood development, it also is important to control for individual, family, and community characteristics that determine the human capital investments and also have direct effects on outcomes of interest. Otherwise the estimated effect includes not only the impact of the human capital investments, but also the effects of individual, family, and community characteristics that directly affect the outcomes of interest and are correlated with the human capital investment because they partly determine those investments. For example, if innate ability affects both investments in childhood development and then schooling and then wages directly due to the impact of ability on production in relation (1) (in addition to any indirect effect through the impact of childhood development on education in relation 2) and if there is not control for innate ability in estimates of the impact of childhood development (whether direct or indirect through education) on wages, the estimated effects are likely to be biassed because the representation of childhood development in relations (1) and (2) (perhaps through education in the former) is partly proxying for innate ability in these estimates.

Fourth, empirically estimated determinants of, and effects of, childhood development investments, basic education, and other human capital investments are for a given macro economic, market, policy, and regulatory environment. The actual returns may change substantially with changes in that environment, such as those associated with changing from administrated to market prices, lessening governmental demands for trained workers, improving markets, opening up an economy more to international markets, establishing greater macro balance, eliminating regulations on migration, or lessening discrimination in labour markets. In a rapidly changing work environment, this means that evaluation of childhood development programmes and other policies from historical data is difficult unless the stable parameters in underlying structural relations determining behaviour (e.g., production functions, preferences) can be obtained in such analysis. Reduced-form relations such as the demand functions in (3) that combine production and preference parameter responses to current and expected future market and other changes are less likely to be stable given such changes, which has implications for evaluation of childhood development-related policies.

Fifth, the impacts of changes in policies may be hard to predict by policy makers and outside analysts. If households face a policy change, they can adjust all of their behaviours in response, with cross-effects on other outcomes, not only on the outcome to which the policy is directed. Provision of food for small children, for example, effectively is an income subsidy to the household, which the household can divert in part at least to whatever use it wishes by cutting back on food provided to the children at home.

Estimation of the demand for childhood development and other human capital investments in relation (3) that is sensitive to these considerations can be informative for addressing a number of relevant questions. For example, how responsive are household childhood development decisions to the prices of resources or programmes for childhood development? How important are incomplete markets, particularly for capital and insurance, in childhood development decisions? Do limitations in such markets mean that children from poorer backgrounds face relatively severe constraints on childhood development because their families have very limited resources for self-financing childhood development investments and cannot readily finance them through capital markets? What role do information imperfections play in the household childhood development decisions? Are potential household/individual investors in childhood development well-informed about the potential returns to childhood development?

With good information on all of the determinants of childhood development that are embodied in relation (3), good analysts could estimate such relations and illuminate important aspects of childhood development. But the problems in estimating such relations are parallel to those in estimating the production functions in relations (1) and (2). Indeed, they probably are more severe, because the essence of childhood development is investment with future returns rather than current production decisions, with the household making the investment decision frequently not knowing with certainty who employers of the child will be long in the future, but only having partial information about the distribution of certain characteristics of potential employers. Likewise, such decisions are made without certain knowledge about the characteristics of other relevant future markets, but only some prior beliefs about prices and options in those markets.

Estimation issues in ascertaining the determinants of and the impact of investments in childhood development

Estimation of the determinants of childhood development by family behaviours and of the impact of childhood development is central to the concerns of this workshop. This section considers first different types of relations that might be informative based on the analytical framework above, then some estimation problems, and finally some possible resolutions of these problems. This material is important for analysts who may be involved in undertaking such investigations. It also is of major importance for those who attempted to interpret what we do and do not know about the determinants of and the impact of childhood development from existing studies. Only by having some sensitivity to these estimation problems can good judgements be made to assess empirical studies regarding what we know and where there are gaps in our knowledge.

Before turning to this discussion it is useful to emphasize that any empirical interpretations depend (although too often implicitly rather than explicitly) on some underlying model. It is important to recognize that what we think we know about causality from empirical studies depends, whether we acknowledge it or not, on assumptions regarding the relevant behaviour—particularly if, as usually is the case, behavioural data are used. It is not possible just to look at the data and see what they say about causal effects that determine childhood development, the impact of childhood development or other behaviours of interest, although it is possible to show correlations. Therefore, to clarify what we really know about causality, it is desirable to be as explicit as possible about the assumptions regarding the underlying models of behaviour.

Estimated relations related to childhood development

Implied by analytical frameworks

Family behaviours, including human capital investments in childhood development, are modeled as determined by the investors (families) maximizing their respective objective functions given relevant market prices, resource constraints, production functions, and objective (welfare) functions. These decisions are made sequentially over time—on the basis of stocks (including human resource stocks) reflecting past prices and constraints and expectations concerning the distributions of currently unknown future prices, policies, and production shocks. The constrained maximization of the objective function leads to demand functions in terms of predetermined assets and prices broadly defined, technologies and preferences, and the distributions of critical variables such as prices, policies and production shocks the actual values of which will be revealed only in the future. Resources broadly defined include income-generating physical, financial and human assets, some of which may reflect past investments and some of which (e.g., genetic endowments) are generally considered to be independent of current behaviour. Prices broadly defined include time as well as money costs for privately provided goods and services and for publicly provided goods and services. The implied relations for investigating the *determinants* of family behaviours related to childhood development are (i) to estimate directly the underlying structural relations that determine childhood development (e.g., childhood development production functions analogous to relation 2 with childhood development as the outcome and the production inputs into childhood development as inputs) and (ii) to estimate demand relations for childhood development or for inputs used to produce childhood development (e.g., expressions that are analogous to relation 3).

Childhood development and other human capital investments that themselves are determined by family and perhaps social programme behaviours are posited to have positive impact on outcomes such as education or labour market productivity. The *impact* of these human resources can be evaluated by (i) estimating directly the underlying production functions in which childhood development is an input directly or indirectly (e.g., relations 1 and 2) and (ii) estimating net profit and output "demand" relations (relation 3), perhaps conditional on childhood development and on other production stocks at the start of the period of interest as well as on what is known about the distributions of variables the actual values of which will be revealed in the future.

This section briefly considers these alternatives as well as two related approaches to which appeal often is made in the empirical literature on the returns to human capital investments—Mincer-type earnings functions and hedonic price indices. For all of these approaches, the considerations regarding what determines human capital investments are critical not only for estimating the determinants of related household and firm behaviours but also for attempts to estimate what are productivity effects of childhood development and of other human capital investments that are the result of earlier family and social sector programme behaviours.

Structural relations—production functions

Structural relations are the basic underlying relations in the models of family and firm behaviours discussed above. The most commonly estimated structural relations are production functions. A linear approximation to a general production function can be represented with firm output (Q_f) produced by two categories of variables relating to the ith worker in the fth firm (XI) and to the fth firm (XF) and by an explicit stochastic disturbance term (U_f):[7]

Relation (1A):

$$Q_f = a_{XI}XI + a_{XF}XF + U_f$$

where the *a*'s are parameters to be estimated that indicate the respective effects on Q_f of changing the respective inputs. The stochastic term captures random effects that are not correlated with any of the other predetermined right-side variables. Sources of these stochastic terms might be weather fluctuations or chance snafus in production processes or other production shocks. Although this production function is written for firms, there also are production functions that are analogous in form, which pose the same estimation problems, for the "learning" or "education" produced in part by childhood development in relation (2) with "firm" replaced by social sector services.

Generally each of the types of variables may represent a whole set of variables. It is useful for the discussion below of estimation issues to distinguish among four different subgroups of variables each for *XI* and *XF*. The superscripts "o" and "u" refer to "observed in the data used" and "unobserved in the data used," the superscript "b" refers to variables that are behaviourally determined within the model used, and the superscript "p" refers to variables that are predetermined within the model used. With these distinctions, the variable list in the general production function relation is XI^{ob}, XI^{ub}, XI^{op}, XI^{up}, XF^{ob}, XF^{ub}, XF^{op}, XF^{up}, U_f. If these were substituted into (1A), each would have its own coefficient "*a*" to indicate its impact on Q_f. The distinctions among these different variables are important because some of the most important and most pervasive estimation problems arise from unobserved variables or behaviourally determined variables, as discussed below.

Table 1 gives some examples of how variables might fall into these different categories in common data sets for firm production functions, for education (affected by childhood development) production functions, and for wage production functions. Of course exactly into which categories various variables fall in a particular case depends on both the underlying model of behaviour (which determines what is behaviourally determined and what is predetermined within the model[8]) and on the data in the particular data set used (which determines what is observed and what is unobserved). Further, as discussed below, there may be an important distinction for estimation purposes regarding what variables are posited as predetermined in the model and what variables are independent of the stochastic disturbance term in the relation being estimated.

The parameters (*a*'s) in the production function give the direct impact of the right-side variables—some of which may directly reflect policies—on Q_f. With good estimates of the appropriate production functions, the direct determinants of many outcomes determined by household behaviours and the direct impacts of many human capital investments could be evaluated with considerable confidence. Such estimates can help to answer many of the questions raised above. Good production function estimates may be difficult to obtain, however, because of the estimation problems discussed below.

Reduced-form "demand" relations

A second set of relations that can be estimated to explore the determinants of and the impact of family and firm behaviours and of policies related to childhood development consists of "demand" relations. These relations give some behavioural outcome as dependent on all predetermined (from the point of view of the entity—family, or whatever—making the decisions) prices and resources and on the parameters in the underlying production functions and preferences. The outcome may be the demand for some good or service (e.g., the family demand for child development or firm demand for trained workers or for profits), or may be the supply of some good or service (e.g., the supply of firm output). These are the relations that most commonly are estimated in the literature. These demand functions in principle are derived explicitly from the constrained maximization behaviour of families (and of firms) that are discussed above. As such they incorporate all of the underlying structural (e.g., production function) parameters that are involved in that process. But all of the choice variables during the period of interest are substituted out, so the demand functions are not underlying structural relations such as production functions, but so-called reduced-form relations because the maximizing behaviour that determines such variables has been combined and "reduced" to the relations that give the behavioural outcomes as a function of purely predetermined and expected prices and resources. In some empirical studies the underlying structural parameters can be identified from estimation of the demand relations. In most cases, however, demand functions are just posited to result from constrained maximization and the underlying structural parameters are not identified in the estimates, though the demand parameters still are some combinations of these parameters. In such cases demand functions permit the estimation of the total effects of predetermined variables on the behavioural variables of concern, but not estimation of the exact mechanisms through which preferences and technical production functions affect the behavioural outcomes. This means that demand function parameters are less likely to be stable if there are changes in markets or policies or expectations than are production function parameters.

On a general level demand functions can be written with a vector of behavioural outcomes (Z) dependent on a vector of prices broadly defined (P) and a vector of resources (R)—with the relevant prices and resources depending on what entity is the demand function. If

TABLE 1. Illustrative examples of different categories of input variables for different production functions in common models and common household surveys[a]

Categories of variables[b]			Production functions for		
Aggregation	o/u	b/p	Firm production	Education	Wage rates
Individual	o	b	Schooling attainment, training, health, work experience	Schooling attainment, childhood development, health and/or nutrition status	Schooling attainment, work experience, health and/or nutrition status, occupation
	u	b	Nutrients consumed, intensity of effort, on-the-job learning	Time studying, intensity of effort	Intensity of effort, on-the-job learning
	o	p	Age, sex	Age, sex	Age, sex
	u	p	Genetic ability and health endowments, motivation	Genetic ability and health endowments, motivation	Genetic ability and health endowments, motivation
Household	o	b		Learning materials	
	u	b		Time other household members help with learning	Time spent by spouse or others that increases productivity
	o	p		Schooling attainment of parents and siblings	Schooling attainment of spouse
	u	p	Household work attitudes and abilities	General household learning environment	
Community	o	b			
	u	b			
	o	p	Weather	Schooling of others in community	Schooling of others in community
	u	p	General work environment	Quality of schools and childhood development programmes, general intellectual environment	General knowledge environment
Firm	o	b	Schooling, formal training, work experience of other workers, products, material inputs		Schooling, formal training, work experience of other workers, products, material inputs
	u	b	Abilities and motivations of other workers, compliance with legal regulations		Abilities and motivations of other workers, compliance with legal regulations
	o	p	Machinery and equipment and other capital inputs		Machinery and equipment and other capital inputs
	u	p	Management capabilities, quality of capital and intermediate inputs		Management capabilities, quality of capital and intermediate inputs

a. The categorization of variables depends both on the model posited (concerning behavioural versus predetermined variables) and on the data available (concerning observed versus unobserved variables). Therefore it changes for different models and for different data sets. But the examples given in this study are illustrative of fairly widespread practices.

b. "b" refers to behavioural variables, "p" refers to predetermined variables within the model, "o" refers to observed variables in the data, and "u" refers to unobserved variables in the data.

there are uncertainties regarding relevant future prices, policies, and shocks, then the characteristics known at the time of the decision of interest regarding the distributions of those outcomes should be included instead of their realized values. A linear approximation to the demand function for a family (or firm) facing prices *PF* and with resources *RF* and a vector of stochastic terms (V_f) is:

Relation (3A):

$$Z_f = b_{PF}PF + b_{RF}RF + V_f$$

where the *b*'s are the parameters to be estimated and indicate the impact of the variables for which they are coefficients on the demands for Z_f. The stochastic term in each relation includes all the effects of all the stochastic terms in all of the production activities in which the family is engaged (i.e., all of the elements of the vector U_f), plus perhaps other chance events. Both prices and resources may be observed or unobserved in the data, so it is useful to indicate that distinction here as above in the discussion of production function inputs (again, using superscripts "o" and "u"). There is one such demand relation (or one element in the vector Z_f) for every behavioural outcome of the family (and similarly for firms), including all human resource investments and all behavioural inputs that affect human resource investments through production relations such as (1A). Each of these demand relations conceptually includes all the same identical right-side predetermined variables, reflecting that there may be important cross-effects (e.g., the nature of food markets may affect housing demand). That means that any predetermined variable that affects any one behavioural outcome may affect any or all other behavioural outcomes. Estimation of such demand relations could help answer some of the questions raised earlier, such as how the price of a certain type of childhood development input affects the whole set of behavioural decisions.

Conditional demand functions

Conditional demand functions, as contrasted with the unconditional ones in relation (3A), include among the right-side variables some variable(s) that are determined by the behavioural model for the decision-making unit—the family or firm—under examination. If the included behavioural variable(s) on the right side is determined at least in part by past behaviour, its effect may be estimated in such relations.[9] This might appear to be a conditional demand function with which the impact of current childhood nutrient intakes on current childhood development could be explored. But the coefficient of current child nutrient intakes is merely the ratio of the effect of the price that has been eliminated in relation (3A-1) relative to the effect of that price in relation (3A-2) (i.e., $b_{31} = b_{11}/b_{21}$). Thus the coefficient of current child nutrient intake in relation (3A-3) does *not* reveal anything interesting about the effect of current child nutrient intakes on current childhood development, but only of the relative price effects (for PF_1) in the two demand relations. For example, the current period firm net profit function might be posited to depend on the start-of-the-period stocks of workers with different levels of education and health, both of which reflect in part early childhood development, which depend on all past behavioural decisions related to childhood development and hiring/separating workers. In such a case, the start-of-the-period stocks of workers with different human resources are just other right-side variables that are predetermined with respect to current prices and (other) resources in the demand relation in (3A). That relation also includes *all* of the current prices. An unbiased estimate of the coefficients of the stocks of workers with different childhood development gives the impact of the start-of-the-period stocks of trained workers on the current-period net profits. That the start-of-the-period stocks of trained workers were determined by past behaviour poses some estimation problems discussed below, but the interpretation of unbiased coefficients of these variables as reflecting their impact on current net profits is clear.

Mincer-type earnings functions

The most common framework for estimating the private rate of return to time spent in school—which again may be affected by prior child development—in terms of labour market outcomes is due to Mincer [5]. In the simplest case, once one finishes school and starts to work, earnings depend only on years of schooling. Let Y_0 be wages with no schooling and Y_S be wages with *S* years of schooling, but with the earnings stream starting *S* years later due to the time spent in school. In equilibrium, the present discounted values of the earnings from the two options are equated, which implies a semilog earning or wage function:

Relation (4):

$$\ln Y_S = \ln Y_0 + r\,S$$

where *r* is the private rate of return to time spent in school. To estimate this relation (or more extended versions of it) a stochastic term (*e*) is added (usually without comment). One possible justification for such a stochastic term would be random measurement error in the dependent variable. Another would be that some individuals have better "market luck" than others, independent of their schooling.

There are numerous estimates of such expressions that purport to measure the private rate of return to time spent in schooling. How do these expressions relate to the production function for wages for the general form of relation (1A) that is summarized in table 1? Implicitly they assume that the impacts of schooling (and, through schooling, of childhood development) are independent of all other inputs (e.g., ability, motivation, other inputs, technology). Thus strong assumptions are

placed on the production technology, such that ability, motivation, and family connections have impact on wages only through their effects on schooling (or childhood development).[10,11]

An alternative interpretation of relation (4) is as a "hedonic" (so the market values depend on the individual's characteristics) wage function. In this case the coefficients are the market valuations of attributes such as schooling, again under the (usually implicit) assumption that there are no effects of variables—such as ability, motivation, and family connections—that are not controlled in the estimation but that may have an effect on both human capital investments and wages.

Estimation problems in attempting to ascertain the determinants and impact of childhood development

There are a number of possible problems in obtaining good estimates of the determinants of, and the impact of, childhood development. Therefore, what are presented as estimates of relations such as those that are discussed above may be biased—i.e., the true determinants of childhood development and the true impact of childhood development are *not* revealed because of estimation problems. These estimation problems all share a common characteristic: the disturbance term in the relation actually estimated is *not* simply an element in U_f or V_f or e that is distributed independently of all the right-side variables in the relation being estimated, but instead is correlated with right-side variables (e.g., because it is a compound disturbance term that includes unobserved variables as well as U_f or V_f or e or because of the way that U_f, V_f, and e are defined for the sample used in the estimates).

Measurement error

Measurement error may contaminate any of the observed variables used for estimates of the relations that are discussed above. Random measurement error occurs if what is observed (C^*) is not the true childhood development variable (C), but the true variable plus a random error (w):[12]

Relation (5):

$$C^* = C + w$$

Whether random measurement error affects the estimates depends on whether the variable measured with error is the dependent or a right-side variable.

Random measurement error in the dependent variable merely adds to the stochastic disturbance term, but does not bias the coefficient estimate of the right-side variable. Therefore random measurement in childhood development does not cause biases in the estimates of the determinants of childhood development.

Random measurement error in a right-side variable causes bias in the coefficient estimates of interest. Consider, for example, the case in which childhood development C is a right-side variable that is posited to affect education (S). The true relation is:

$$S = bC + v \quad \text{(1B)}$$

and the relation estimated is:

$$S = bC^* + v + bw \quad \text{(1C)}$$

Intuitively, because the observed childhood development is a noisy measure of true childhood development, the true dependence of childhood development on education is masked, and the result is an underestimate of the childhood development effect. Formally, the estimate of the childhood development impact is:[13]

Relation (1D):

$$\hat{b} = bF_C^2/(F_C^2+F_v^2)$$

Because $F_C^2/(F_C^2+F_v^2)$ is less than one, the estimate is biased towards zero. The bias is greater the larger the variance in the measurement error relative to the variance in the true value.

Omitted variables

In both production function estimates and demand function estimates, there may be variables that should be included among the right-side variables but that are not observed and therefore not included.[14]

For the production function estimates, for example, there may be unobserved inputs such as inherent ability, motivation, and management capabilities. In terms of relation (1A) with the subcategories of variables, the basic estimation problem is that the observed right-side variables (XI^{ob}, XI^{op}, XF^{ob}, XF^{op}) may be correlated with the unobserved variables (XI^{ub}, XI^{up}, XF^{ub}, XF^{up}) that are included in the compound disturbance term with U_f.[15] Therefore the estimates of the impact of the observed variables include not only their true effects but also part of the effects of any correlated unobserved variables. As a result, Ordinary Least Squares estimates of their effects are likely to be biased, with the bias either up or down depending on the exact model and magnitudes.

For the demand relations (3A), the compound disturbance term includes, in addition to V_f, the other unobserved variables (PF^u, RF^u). If any of the observed variables on the right side of relation (3A) are correlated with any of the unobserved variables, their coefficient estimates are biased, because, in addition to their own effects, they represent in part the effect(s) of the correlated unobserved variable(s). Further, in conditional demand functions in which some variable such as the start-of-the-period health stock discussed above is included among the right-side variables, such predetermined behavioural variables may be correlated with any of the right-side unobserved variables, because such variables entered into the determination of these predetermined behavioural variables in earlier periods. For example, in conditional net profit functions, the start-

of-the period stocks of trained workers may be correlated with unobserved workers' abilities and motivations. Often such possible biases are ignored.

The sign and magnitude of omitted variable bias depends on the effect of the omitted variable(s) and on its correlation with included variables. Consider the case of a simple wage production relation in which childhood development (C_i) and ability (A_i) together with a stochastic term (v_i) determine wages for individual i (Y_i) (with any intervening variable such as education substituted out for this example):

$$(1E)\ Y_i = aC_i + bA_i + v_i$$

If ability is not observed, the compound disturbance term is $bA_i + v$ and the estimate for the coefficient of childhood development is:

Relation (1F):

$$\hat{a} = a + br_{C,A}$$

where $r_{C,A}$ is the coefficient in the regression of ability on childhood development. The sign and magnitude of the omitted variable bias is given by the last term. It depends on the sign and magnitude of the true impact of the omitted variable (b) and on its regression coefficient ($r_{C,A}$). If ability has direct positive effects on wages and on childhood development, in the present case the bias is upwards.[16]

Simultaneity

Simultaneity bias occurs when a variable that is determined in the current period within the model appears as a right-side variable in some other relation. Among the relations discussed above, production functions are the ones for which simultaneity might be a problem. For example, consider a production function for child development parallel to relation (1A) in which one of the inputs is current nutrition inputs consumed by the child. Assume further that there are no problems with measurement errors and no problems with unobserved inputs. In general, nutrients consumed in the current period (and any other right-side variable that is behaviourally determined within the period) are correlated with the disturbance term in this relation. This is the case because for nutrients consumed in the current period (and for all other variables determined within the period) there is a demand function of the form of relation (3A). Included on the right side of that relation is a stochastic term (V_f) that includes the stochastic terms from all of the production function relations in the model—including that for production of child development. This results in a correlation between nutrients consumed in the current period and the stochastic term in the production function for child development that causes biases in the estimated impact of such nutrients on child development. The sign and the magnitude of the bias depend upon the exact structure of the model.

Selectivity

Selectivity bias may result if observations are available only for a selected subset of the sample. Such selectivity may occur for any of the relations that are discussed above. For instance, suppose that tests of cognitive development are administered to children in childhood development programmes, but not all children of the eligible age range are enrolled in such programmes. If it were desirable to know the impact of childhood development program quality on cognitive development, a function of the general form of relation (3A) could be estimated. But this relation can be estimated only for those children enrolled in a programme, because there are test scores only for those children.

Figure 2 provides a simple illustration of selectivity bias. Consider a group of children who are the same age and sex but who have been exposed to childhood development programmes of different qualities (including no exposure for those not enrolled in childhood development programmes). If there were observations on cognitive test scores and childhood development programme quality for everyone in the sample, the true relation in relation (3A) could be estimated. The solid line in this figure represents this true relation between cognitive test scores and childhood development programme quality, with a slope of g. Of course the observations for most individuals do not fall exactly on this line. For a given childhood development programme quality (e.g., C_1), some observations are above the line (e.g., point A), some are below (e.g., point B), and some may be on the line (e.g., point C). But the true line best summarizes the cloud of points of cognitive achievement test scores-childhood development programme quality combinations for all the children in the whole sample.

However, cognitive achievement test scores are not

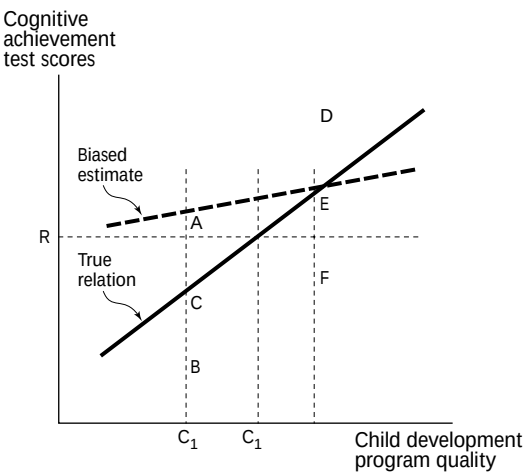

FIG. 2. Selectivity bias in estimated relation of cognitive achievement test score to child development program quality

observed for everyone in the sample. In fact such test scores are only observed for children for whom their parents expected the gains from enrolment in childhood development programmes to be sufficiently large to offset the costs. For simplicity, assume that this means that only children whose test scores would have been, were they enrolled, equal to or greater than the horizontal dotted line at R on the vertical axis in figure 2 are in fact enrolled. Therefore the estimate of the programme impact is based only on the test-childhood development programme subsample above this horizontal line. The problem is that this subsample is not randomly selected. For childhood development programme quality levels below the level at which the true relation crosses R (i.e., C_2 in the figure), only children who have sufficiently positive disturbances to get them to R or above are selected into the subsample (e.g., for C_1, the child at point A, but not the ones at points C and B). For childhood development programme quality levels above the level at which the true relation crosses R, only children who have sufficiently negative disturbances to get them below R are selected out of the subsample (e.g., for C_3, the child at point F is selected out of the subsample, but those at points E and D are selected into the subsample). Thus the subsample selection procedure, with its systematic relation between the disturbance term in the true relation and childhood development programme quality, creates a correlation between the disturbance term and childhood development programme quality for the subsample for which estimates of the desired relation can be made. As a result, if this relation is estimated using only this subsample, something like the dashed slope line is obtained, with a biased estimate of the true relation between cognitive achievement test scores and childhood development programme qualities.

Possible resolutions for estimation problems

More and better data

If more and better data could be obtained at no or little cost, more and better data clearly would be desirable. If information could be collected on more variables that are unobserved in current data sets being used for analysis, the problem of omitted variable bias due to unobserved variables could be lessened.[17] Unfortunately, information on some such variables—e.g., genetic endowments—is likely to be very difficult to obtain. Nevertheless some researchers have made efforts (not without controversy) to obtain such data (e.g., the use of Raven's test to represent innate abilities in Kenya and Tanzania [14]).

Measurement error bias could be lessened with better data in the sense of more accurate variables. For example, instead of using parent-reported time in formal childhood development programmes, one could obtain the actual time recorded in the records of the childhood development programme(s) attended. For events for which timing in the past is important, one can help fix the timing through reference to significant events in the individual's life (e.g., major disasters, major rites of passage, major political events). Measurement error bias also could be eliminated with alternative reports on the same variables that could be used as instruments (see below) if the measurement errors in those reports (even if large) are not correlated with the measurement errors in the original variable. To illustrate, schooling reports from adult siblings or from adult children have been used for this purpose, as in some recent studies [7, 9].

But more and better data do not come free or, usually, at little cost (either in terms of money or time or the co-operation of respondents). So decisions always have to be made about the trade-offs, which vary depending on the analyses that data will be used for.

Experiments

A major problem in evaluating policy and other determinants of household and firm behaviours, and in evaluating the impact of childhood development and other human resources on various outcomes, is that the right-side variable, the impact of which is of interest, is not independent of the compound disturbance term (including any unobserved variables) in the relation being estimated. A possible resolution of this problem, at least in some circumstances, is to conduct experiments with random assignment of the "treatment" and a comparison group for control.

For example, in order to evaluate the impact of a new childhood development programme on later schooling success, in principle, participation in such childhood development programmes could be given to a random subset of children of eligible age, with before-and-after comparisons made of changes in the school experiences of those randomly selected for the childhood development programme (and for those not selected). With such an experiment one could obtain an estimate of the *household demand* response to the new childhood development programme. Note that what is obtained is *not* the production function response in relation (1). This is the case because, from the point of view of the household, the new childhood development programme is an added household in-kind resource that can be distributed (at least in part) to whatever use the household wishes (e.g., by reducing other childhood development investments that might have been undertaken in the absence of the programme). For this reason it would be desirable to tie such experiments to household surveys so that the possible effects on other outcomes could be measured.

Well-conducted experiments, thus, would provide additional useful information for evaluation of many policy options, including some related to childhood development. Linking such experiments to household

survey data might usefully permit exploration of "spillover" effects and possible selective attrition. But it is difficult in many contexts to conduct such experiments—though families interested in childhood development might be randomly selected into experimental and control groups, those who are not interested cannot be so selected, so the population for which an experimental sample is useful is a selected sample. It also is difficult to assure that the experimental "treatment" in fact is received by all of the experimental group and not (nor some close substitute) by the "control" group. Moreover, "experimental effects" may cause distortions, and it is difficult to devise experiments relating to childhood development in which there is a placebo that can be administered that appears to participants and to administrators to be identical to the experimental treatment of interest. Further, questions of fairness or of ethics may preclude a number of experiments.[18] Finally, conducting experiments usually is relatively costly and often difficult to arrange because of pressures on those administering the experimental treatment to include others than just those in the experimental group.[19]

Fixed effects

In fixed effects estimates, dummy variables are included for the unobserved fixed effects at the aggregation level of interest (i.e., individual, family, firm, community). Therefore the correlations between these unobserved variables in the compound disturbance term and the observed variables are eliminated, so this possible source of omitted variable bias is eliminated. To use fixed effects, multiple observations are required that have the same fixed effect in the same relation being estimated (i.e., observations on various children in each of a number of families at a point of time or on the same children in different childhood development programmes over time for family fixed effects).[20] These dummy variables control for all the factors that are common and fixed for the level of aggregation for which they are used. Family fixed effects, for example, control for all the observed and unobserved fixed family characteristics that enter into production functions in relation (1) or demand functions in relation (2)—for instance, for fixed but unobserved parental preferences for child quality and parental child-rearing capabilities. Therefore their use eliminates omitted variable bias at the level(s) of aggregation for which they are used.

Limitations of fixed effects estimates include: (1) they can only control for predetermined fixed unobserved variables and not predetermined time-varying unobserved variables; (2) they do not permit estimates of the impact of observed fixed variables for the same aggregation level as are the fixed effects (i.e., with individual fixed effects based on data over time one cannot obtain estimates of the impact of observed individual variables that are fixed over time as, for example is usually the case for adult schooling); and (3) they exacerbate random measurement problems because the estimates for the effect of variables that vary within the group of observations for which there are fixed effects are based on deviations from the means for that group, so random noise is relatively much more important than in level estimates without fixed effects.

Instrumental variables

In instrumental variable estimates, the intent is to replace observed right-side variables that are correlated with the compound disturbance term with their estimated values, based on a set of instruments, that are not correlated with the compound disturbance term. This procedure can thus eliminate correlations between observed right-side variables and the compound disturbance term that arise because of unobserved variables, because of simultaneity in production function estimates, and because of unobserved variables in demand function estimates. The right-side variables that are instrumented generally include behavioural variables within the model in production functions but may also include variables that are considered predetermined within the model in either production function or demand function estimates. If parental schooling levels are among the right-side variables in cognitive achievement production functions and unobserved parental or child (given genetic inheritance) innate abilities are in the compound disturbance term, for example, estimates of parental schooling effects are subject to an omitted variable bias problem just as are estimates of observed right-side variables that are behavioural in the model. That is, the relevant notion of predetermined for estimation purposes is independence from the compound disturbance term, not just what is assumed to be given *a priori* in the model.

Good identifying instruments have the following properties: (a) they do not appear in the relation being estimated; (b) there is at least one such observed instrument for every observed behavioural right-side variable in the relation being estimated;[21] (c) they are independent of the compound disturbance term (which includes all of the relevant unobserved variables) in the relation being estimated; and (d) they are sufficiently correlated with the observed right-side behavioural variables. If instruments are used that have these properties, the correlations between the observed right-side behavioural variables and the compound disturbance term are eliminated by using for the former their estimated values based on the instruments. Primary candidates for identifying instruments in a production function are the right-side variables in the demand relations for the right-side behavioural variables that do not appear in the relation being estimated—basically the predetermined prices and resources broadly defined [with the latter subject to condition (a)] in the demand relations (3) discussed above. For demand function es-

timates, any variables that are included in the demand functions do not satisfy condition (a). For conditional demand functions with variables predetermined from an earlier period, the natural instruments for these variables are the subset of their past determinants that are independent of the current right-side predetermined variables, such as past price shocks or other shocks.

In practice, finding such instruments is often difficult. In particular for production functions, if there are unobserved behavioural variables (XI^{ub}, XF^{ub}) in the compound disturbance term, these depend on the same predetermined variables in the demand relations as do the observed variables, so that set of predetermined variables does not satisfy condition (c). Therefore most instrumental variable estimates of production functions are unbiased conditional on the (often implicit) assumption that there are no unobserved behavioural inputs. But this generally is likely to be a strong assumption, as is suggested by table 1. This particular problem does not exist for demand relations. But for demand relations, as for production functions, the past data necessary to instrument variables that are determined prior to the period of estimation are not available in many data sets. For such reasons, instrumenting for variables determined within the model, and for measurement error and fixed effects for controlling for unobserved fixed variables are combined in a number of studies.

Selectivity control

The basic approach to controlling for selectivity is to incorporate the sample selection decision rule into the analysis. That is, for the case discussed above of estimating the relation between cognitive test scores and child development programme qualities, the approach is to incorporate the decision rule for whether or not a child is enrolled in a child development programme into the analysis. There are various ways of incorporating the sample selection decision rule into the analysis. Perhaps the most widely used method is Heckman's two-step method. In the first step, the selectivity rule is estimated, and in the second step, the relation of interest is estimated including among the right-side variables a statistic calculated from the first-stage residuals that corrects for the effect of sample selectivity on the original disturbance term (so that it no longer is correlated with the observed right-side variables).[22]

Framework for policy choices related to childhood development

Standard economic rationale for policies includes concerns about efficiency/productivity and about distribution, concerns that interact. This rationale holds for policies related to childhood development and other human resource investments, just as for policies related to other aspects of the economy. This rationale may be of interest for individuals working in childhood development not only to help them think about the nature of policy choices that they want to make, but to make them more effective advocates in debates with others, such as those in the Finance Ministry, about public resources devoted to childhood development.

Brief definitions of basic motives for policy changes

Economic efficiency

A situation is efficient if no one person could be made better off without making someone else worse off.[23] Or, to make the statement in reverse, if there is inefficiency, some people could be made better off with the same resources without making anyone worse off. Or, equivalently, everyone could be made better off with the same resources. It would seem from such statements that inefficiency, all else equal, is clearly not socially desirable.

Some critics claim that efficiency relates to small static gains, not the radical restructuring needed for the process of development. But even though many of the examples given and estimates made about efficiency are static in that they relate to gains/losses from reallocating production inputs and/or the composition of output at a point of time, there is nothing inherent about the notion of efficiency that limits its applicability to static considerations. Efficiency can be considered with regard to questions of production/consumption/factor use over time as well as at a point of time. Moreover, efficiency in a static sense is likely to be necessary, though not sufficient, for dynamic efficiency.

In the real world, furthermore, information problems are pervasive. These information problems make effective directive policies, including those to restructure radically economies and societies, very difficult to know, implement, and monitor. Given these information problems, in many contexts, the best policies from an efficiency perspective may be ones that assure that the private incentives for behaviour are the same as the social incentives for behaviour, which is just the condition for efficiency.

Inefficiency may arise from "market failures" such as externalities (i.e., effects of one unit that are external to that unit in ways that are not transferred through market prices), increasing returns to scale over the relevant output range (so that prices do not reflect the true marginal social costs), and public goods (in which case the marginal cost of providing marginal benefits is zero, so pricing at marginal costs cannot provide revenues to cover total costs). Inefficiency also may arise from "policy failures" such as restrictions on prices (including wages) so that they do not reflect marginal costs and restrictions on entry and exit so that sellers or buyers can affect the prices that they face (and therefore have incentives to set prices different from marginal costs).

Distribution

Distribution is a major policy motive distinct from efficiency. A very efficient economy might have a very undesirable distribution of command over resources. Society well might want to assure, for example, that everyone has basic education and employment skills even at some cost in terms of efficiency/productivity.

An important question is whether there are distributional reasons to subsidize programmes for children, including childhood development, health, and nutrition programmes, particularly in light of the questions about how choices should be made among policy options.

One argument in favour of such subsidies is that they are a means of getting resources to poorer families. For this to be a justifiable motive for such subsidies, they have to be targeted effectively towards children from poorer families, not towards all children. Most social sector programmes in fact do not succeed all that well in concentrating resource transfers to the poor, so this is not a trivial consideration. Secondly, there has to be a more effective way to transfer resources to poorer families than subsidizing other goods and services used by such families (e.g., basic staples) or simply transferring cash. Again, this is not a trivial concern. If the object is to increase the welfare of the poor as much as possible, for example, it would seem that the most efficient mechanism would be to transfer generalizable resources such as money or earning power to them, not particular goods or services in kind such as subsidized child development programmes.

A second argument in favour of such subsidies is that society has a distributional interest in avoiding extreme poverty for any generation, and the most effective way to lessen the probability of current children living in poverty from experiencing similar poverty when they become adults is to improve their human resources so that their command over resources will be greater when they are adults because of labour market returns to those human resources. An essential part of this strategy, moreover, is establishing the fundamentals of their human resource development through strong child development. As stated, this argument is for subsidizing human resource investments in those children who are at greatest risk of being in poverty as adults, not necessarily children who live in poor households and certainly not all children. But because perceptions are that intergenerational correlations of poverty are high, a major target group for this reason often is children in poor families.

A third argument sometimes made is that society as a whole has more interest in the next generation than do individual parents, so investments in children should be subsidized. Although this argument might have merit on distributional grounds, in most societies it is not a distributional argument in favour of poorer members of society. On the contrary, for most societies the long-run secular positive trend in economic growth means that on the average current children are likely to be better off in economic terms than their parents.

A fourth argument is that better child development will reduce the probabilities of subsequent subsidies for public services such as for health and welfare transfers given current pricing/subsidies for social sector policies. But arguably better child development will increase the probabilities of subsequent subsidies for other public services, such as for schooling, so it is not clear what is the net effect. Moreover, the more fundamental question pertains to pricing all the social sectors correctly in the sense discussed below.

A fifth argument is that children have basic rights that society must guarantee if they are not provided by their own families. This would argue for targeting publicly subsidized child development programmes, to the extent that they are justifiable, on these grounds towards children who otherwise would not have such rights fulfilled, not towards child development more generally.

Choosing among policies

There are a number of reasons why private decisions relating to childhood development and other human resource investments may not be efficient within a particular market and policy environment. Explicit examples are discussed below. There also are concerns about distribution—most commonly, the command over resources of the poorer members of society—that often have been among the motives for policies related to childhood development.

If all other markets in the economy are operating efficiently and there are differences between marginal private and social incentives in the human capital investment market for childhood development so that private incentives are to invest at levels other than the efficient levels, policies that changed the human capital investment to the socially efficient levels would increase efficiency.[24] However, that still does not indicate what policies would be best to induce human capital investments, including those in child development, at desirable levels. There are a large range of possibilities, including governmental fiats and regulations, governmental provision of childhood development services, price incentives in the market for human capital investments, price incentives in other markets, changing institutional arrangements in various markets, etc.

Three important considerations should guide choices among alternative policy changes.

First, policies have costs—not only the direct costs of implementation and monitoring, but also the distortionary costs introduced by policies that may encourage socially inefficient behaviour. These include the distortionary costs of raising revenues to finance fiscal expenditures that are necessary for policy formulation and implementation, which in some cases are

estimated to be considerable (e.g., [16]). In fact the costs may be sufficiently large that it is not desirable to attempt to offset some market failures by policies. But, if it is desirable to do so, there is a case generally for making policy changes that are directed as specifically as possible to the distortion of concern (or as high as possible in a policy hierarchy defined by increasing distortion costs) because that lessens the distortion costs introduced by the policy. The less well focused are policies, the more widespread and more substantial are likely to be the distortion costs of the policies themselves, in addition to any distortion costs from raising revenues to finance the policies.

Second, there are tremendous information problems regarding exactly what effects policies have, particularly in a rapidly changing world. This is an argument in favour of policies that are as transparent as possible, which probably generally means higher in the policy hierarchy with regard to distortion costs because more direct policies are likely to be more transparent. This also is an argument for considering an experimental approach to evaluating policy alternatives—that is, rather than introducing a reform countrywide, introduce variants of reforms for childhood development programmes, schools, and other social services selected randomly with carefully monitoring of the results (though there are limitations to the use of experimental approaches. The information problems are often an argument for price policies (taxes or subsidies), because if there are shifts in the underlying relations they are likely to be more visible in a more timely fashion if they have impact on governmental resources than if they only change the distortions faced by private entities, as tends to happen with quantitative policies. Furthermore, there is a strong argument for governments to subsidize the collection and provision of more information about childhood development markets more generally, because information is not likely to be provided optimally otherwise by private providers. Information has "public goods" characteristics in the technical sense of that term. The marginal cost of providing more information is very small and possibly declining, so private providers cannot cover their costs of provision except by restricting the quantities provided and charging a price above the low marginal social costs. The relevant information includes not only information about the functioning of human resource markets and possible market failures, but also serious evaluations of governmental policies that are related to childhood development and possible policy failures. Too often policy evaluation is an afterthought at best, with little attention before policy changes to establishing critical baseline data and little attention in the analysis to the incentives created by the policy changes for private behaviours and to the estimation problems that are discussed above.[25]

Third, as noted above, distribution is a concern separate from efficiency. Moreover, there well may be tradeoffs between policies that increase efficiency and distributional ends. If increasing childhood development for those for whom the rates of return in terms of productivity are highest is efficient, and if there are positive complementarities between childhood development and schooling, as is often claimed, then there is a tradeoff between increasing childhood development for persons for whom the productivity effects are greatest and increasing childhood development for the persons who are poorest.[26] Society might have the objective of assuring that everyone (or everyone but those who are disabled or too young or too old) have basic education. But presumably it is desirable to assure that everyone has basic education at as little cost in terms of productivity as possible. Therefore, rather than ignoring efficiency considerations in pursuit of distributional goals, it is desirable to choose policies as high as possible in the efficiency policy hierarchy and still assure that the basic education targets are met. Efficiency considerations play an important role in interaction with the pursuit of distributional goals.

Thus, for efficiency/productivity reasons, particularly given that information is imperfect and changes are frequent, there is an argument generally for choosing price policies as high as possible in the policy hierarchy defined by the extent of distortionary costs—and thereby using interventions that are as focused on the problem as possible in light of the distributional tradeoff and possibly other constraints on policy choices. Note further that this means that if there is a good efficiency/productivity reason for public support for childhood development or for other human capital investments, that does *not* mean that the best way to provide that support is through governmental provision of the related services. Higher in the policy hierarchy than direct governmental provision of such services, for example, are likely to be subsidies or taxes that work through individuals or firms to create incentives for the efficient provision of these services whether the actual providers are public, private, or some mixture. On the other hand, policies that discriminate against one type of provider—for example, by making the availability of such subsidies dependent on whether the provider is public—are generally likely to be lower in the policy hierarchy than policies that do not have such restrictions. Information problems are likely to be pervasive, finally, and may in themselves warrant policy changes.

Specific examples of possible inefficiencies in childhood development

Related markets, empirical evidence, and policy options

It is useful to consider some explicit respects in which childhood development-related markets might be inefficient in the absence of policy changes. Of course it

is impossible to give generalizations that apply to all or even to most countries. For serious policy recommendations, there must be careful consideration of the specific situations in a particular case, with sensitivity to the underlying behaviours and to the problems in interpreting those behaviours, given limitations on information. Nevertheless, there are some general arguments that have been put forth for policy changes related to childhood development that merit attention, even if definitive conclusions about their merits in particular contexts only can be reached with confidence by considering in detail those particular situations.

The private incentives for investments in childhood development and other human resources are largely those that are given by markets that individual units—households and firms—engage in (although there may also be some important incentives other than market incentives, such as those within units such as household or firms, that could lead to inefficiency[27]). Under standard assumptions regarding production technologies, if prices are "right" in the sense that they reflect the true social marginal benefits and costs and markets are complete, an entity (family, household, farm, household enterprise, factory, trading firm, or whatever) that is maximizing its own revenue net of costs chooses the efficient combination of inputs for each product, efficient quantities of all inputs, and efficient quantities of all outputs. Such production entities, under these assumptions, behave efficiently by following the marginal conditions discussed above, given that from their individual perspectives prices are fixed by markets. Likewise, if prices are right in the above sense and markets are complete, families that maximize their objective functions by satisfying the marginal condition that marginal welfare for the last rupee (peso or whatever) spent on all goods is the same, choose efficient consumption bundles. Inefficiencies thus usually are deemed to reflect "market failures" in the sense that market prices fail to incorporate all social marginal benefits and costs, or that markets are incomplete, or "policy failures" if the reasons that prices do not reflect social marginal benefits lie not in production technicalities but in policies.

Figure 1 can be reinterpreted to consider the question of whether investments in childhood development or in other forms of human capital are efficient. If the private incentives for such investments are the same as the social incentives, the solid curves in figure 1A represent both the marginal private and the marginal social incentives and H^* is the privately optimal and the socially optimal (efficient) level of human capital investment. In this case the private and the social rates of return to this investment are the same. Also in this case, even if this rate of return is quite high, there is no efficiency reason for public resources to be devoted to childhood development. Private behaviours result in just the right investments from a social perspective.

Now consider what happens if the private and social incentives differ for human capital investments, first with respect to the marginal benefits and then with respect to the marginal costs. Note that in each of these cases the social rates of return for this investment differ from the private rates of return, which suggests an efficiency argument for a policy change.

Let the dashed line in figure 1B represent the marginal social benefits for human capital investments that are drawn to be greater than the marginal private benefits.[28] In this case the private incentives are to invest in H^*, which is less than the socially optimal (efficient) level of human capital investment H^{**}. Therefore there is an efficiency argument to consider policies to induce or to require private investments of H^{**} instead of H^*.

Why might marginal social benefits exceed marginal private benefits for human capital investments? Among the most frequent answers to this question are some that primarily reflect market failures (e.g., examples 1–2, 4–5, and 9–11 below) and others that reflect policy failures (e.g., examples 3, 6–8 below):

1. Private investors in childhood development and other forms of human capital underestimate the true private and therefore social returns from such investments. Policies that would seem to be high in the efficiency policy hierarchy for this reason would be policies that subsidized provision of current information on patterns in expected returns to human resource investments: costs of different types of childhood development investments and schooling, enrolment rates, placement and schooling and job progression of graduates (e.g., tracer studies), education and childhood backgrounds of different types of workers (e.g., reverse tracer studies)—all related to different types of childhood background. As noted, because of the public goods characteristics of information, such information is not likely to be provided sufficiently by unsubsidized private entities. Less high in the hierarchy would be policies that subsidized childhood development per se. And relatively low in the hierarchy would be direct public provision of childhood development programmes. The beneficiaries of such policies might include the poor, but also are likely to be considerably those in the middle- and upper-income classes who have the basic education that permits them to exploit better information about childhood development options.
2. More investment in childhood development, in addition to the direct eventual impact on the individual's own benefits through facilitating subsequent education and learning capacities, may increase the productivity of others through technological, institutional, and market innovations that are not reflected in the individual's or firm's investment returns because information about such in-

novations is spread other than through markets. There are questions regarding the extent to which childhood development contributes to the development of such capacities. But if basic education is important for the adoption of new technologies, strong child development may be important. In important recent studies, for example, Foster and Rosenzweig [22, 23] provide empirical evidence that on-the-job experience interacted with basic education to generate external benefits in the initial spread of Green Revolution agricultural technologies in India. To my knowledge systematic empirical investigations of similar possibilities for basic education in other contexts are not available.[29] Although such an externality, if it exists, might rationalize public subsidies for childhood development investments, it would not seem that such subsidies (and much less direct governmental provision of childhood development) would be at the top of the policy hierarchy for dealing with this market failure. Higher in the policy hierarchy would seem to be subsidies directly for experimenting and attempting to adapt new innovations, because that is the direct process that generates externalities through learning. Probably policy changes that are highest in the efficiency policy hierarchy would have unequalizing effects on distribution, or at least not reach the poorer members of society, because early experimenters are likely to be among those better off, or at least not the poorest members of society.

3. Families with children with higher than average unobserved motivation and unobserved abilities, given their characteristics that will be observed by potential employers, are not able to self-finance such human capital investments, because they cannot borrow for such investments. There is considerable indirect evidence consistent with this possibility, in that the characteristics that usually are thought to be readily observed in labour markets—schooling, age, gender, past work experience—are consistent with but a limited part of wage variations. Subsidizing childhood development and other education might be high in the efficiency policy hierarchy for providing a means of signaling such characteristics. There are some studies that suggest that at least in some developing country contexts, formal schooling plays such a signaling role in that its effects remain significant in some empirical wage relations even with control for cognitive skills acquired in part through schooling (e.g., [25, 26]. The policies that would seem to be highest in the efficiency policy hierarchy in this case would be ones that addressed directly the capital market and wage restrictions that preclude self-financing of childhood development and other forms of education (both of which are discussed below). Less high in the hierarchy, but still fairly high, would seem to be various means of certifying skills, abilities, and motivations—although the potential for having useful certification for children of the age in which investments in child development occur would seem to be limited. Subsidies for certification tests might be one such mechanism. Such policies would be likely to benefit some of the poorer members of society (because they are more likely to be constrained from self-financing such investments), but probably not many of the poorest.
4. Uncertainty in combination with households wanting to avoid risk and imperfect or costly insurance options means that the private incentives are to underinvest in childhood development and other human capital from a social point of view, because on an aggregate level such risks are reduced by pooling them across members of society. The considerable dispersions of labour market returns to persons with the same education in most societies are consistent with the possibility that there is considerable uncertainty regarding the returns to human capital investments, although part of these dispersions may reflect variations in abilities and motivations that are observed by people making these investment decisions, although not by policy makers and analysts (so the latter groups' perceptions may be biased by omitted variable bias. High in the efficiency policy hierarchy to address this possibility would be the development of insurance markets, but the possibility of developing such markets well might be limited because of the standard moral hazard and adverse selection problems. Not quite as high, but still relatively high in the policy hierarchy would seem to be policies that subsidized risky investments in combination with income taxes. If childhood development and other forms of investment in education are relatively risky investments, then they would be covered among other risky investments. Such policies would seem to have the potential of benefiting considerably poorer members of society who are less able to self-insure their investments and may have higher risk aversion (Binswanger's is a seminal study on the latter [27]).
5. There are social gains beyond the private gains to childhood development and other human capital investments because basic human resources reduce the probabilities of illnesses and unemployment, both of which have social benefits beyond the distributional ones through reducing respectively the stress on public health systems and the probability of illegal activities. Public subsidies for childhood development and other basic human resource investments might be high in the policy hierarchy for such purposes on *a priori* grounds, although there remains the question of empirical evidence regarding their effectiveness in this regard. Such policies would seem likely to have distributional benefits for relatively poorer members of society.

6. Policies limit price flexibility (e.g., administratively set prices, minimum wages, price floors and ceiling for basic food staples), labour market flexibility (e.g., mandatory termination payments, health insurance and pensions tied to a particular employer) and childhood development programmes (e.g., limiting subsidies to public childhood development programmes) that distort the incentives for childhood development. In recent years, however, there has been some tendency for such regulations to be lessened in many countries. In any case highest in the efficiency policy hierarchy are changes simply to eliminate such policy distortions. The reluctance to do so often is for distributional reasons. Relatively well-off workers with employment in formal sector firms (including providers of child development related services) and relatively well-off governmental employees may have vested interests in maintaining such policies due to the rents they receive from them. There is little evidence that poorer members of society benefit from such policies in most developing countries.
7. Positive marginal income tax rates mean that the private marginal returns to an individual's human capital investments are less than the marginal social returns. This possibility seems logically to be true *ceteris paribus* but not very relevant currently for most workers in developing countries and even less relevant for considering child development policies. Furthermore such taxes might be part of a second-best policy package in the absence of insurance markets. In current contexts, removing existing income taxes in developing countries are likely to have benefits primarily for those who already are relatively well off.
8. More investment in childhood development and other forms of human resources may have marginal social benefits above the private wages received because of administratively set wages (e.g., public school teachers, public health workers, public researchers). This appears to be a fairly widespread phenomena in many developing countries. The policy change that is highest in the efficiency policy hierarchy in this case is to pay wages that are competitive with those paid in the private sector. The constraints from doing so often appear to be budgetary in combination with past governmental employment policies that were not oriented primarily towards the efficient provision of governmental services. In many instances steps are under way towards rationalizing the public sector in ways that will lessen this problem, but there are strong vested interests in previous practices. The distributional questions are likely to involve, primarily, who among the relatively well-off members of society will benefit from such restructuring and who will suffer losses.
9. There are incomplete markets for household production of human resources that affect the productivity benefits of childhood development, so different households maximize their welfare functions with regard to different trade-offs rather than the true relative social marginal costs. For an explicit example, in poor populations individuals who are healthier and have better nutritional status may be more productive, but for many tasks monitoring problems may mean that labour markets do not reward such productivities. Therefore different households effectively make their decisions regarding investments in health and nutrition—that may affect the effectiveness of childhood development—with regard not to the same relative market prices as would be necessary for efficiency, but with regard to different trade-offs. Empirical evidence suggests that this is the case at least in poor rural labour markets (e.g., [28-31]). Policies that would seem to be relatively high in the efficiency policy hierarchy in this case would be ones that improved information about health and nutrition and related productivity of poor people. Possibly childhood development and other educational programmes could serve this purpose, though I am not aware of empirical evidence that is focused on this possibility. If so, the impact would be largely on poorer members of society who are more at risk of not being able to signal their true productivities for such reasons.
10. The productivity benefits of childhood development and other human capital investments are in the future and the social discount rate is less than the private discount rate. Although this is a possibility that has been raised in considerations of whether there are reasons for policies to encourage more investment than individuals would choose on their own, I am unaware of any relevant empirical evidence. Presumably such evidence would have to be based on some weighted responses of a nation's population that indicated that they would like to give up more current consumption for the purpose of future consumption than they individually decide to do. If this is a reason for public subsidies for childhood development in a particular context, then it would seem that such subsidies for childhood development would not be very high in the policy hierarchy. The basic problem is a very general one about trade-offs between present and future consumption, and not one concerned particularly with childhood development. Higher in the policy hierarchy than policies that directly related to childhood development would be policies that penalized current consumption and encouraged general investment in the future, such as consumption taxes and subsidized interest for investments generally. Probably general policies that discouraged current consumption would, in terms of distribu-

tion, be regressive because consumption tends to absorb larger proportions of the income of poorer households. Subsidized interest rates that were available to all, on the other hand, might benefit poorer households who currently do not have access to capital markets (although there remain problems of adverse selection and moral hazards in regard to those markets).

11. There are social gains beyond the private gains to childhood development and other human capital investments because basic human resources for all are viewed by society as inherently valuable in themselves in addition to their effects on individual economic productivity and consumption. Again, as for the previous possibility, while there often is appeal to such a notion, sometimes on nationalistic grounds, it is not clear what empirical evidence is available. Again it would seem that the possible empirical evidence would have to document differences between collective and individual preferences. In this case, however, policies to subsidize childhood development and other human resource investments would seem to be relatively higher in the efficiency policy hierarchy because they more directly address the problem than when the problem has to do with generalized consumption paths. Whether such policies would be equalizing or unequalizing in terms of distribution would depend very much on in what respects human resources are viewed as collectively more desirable than individually. On one hand, everyone having basic human resources might be given emphasis, in which case the policies that are higher in the policy hierarchy would tend to be equalizing or at least propoor. On the other hand the goal might be to have world class intellectuals or scientists, in which case the focus would be on the upper end of the distribution, which might be unequalizing (although increasing mobility for a few very bright but poor individuals).

Now let the dashed line in figure 1C represent the marginal social costs for human capital investments that are drawn to be less than the marginal private costs.[30] In this case the private incentives are to invest in H^*, which is less than the socially optimal (efficient) level of human capital investment H^{***}. Therefore there is a an efficiency argument to consider policies to induce or to require private investments of H^{***} instead of H^*.

Why might marginal social costs be less than marginal private costs for human capital investments? Among the most frequent answers to this question is one that points primarily to a market failure and one that points primarily to a policy failure:

1. There are capital and insurance market imperfections, more so for childhood development and other human capital investments (in part because human capital is not recognized as collateral) so that the marginal private costs for such investments exceed the true marginal social costs, particularly for those from poorer families who can not relatively easily self-finance and self-insure such investments. Conventional wisdom is that these problems are widespread. Empirical evidence is that childhood development and other educational investments often are constrained by household income, which is consistent with this conjecture if there are not current consumption aspects to such education (e.g., [32]). The first best resolution is to improve these markets, which in many cases may mean public subsidies for improving information about potential borrowers or for providing insurance for them. Less high in the efficiency policy hierarchy, but still probably fairly high (particularly if such problems are greater for educational investments than for many other investments) are public subsidies for childhood development and other education targeted towards poorer members of society. Effective efforts to lessen these problems are likely to benefit relatively poorer members of society who have potential for such education because they are the ones that are most likely to be constrained from undertaking such investments by limited capital and insurance markets.
2. The sectors that provide services related to human capital investments, such as childhood development and schooling, produce inefficiently. This appears to be the case broadly, though the systematic evidence is limited. The insignificance or "wrong" signs of many inputs in many educational production function estimates for developing countries, for example, suggests that the production of these services often is not very efficient (e.g., [33]). High in the policy hierarchy for dealing with this problem would seem to be to create incentives for more efficient production of education by subsidizing information about the value added of alternatives (because such information is a public good, as discussed above), using market pressures to guide production (e.g., through pricing, with vouchers if public subsidies are warranted), and treating all suppliers equally (whether public, private, or nongovernmental organizations) rather than limiting entry or subsidies to certain types of providers. With respect to the distribution of beneficiaries, they would seem to be fairly widespread. But many poorer members of society would be among them because the poor are more likely to be dependent on such institutions and to have been less able to self-finance or use family connections to assure alternative means of acquiring relevant education.

Endnotes

1 Some prices may be easy to observe, such as wages. Others may be difficult to impute, such as the price of child happiness. Discounting makes possible the comparison of two streams of costs and benefits over time by converting them into their present or current values. Discounting is critical for comparing investments in which there are different lags between the investments and the payoff. If the interest rate is *r* per year, the present discounted value of a rupee received next year is $1/(1+r)$ rupees, because if one had that much currently, one could obtain an interest rate *r* and have 1 rupee next year. More generally, the present discounted value of a rupee received or paid in *n* years is $1/(1+r)n$. A gain of one dollar in 15 years, for example, is worth only \$0.47 now if the appropriate discount rate is 5%, only \$0.22 if the appropriate discount rate is 10%, and only \$0.11 if the appropriate discount rate is 15%. The failure to discount for comparing events that happen at very different points in time, such as for exploring the impact of reducing childhood iron anaemia on adult productivity, can lead to quite misleading results (e.g., overstating considerably the gains from childhood development programmes).

2 These are present discounted benefits and costs (see the previous note).

3 For the last three of these comparisons, the otherwise identical individuals would have to live in different economies.

4 A number of these examples, both on the marginal benefit and the marginal cost side, depend on their being imperfect capital and insurance markets. For example, if capital markets are perfect, heterogeneities in discount rates across households do not have an effect, because all households maximize the present discounted value of their investments at identical market interest rates. Likewise, there is not differential access to financing across households for such investments. If insurance markets are perfect and insurance is costless, moreover, risk does not affect households differentially. But it is widely perceived that capital and insurance markets for human resource investments are missing or quite incomplete.

5 A simple model for the impact of public school quality on household schooling investments is presented and estimated for Brazil in Behrman and Birdsall [2]. If the investor must pay for greater human resource service-related quality, however, investment does not necessarily increase with a higher-quality option. What happens to the equilibrium investment depends upon where the marginal private cost curve for the higher-quality option is, in addition to the location of the marginal private benefit curve.

6 Though this tendency may be offset if, for example, human capital substitutes sufficiently for financial and physical transfers in marriage markets (e.g., Rao [3]).

7 I use linear approximations here because they are the simplest forms that still permit characterization of various estimation issues. Log-linear forms in which all of the variables are replaced by the logarithms of their values (which implies interactions among all the right-side variables) are identical in representation once the variables are redefined. In empirical studies, linear and log-linear specifications are very common, but other functional forms also are used at times. For other functional forms, the essence of the estimation issues is the same. If the functional form that is used is not a good approximation to the true functional form, there is misspecification error that is akin to omitted variable bias discussed below (with the unobserved variable being the variable that would have to be added to transform the assumed specification to the true functional form).

8 For example, all community characteristics usually are assumed to be predetermined. But households, individuals, and firms can change community characteristics by migrating, which is incorporated into some modeling (e.g., [4]).

9 It is not possible, however, to estimate the effect of one behavioural variable determined in the current period on another with demand relations. This point is not always understood, so it is developed briefly in this note. For example, current childhood development may be posited to be determined simultaneously with current child nutrient intakes. Consider the following two demand relations for current childhood development (Z_C) and for current child nutrient intakes (Z_N) as dependent on two prices (PF_1, PF_2), predetermined resources (RF), and stochastic terms (V_C, V_N):
(3*A*-1) $Z_C = b_{11}PF_1 + b_{12}PF_2 + b_{13}RF + V$C and
(3*A*-2) $Z_N = b_{21}PF_1 + b_{22}PF_2 + ba_{23}RF + V$N.
These two relations imply:
(3*A*-3) $Z_C = b_{31}Z_N + b_{32}PF_2 + b_{33}RF + V_C'$.

10 A number, but not all, of recent studies report evidence using twins or other sibling data or direct measures of ability that suggest that usually unobserved endowments have direct effects on wages (e.g., [6–13].

11 To be able to learn about the *productivity* rather than the earnings impact of schooling, moreover, there must be knowledge of the relation between private earnings and marginal productivities.

12 Usually it is random measurement error that is emphasized; it is discussed here. Measurement error also may be systematically related to the true variable, with implications that depend on exactly what is the nature of the systematic relation.

13 F_C^2 is standard statistical notation for the variance in *C*, which is simply a measure of how much the individual observations of *C* differ from the average (mean) value of *C*.

14 Conditional on the assumptions for the Mincerian earnings functions, there is not such a problem in this case. But the assumptions on the production technology are quite strong, and some studies suggest that they are not justified in fact (e.g., for estimates of schooling responses to endowments, see [9, 10]). Hedonic wages/prices may have an omitted variable problem, because all characteristics of the person/item being priced are not observed. For example, observed schooling may be correlated with unobserved factors that affect wages, such as ability, motivation, and family connections.

15 The compound disturbance term includes all the unobserved variables unless their effects are controlled in

some way (see the discussion of fixed effects below).

16 Misspecification of the functional form has similar effects. If there should be interaction terms, for example, but they are not included and they are correlated with any of the included terms, the estimates of the included terms are biased in way that is analogous to omitted variable bias.

17 Strictly speaking, this should read that "the problem of omitted variable bias due to unobserved variables *probably* could be lessened." If there is only one cause of bias in an estimate, eliminating that cause eliminates the bias. If there is more than one cause for a bias, eliminating any one cause does not necessarily lessen the bias, because some other bias may have been offsetting the one the cause of which is eliminated. But in the absence of information suggesting that eliminating any particular bias exacerbates the problems due to another counteracting bias, the presumption is that eliminating a particular bias probably lessens the total bias. This is analogous to considerations about efficiency and eliminating distortions that are mentioned briefly below.

18 In some circumstances, such as the introduction of a new programme or a new programme feature, the change cannot immediately be instituted nationwide in any case. Therefore there is potential for introducing it randomly initially, a possibility that has been exploited in a few recent cases.

19 There have been considerable efforts at conducting experiments to evaluate other human resource investments, such as training programmes in the United States. Heckman et al. [15] review these efforts and elaborate on the limitations of these experiments.

20 This means that panel (longitudinal) data generally must be used to control for individual fixed effects (though there are a few exceptions, such as using data on identical twins to control for fixed individual genetic endowments).

21 This statement assumes that identification is by exclusion restrictions, which is the most common assumption, but not the only possibility.

22 Implementation of this method requires that the statistic used from the first stage (the "inverse Mills ratio") be identified by variables that enter into the decision rule but not directly into the second stage or by functional form. For example, family firm product prices may affect whether a child is enrolled in a childhood development programme, but perhaps not what the child learns if the child does enroll.

23 Note that this is not the same as engineering or scientific efficiency. An engine that is very efficient in the engineering sense, for example, may be very inefficient economically because it uses inputs that have better uses elsewhere.

24 If all other markets in the economy are *not* operating efficiently, policies that narrow the differences between private and social marginal incentives in the human capital investment market or in some segment of that market do not necessarily increase efficiency and productivity. Clearly, in the real world there are many market failures and incomplete markets, so some distortions may be counterbalancing others. But in the absence of specific information to the contrary (such as on the existence of two counterbalancing distortions), a safe operating presumption is that lessening any one distortion between social and private incentives is likely to increase efficiency.

25 For example, to analyse well the impact of policies, it often must be recognized that policies are not predetermined, but are made by individuals or groups of individuals with various objectives in mind, including accommodating to pressures from and needs of constituents. The failure to control for the determinants of governmental policies may cause substantial misestimates of their effectiveness [17]). The basic intuition is clear from considering the simple example of evaluating the impact on cognitive development of childhood development programmes from cross-sectional data from a number of communities. If the resources devoted to such programmes tend to be concentrated in communities that have greater political power, wealth and better-off children net of their effects, the association between child cognitive development and resources devoted to childhood development programmes *over*states the effectiveness of the programmes on cognitive development unless there is control for resource allocation among childhood development programmes in different communities. On the other hand, if the resources devoted to such childhood development programmes tend to be concentrated in communities that have poorer health environments, greater poverty, and less well-off children net of the effects of the childhood development programmes, the association between child cognitive development and resources devoted to childhood development *under*states the effectiveness of the childhood development programmes on child cognitive development unless resource allocation among childhood development programmes in different communities is controlled for. A number of recent studies both characterize the underlying objective functions for governmental behaviours and find that controlling for such behaviours alters substantially the estimated impact of governmental programmes (e.g., [18, 19]).

26 The available studies on the positive relations between productivity (or wage) gains and childhood development—education interactions, however, may overstate the causal effect because of the failure to control for the selectivity of childhood development in the presence of important unobserved (by analysts) attributes, such as ability and motivation.

27 Udry [20] provides a recent empirical study of inefficiencies within African households with regard to the allocation of productive resources, including labour time, between men and women. Other studies are reviewed elsewhere [21].

28 The marginal social benefits also could be lower than the marginal private benefits, in which case the marginal social benefits curve would be below the marginal private benefits curve, and policies to attain efficiency would have to reduce the private incentives to the social levels. The basic analysis would be the same, but with the opposite sign on the differences between the marginal private and social benefits and therefore on the appropriate policies. To keep the presentation as simple as possible in the text, I consider only the case

in which the marginal social benefits exceed the marginal private benefits, which is the case usually emphasized in the literature on human resources.

29 The empirical evidence to which reference usually is made regarding educational externalities includes micro individual or firm-level evidence of the economic impact of education on wages or productivity. Most studies are not very sensitive to the estimation issues that arise, because education reflects behavioural choices, so it is hard to know how to interpret such estimates. But even if it is assumed that they are not biased due to such problems, they do provide estimates of the private rates of return to time spent in school (and possibly indirectly childhood development) and estimates of the "social" rates of return that incorporate, in addition to the private costs, the public costs. For low-income countries, for example, the average estimated "social" rates of return to primary, secondary, and tertiary schooling are 23.4%, 15.2%, and 10.6% [24]. *Prima facie* this might seem to be a strong case for public support for basic schooling in low-income countries. But these "social" rates of return say nothing very useful about differences between social and private rates of return. True, the same source summarizes the average private rates of return to these three levels of schooling to be different from the "social" rates of return, with the average private rates of return, respectively, at 35.2%, 19.3%, and 23.5%. But if the comparison were to be interpreted to tell anything about efficiency motives for policies, the conclusion would be that public schooling subsidies should be reduced to zero to eliminate the differences between the "social" and the private rates of return, *not* maintained or increased. However, this conclusion does not require any estimates, but follows directly from the way in which the "social" benefits are calculated, i.e., effectively adjusting the estimated private rates of return to include public costs beyond the private costs. These "social" rates of return make no effort to incorporate differences in private and social benefits due to externalities. Thus they provide no basis for concluding that on efficiency grounds there should or should not be subsidies for schooling, nor that on efficiency grounds one level of schooling should be subsidized more than another.

30 The marginal social costs also could be higher than the marginal private costs, so a comment parallel to that in a previous note also applies here.

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Books received

Rapid assessment procedures (RAP): Ethnographic methods to investigate women's health. Joel Gittelsohn, Pertti J. Pelto, Margaret E. Bentley, Karabi Ghattacharyya, and Joan Jensen. International Nutrition Foundation, Boston, Mass., USA, 1998. (ISBN 1-892468-01-8) 196 pages, paperback. US$15.00 plus $3.00 shipping and handling. (Developing country individuals and institutions, US$10.00 plus $5.00 shipping and handling).

This manual contains guidelines and procedures for carrying out an ethnographic study of women's health. It provides tools for the generation and analysis of data to facilitate programme development, implementation, evaluation, and improvement by governmental and non-governmental institutions concerned with women's health. The main body of the manual focuses on a series of data-collection exercises that will permit an organization to develop a sizable body of data on local perceptions and practices regarding women's health in the study area. It differs from other ethnographic manuals in its focus on the health problems of women rather than a specific disease or cluster of diseases, it provides detailed suggestions for the appropriate training of data collectors, and it provides for the optional use of specialized computer software packages.

News and notes

The Prince Mahidol Award

The Prince Mahidol Award Foundation of Thailand is soliciting the nomination of individuals for consideration by an international award committee to receive awards for 1999. The Foundation was established to honour Prince Mahidol of Thailand, who is considered to be the father of modern medicine and public health in the country. There are two awards given annually. Each award consists of US$50,000 in cash. The award ceremony will be held in Bangkok and will be presided over by His Majesty the King of Thailand.

The award will be bestowed on individual(s) who have made significant contributions that have been shown to be of immense benefit for the improvement of the health of a large number of the population of the world. Alternatively, the award could be given to the individual(s) who have applied certain scientific knowledge successfully towards the improvement of the health of a large number of the population.

Readers of the *Food and Nutrition Bulletin* will be pleased to note that three of the awards went to individuals whose major contributions were in the field of nutrition. In 1993, one of the awards went to Dr. John Stanbury for his early studies of endemic goitre in Argentina, Ecuador, and Peru, and his promotion of the control of iodine-deficiency disorders through the International Council for the Control of Iodine-Deficiency Disorders (ICCIDD).

In 1997, one of the awards was shared by Dr. Guillermo Arroyave, originally from the Institute of Nutrition of Central America and Panama (INCAP) in Guatemala, for his demonstration of the feasibility of vitamin A fortification of sugar on a national scale and his earlier contribution to demonstration of the feasibility of using potassium iodate for the control of endemic goitre. The award was shared with Dr. Albert Sommers of Johns Hopkins University for his demonstration of the reduction of child mortality through vitamin A supplementation.

Although the 1995 award was shared by Fred Sai of Ghana for his contribution to family planning in Africa and globally, his earlier studies of protein-calorie malnutrition were also recognized.

Nominations of additional individuals who have made outstanding contributions to the control of nutritional diseases will be welcome. Nomination forms and the charter of the Foundation can be requested from the Royal Thai Embassy in the countries, and submitted to the Embassy or obtained from the office of the Secretary General:

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Iron-deficiency anaemia

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