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# NUTRITION, HEALTH AND LEARNING:

## *Current Issues and Trends*

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## I. INTRODUCTION

Over the last three decades, humanity has been privileged to witness impressive progress in the struggle of millions of newborns to celebrate their first birthday. The success of these tiny citizens in surmounting the often overwhelming barriers erected between infancy and childhood is a triumph of immense proportions. Currently, 92 percent of all children born survive to age one; in contrast, only 83 percent of those who entered the world thirty years ago lived more than twelve months.

What accounts for this dramatic shift in the chance an infant born today has of becoming a toddler? At the risk of overly simplifying a complex issue, the headway made represents the union of *policy, technology, investment, and consensus* among the planet's citizens that life is an entitlement conferred at birth.

It is expected that by the year 2000 only one out of every twenty children born will fail to survive to age one. Thus, it seems urgent for us to begin refocusing our attention away from questions of survival. We must now address the quality of life that millions of once imperiled infants will have as children. To achieve such a "paradigm shift" in our agenda will once again require creating a union of policy, technology, investment, and consensus about the "post-survival" child's life.

This monograph examines one critical dimension of that life: the opportunity to acquire – through schooling – skills, knowledge, attitudes, and habits that foster personal, community, and national development. Specifically, the present study reviews how *health and nutrition factors* may impinge on a child's ability to participate in or take full advantage of schooling. Within these parameters, the monograph seeks to lay a foundation for four pillars of progress: policy, technology, investment, and consensus. It is these four pillars that must undergird successful programs designed to meet the post-survival child's needs.

## II. THE CASE FOR EDUCATION

At the very heart of efforts to assist the world's most impoverished people in their struggle to obtain the essentials of life – food, shelter, livelihood, and a secure future – lies education. An impressive and seemingly incontrovertible body of evidence links educational attainment to virtually all development indicators of significance. Furthermore, the linkages documented are both intra- and inter-generational.

Thus, for example, a mother with just a few years of schooling is more likely to provide her children with the care and stimulation that will dramatically improve their early, formative years than the mother who has never received any formal education at all. Illustratively, one study found that a single year of mother's education was associated with a 9 percent decrease in child mortality. In Africa, an increase of one percentage point in the national literacy rate was associated with a two year rise in life expectancy (Cochrane, as cited in Lockheed and Verspoor).

Although often treated by citizens and politicians alike as a social service, education is best understood as an investment in human resources. The evidence to support channeling capital to education is impressive.

Adult literacy rates, for example, positively correlate with returns on investments in social infrastructure projects (e.g., health, water, sanitation, family planning). Formal education also acts as a powerful determinant of economic productivity, even when the level of schooling attained is modest. Individuals who have completed primary school tend to have higher earnings, more modern attitudes, and lower fertility as well as better health and nutrition status than their less schooled fellow citizens. They save more of their incomes, adopt new technologies more readily, and participate more often in civic affairs.

These relationships between formal education and development "precursors" are best explained by the role schools play in promoting the cognitive development of students. Studies undertaken in pre-industrial societies show that children with a few years of formal schooling perform better than their unschooled peers on a variety of cognitive tests (Wagner; Stevenson et al., as cited in Pollitt, 1990). Despite the inadequate conditions under which most schools operate in developing countries, formal education nonetheless helps students acquire learning skills and the ability to use information effectively. The renewed interest (and accompanying investment) in basic or primary education on the part of many multilateral and bilateral donors vividly reflects the emerging consensus that "when schools are good, and many children are educated, the process of development occurs more quickly." (Lockheed and Verspoor)

Although education represents a powerful tool for meeting the aspirations and needs of millions of people throughout the developing world, too few children complete (or even begin) basic education studies, and funds available for the expansion of coverage are disappointingly modest. For example, among boys of primary school age, only 14 percent are enrolled in Somalia. In Guinea, the rate is 31 percent, while in Togo it is 87 percent. For girls, the primary school enrollment rates are markedly worse: 8 percent in Somalia, 15 percent in Guinea, and 20 percent in Burkina Faso (Haddad et al.).

Among the 21 countries with low-income economies for which data were available, only 12 had more than half their primary school aged boys actually enrolled in school during 1984-86. Only eight of these countries had more than half the girls actually enrolled. Among 20 middle-income countries for which data are available, approximately one-fourth have not yet achieved primary school enrollment rates in excess of 75 percent (drawn from tables in Haddad et al.).

Low enrollment ratios reflect large numbers of children who have never attended school as well as the many boys and girls who fail to complete the requisite primary school course of study despite having entered the first grade. Thus, among the 23 reporting low-income economies, only 14 succeeded in having more than half their first graders complete primary school six years later. And, among 33 middle-income countries, just under half (16) were able to graduate more than three-fourths of their entering first graders after six years (drawn from tables in Haddad et al.).

Such low levels of primary school completion are the result of many phenomena: unavailability of school places for all students who desire to attend the upper primary grades; high rates of academic failure and grade repetition that lead to school desertion; economic pressures on children to enter the labor force or to perform child care and other familial responsibilities; as well as voluntary abandonment of school because of its perceived irrelevance.

While these problems are complex and pressing, the resources to tackle them are scant. Only six of 23 **low-income countries** report per pupil primary education expenditures in excess of $50 per year, despite that fact that almost all of them are investing at least 10 percent of their national budgets on education. Approximately half of all **lower-middle income economies** spend less than $100 per primary pupil annually despite the fact that these nations are allocating an even higher proportion of their national budgets to education than their low-income counterparts.

In summary, education – particularly universal primary schooling – is increasingly recognized as an indispensable element for achieving social and economic development goals. Coverage, however, as captured by enrollment rates, is far from complete. The financial resources required to extend coverage are not likely to be readily forthcoming from developing country governments given that they are already devoting a very high proportion of their national budgets to education. Thus, developing country governments and donors are confronted with a major challenge: *how to maximize returns to education investments already in place while gradually increasing per capita outlays for primary schooling.*

**A New Approach: Improving Child Quality**

A child's school enrollment, attendance, and achievement are influenced by a host of variables including *the capacity of the child as a biochemical organism to process and respond to stimuli.* As the quality of the biochemical organism sitting in the classroom improves, so too does the efficiency of a child's learning, all other things being equal, until the child's innate aptitude is realized. Nutrition and health problems impinge on the quality of the biochemical organism and impede the acquisition of skills and abilities needed to progress satisfactorily in primary school. A child who is malnourished and carrying a large parasite burden cannot adequately take advantage of instructional resources. A chronically ill student, or one who is malnourished and whose nutrient and energy intake does not meet basic physiological requirements, is likely to be educationally disadvantaged.

A good school plant and high quality instruction cannot produce the intended educational outcomes when children are too sick, too weak, or too distracted to learn. When there are many such children enrolled in primary school, the education sector performs inefficiently, optimal returns on investment are not achieved, and progress toward a wide range of development goals is forestalled. And, if significant numbers of children are no longer participants in the formal school system because their health and nutrition status have rendered satisfactory academic progress an unattainable goal, the result is development – and dreams – dangerously deferred.

In recent years, two terms, applied interchangeably, have come into use to refer to the child's characteristics in the teaching-learning process: "educability" and "teachability." Both can be defined as *the potential a child has to achieve age-appropriate, specific curricular learning objectives, regardless of whether or not the child is actually enrolled in school.*

Unfortunately, both terms convey the image of children who passively receive information transmitted by a classroom teacher. The child is object and the teacher is subject in such a teaching-learning equation. "Educability" and "teachability" imply that the development of new skills and knowledge is something "done" **to** children without their active participation or involvement. In reality, however, optimal learning actually takes place when children are actively engaged in exploring stimuli, processing information, and exercising their creativity by applying what they have learned to novel situations. Thus, these terms, by reinforcing obsolete conceptions of education, do a disservice to efforts designed to improve the degree to which basic education programs mesh with long-term development requirements.

Introducing the notion of a child's **active learning capacity (ALC)** into a discussion of health, nutrition, and school outcomes would, seemingly, advance the debate. ALC can be defined as *a child's propensity and ability to interact with and take optimal advantage of the full complement of resources offered by any formal or informal learning environment.* Implicit in this definition is the notion that the child is an active partner in the learning process and that the teacher's role is not primarily to impart information but rather to facilitate a child's mastery of curriculum objectives.

What factors chiefly influence a child's ALC? There are multiple determinants including nutrition status, health status, socioeconomic status, degree of parental stimulation, and overall quality of the home and school environments. The significance of the ALC construct, however, lies in its implied focus on the quality of the child and what the child brings to the school experience.

Attempts to raise child quality (largely through micronutrient supplementation, deworming programs, early childhood interventions, and the provision of school meals or snacks) as a means of improving school performance represent an important complement to more traditional change strategies for the sector: curricular reform, teacher training, school construction, and learning aid (particularly textbook) distribution. In effect, child quality completes a "learning achievement tripod." The other two legs, the quality of the teaching process (improved through curriculum development and teacher training efforts) and the quality of the school plant, have long received consideration from education sector specialists. Indeed, efforts to improve child quality – specifically, by enhancing the active learning capacity of children – could well represent the "third wave" of programs designed to expand educational opportunities available to children in developing countries.

The first wave, school construction, occurred primarily during the 50's and 60's and held out the hope to countless thousands that education was well within their grasp. Disappointingly, all too often, opening the school doors revealed a hidden truth: that the services being offered inside the schoolhouse were inadequate in relation to prevailing needs and expectations.

Consequently, a second wave of education sector programming was launched: teacher training and curricular reform. By the late 60's, educational radio and television were widely hailed as a panacea for many of the sector's ills. Later on, particularly during the 70's and 80's, basic education reforms were ushered in which purported to offer instruction geared to broad-based development objectives. Yet, once again, not all of the hoped-for outcomes were achieved. While enrollment ratios increased, many children – particularly those situated at the margins of society – failed to make the requisite academic progress and either dropped out of school or were held over to repeat one or more grades.

Interventions to improve child quality and ALC, the third wave, address some of the underlying causes of unsatisfactory school achievement in the face of greater access to schooling and curricular reform. These "third wave" efforts are a critical complement to the extension of basic education services and fulfillment of the pledge to universalize primary schooling made by most of the world's governments at the 1990 World Conference on Education for All held in Jomtien, Thailand under the joint sponsorship of UNDP, UNESCO, UNICEF and the World Bank.

Seen in a historic context, programs to improve child quality by raising ALC may well complete a cycle of educational reform. For the last forty years, reformers have focused on creating the conditions under which all children can go to school and learn something of value to themselves and their communities. The health and nutrition interventions that form part and parcel of child quality improvement programs are designed to remove significant impediments to learning that thwart achievement of this vision.

There are two ways in which introducing child quality onto the education agenda represents a historic milestone. First, efforts aimed at enhancing child quality must be multisectoral because of the strong influence health and nutrition factors exert in determining a child's active learning capacity. In contrast, attempts to expand educational opportunity have, until now, been almost exclusively within the purview of the education sector.

Second, systematic attempts to enlarge children's active learning capacity may well be the capstone for two of the most important and successful development initiatives of the 80's and 90's: child survival and basic education. In many countries these twin engines of change have already made it possible for increasing numbers of children to enter school. Indeed, despite the formidable need for greater progress, barriers to school access are steadily disappearing in many developing countries as both enrollment ratios and cohort sizes rise. Strategies designed to improve child quality represent the bridge between child survival initiatives and the universalization of schooling. Child quality improvement programs enable children to both survive **and** thrive by being able to take advantage of the educational opportunities increasingly being extended to them. Such efforts assume critical importance as enrollment ratios climb, and ever more marginal populations enroll in school. It seems likely that children from these historically bypassed groups will enter school with substantially more health- and nutrition-related problems than earlier cohorts have had in light of the relationship between poverty, illness and well-being. Thus, proportionately, the need for child quality improvement interventions may be greater than ever before.

**New Technologies, New Opportunities**

While the need for health- and nutrition-related services may be rising, the knowledge and technical ability available to respond to it is also steadily improving. An examination of data for the six most highly prevalent helminthic parasites and the three most significant micronutrient deficiency disorders (conditions which, in various combinations, may affect up to 400 million school-aged children) indicates that each can be treated through highly efficacious chemotherapy (Berkley and Jamison).

Albendazole and prazinquantel, for example, are two drugs that can be administered on a single dose basis, in combination, to reduce dramatically individual worm burdens of all species of schistosomes, intestinal helminths, and human tapeworms. Administration is safe and can occur outside a medical setting. The drugs are also highly effective. These characteristics, safety and efficacy, make a school-based strategy of targeted mass chemotherapy very feasible in areas where these conditions are endemic. Annual operational costs of a treatment program are considered to be between $1.00 and $1.50 per child. This estimate includes the purchase of albendazole, praziquantel, vitamin A and iodine as well as program administration (Berkley and Jamison).

Despite the probable benefits of extending such a program to school-aged children, most developing countries have been slow to adopt these or similar measures. The reasons are many: scarce resources and a concomitant reluctance to divert education sector funds to health programming in light of pressing shortages of books, teachers and buildings; lack of information on how micronutrient deficiencies and helminthic infection deter the health, growth, nutritional status and cognitive development of children thus preventing them from taking full advantage of limited educational opportunities; scant recognition on the part of donors concerning the affordability and potential impact of child quality interventions; and, a lack of political will to harness low-cost technologies for the benefit of school-aged children.

## III. THE EFFECTS OF CHILD HEALTH AND NUTRITION ON SCHOOL PERFORMANCE

### Principal Issues

Malnutrition and infection are widespread in almost all developing countries. Among the most common conditions are protein-energy malnutrition (PEM), micronutrient deficiency disorders, helminthic (worm) infection, and upper respiratory illness. These conditions often combine to create negative synergies; thus, for example, PEM and infection frequently co-exist and multiply the ill effects that each would cause the organism if present alone.

The endemic nature of malnutrition and infection is probably also at the root of additional health problems that impede learning among school-aged children. Poor vision and auditory impairment, for example, are conditions that directly relate to infection and micronutrient deficiencies.

Prevalence data, therefore, suggest that programs designed to improve the quality of primary schooling in developing countries must also include efforts to improve the health and nutrition status of students exposed to that schooling. Targeted health and nutrition interventions can confer important educational benefits.

Five major health and nutrition problems seem especially suitable for intervention strategies given their prevalence, probable impact on learning and school performance, as well as their amenability to treatment. These are PEM, micronutrient (specifically iron, iodine, and vitamin A) deficits, helminthic infection, sensory (hearing and sight) impairment, and temporary hunger. Each of these problems will be discussed in turn with respect to prevalence and impact on school-related outcomes.

*1. Protein-Energy Malnutrition (PEM)*

Among developing countries, PEM is one of the two most widespread nutritional deficiencies (Pollitt, 1990). The condition is often worsened by a child's parasite load. Caused by poor diet, PEM is almost always linked to conditions of extreme poverty and the additional accompanying threats to the child's normal growth and development that such an environment poses. A complex disorder, PEM is also often associated with different levels and types of nutritional deficiencies, such as iron and vitamin A as well as infectious disease (Israel and Hornsby).

Because of the interaction between malnutrition and the adverse social and environmental circumstances in which it occurs, evidence of a direct causal relation between mild-to-moderate PEM alone and impaired intellectual competence has not yet been established (Ricuitti and Brozek). Thus, there is a need for research to examine the question of how mild-to-moderate malnutrition and sociocultural, economic and other environmental influences combine in affecting mental development and cognitive capacity. One important aspect of this question is whether the consequences of mild-to-moderate PEM and of improved nutritional status due to supplementation vary as a function of an individual's social and physical environment.

Relatively little is known about the degree to which PEM is present among school-aged children. However, studies undertaken in a wide variety of developing country contexts including India, the Philippines, Nepal, China and Kenya reveal a high level of PEM present in poor rural populations. In the Uttar Pradesh India study, for example, only 13.5 percent of the sample had heights and weights which were normal for their age. The Kenya researchers identified over 30 percent of children in school as stunted and underweight. Similarly, the Nepal study team found the proportion of boys at less than 75th percentile for weight-for-age (a reflection of current nutritional status as well as prior history) ranged from 59 percent among six-year-olds to 84 percent for the ten- to eleven-year-old study cohort (Pollitt, 1990).

While our knowledge about PEM prevalence among school-aged children is incomplete, the data available from relatively small samples in a few countries point to some important differences both between and within countries. In Guatemala, India, Kenya and the Philippines, for example, the degree of stunting and wasting found among school populations is high. Illustratively, over 30 percent of Kenya's school population was stunted and underweight. In summary, large numbers of school-aged children in developing countries appear to be both nutritionally and educationally at risk (Pollitt, 1990).

Several studies have explored the relationship between nutritional anthropometric indicators and such school indicators as grade level, age at enrollment, absenteeism, achievement test scores, IQ, and performance on selected cognitive tasks including concentration in the classroom. Of the nine studies reviewed by Pollitt (1990), all reported significant findings between the nutritional status indicators and cognitive test scores or school performance indicators. Consistently, past and present nutritional status (as captured by height-for-age and weight-for-height respectively) were linked to higher cognitive test scores or better school performance. Taller children were also likely to be enrolled in school earlier than shorter ones. In China, height-for-age was also a predictor of the degree to which a child's grade level was age-appropriate. One standard deviation improvement in height represented an increment of .3 years "less far behind" in terms of school grade-for-age (Jamison).

Sigman and others (cited in Pollitt, 1990), for example, found that Kenyan children who were better nourished had higher composite scores on a test of verbal comprehension and the Raven Progressive Matrices. Furthermore, better nourished girls were more attentive during classroom observations than their malnourished female counterparts. For the children as a group, the best predictors of cognitive scores were duration of schooling, food intake (current nutrition), physical stature (nutritional history), and socioeconomic status. Regardless of the social and economic resources of the family, *children who had more adequate diets scored higher on the cognitive battery than those with less adequate intake.*

Similarly, Florencio concluded from her study in the Philippines that the academic performance and mental ability of pupils with good nutritional status were significantly higher than that of pupils with poor nutritional status, as a whole, even when family income, school quality, teacher ability, or mental ability were controlled. Although the relationship between health and nutritional status on the one hand and academic achievement on the other varied by grade level and subject matter, a significant positive relationship was found linking nutritional status to mental ability and academic achievement.

Many of the clinical studies on the relationship between PEM and cognitive development have focused on the long-term consequences of malnutrition experienced by infants and preschool children. An important set of implications for the academic performance of school-aged children emerges from this work (see, for example, Balderston; Beaton and Ghassemi; Chavez, Martinez and Yaschine; Cravioto and De Licardie; De Licardie and Cravioto; Husain et al.; McKay et al.; Rivera et al.).

Collectively, the studies present a comprehensive view of cognitive function which might be defined as *the ability to learn categories, to process and structure information, and to learn and react to social and environmental cues. Cognitive function also includes the ability to ask appropriate questions and provide appropriate answers within a given environment and to identify and solve relevant problems. Furthermore, it embraces general conceptual ability, appropriate actions within a given culture, and the mental agility needed to entertain new categories and see new possibilities* (Levinger). Based on the findings presented in those studies that examined the relationship between PEM and cognitive development on the basis of episodes of malnutrition experienced in infancy or early childhood, it appears that mild-to-moderate malnutrition, while not causing primary learning deficits, does alter processes associated with cognitive function. Passivity, apathy, shortened attention span, reduced short-term memory, failure to acclimate to repetitive stimuli, and a lag in the development of sensory-integrative capacity are all associated with mild-to-moderate malnutrition (Levinger). Furthermore, among infants and preschoolers, PEM has been shown to reduce playful and exploratory activity as well as motivation and arousal while increasing irritability and apathy, *even before anthropometric deficits occur* (Landers).

Because mild-to-moderate PEM acts synergistically with social and environmental factors, the risks for a malnourished child, living in a culture of poverty, are multiple, interactive and cumulative. However, both human and animal studies show that a developmentally facilitative environment can mitigate the potentially harmful consequences of early malnutrition. Reversibility and remediation are possible when the child's environment is manipulated to make it more conducive to cognitive growth. Although improvement in a child's diet alone can lead to cognitive changes, greater intellectual development can be achieved when the child's diet **and** psychosocial environment are enriched (McKay et al.).

Adaptive behaviors developed as a response to PEM work to prevent children from taking maximum advantage of the learning opportunities available to them in their environments. In other words, PEM-induced dysfunctions directly impinge upon and stunt the development of a child's ALC. Not surprisingly, children with PEM tend to function at reduced levels of intellectual development and academic achievement. They appear to adapt to malnutrition by seeking out more quiet and restful activities (Levinger).

In conclusion, a synthesis of the findings obtained from studies of infants, preschoolers and children in school, yields three important lessons. First, the nature of the developmental effects of PEM depends on the timing of the nutritional deficiency. **Early** malnutrition can affect school aptitudes, time of enrollment, concentration and attentiveness. However, there is little evidence or theoretical support for the view that **current** malnutrition influences basic aptitudes for school learning *except with respect to a child's ability to attend to and concentrate on stimuli present in the learning environment* (Pollitt, 1990).

Second, the school achievement of children with a history of severe undernutrition or with low height-for-age is inferior to that of matched but well nourished comparison groups. Children with a history of severe malnutrition also perform less well on tests of IQ and specific cognitive functions than children in matched comparison groups. These differences are not dependent solely on the child's prior nutrition but also reflect the social environment in which malnutrition takes place (Pollitt, 1990).

Third, children with a history of undernutrition in infancy and early childhood **are** capable of successful school performance. However, the treatment program required for them to overcome the behavioral dysfunctions induced by PEM is complex. Key elements in a recuperation program include nutritional rehabilitation and cognitive stimulation (Pollitt, 1990). Wherever possible, preschool programs should be explored along with parent education programs as a vehicle for vitiating the impediments to successful school participation experienced by chronically undernourished children. Once children are enrolled in school, compensatory education interventions for first graders whose height-for-age places them at risk should be introduced as feasible.

2. *Micronutrient Deficiency Disorders*

The literature on micronutrient deprivation and its impact on school populations is principally concerned with iodine, iron and vitamin A. Each deficiency disorder will be discussed in turn.

Of the 680 million people estimated to suffer from **iodine deficiency**, some 60 million of them are school-aged children (Berkley and Jamison). Iodine deficiency disorder (IDD) is perhaps the most thoroughly studied of the micronutrient deficiency conditions, particularly in Latin America where prevalence estimates include a high of 65 percent in Bolivia and 53 percent in Colombia among children six to 18 years of age to more moderate rates of approximately 25 percent in Paraguay and Peru (Israel and Hornsby).

In Africa, IDD afflicts almost 40 percent of the population in Kenya, 70 percent in Sudan and 75 percent in Cameroon. Rates are also high in Asia. Burma, Nepal and Indonesia, for example, all report prevalence rates around 70 percent (Galloway, as cited in Israel and Hornsby). Prevalence is higher among females. To the degree that IDD affects school enrollment and performance, gender differences in educational attainment, already significant, are further exacerbated by this differentiated pattern of IDD incidence (Simon et al.).

The consequences of IDD are significant in terms of school achievement. Conditions associated with IDD include reduced intelligence, psychomotor retardation, mental and neurologic damage, and cretinism. Among the specific aptitudes that appear to be most vulnerable to iodine deficiency are visual-perception organization, visual-motor coordination and, possibly, speed of information-processing (Pollitt, 1990). Children living in iodine deficient areas have also been shown to have impaired hearing. Yet, annual oral supplementation is an effective and low-cost treatment in populations where fortification of salt or other products is not feasible (Berkley and Jamison).

Bautista and others in their study on the effects of oral iodized oil on intelligence and growth in school-aged children from an area of Bolivia with high prevalence rates for goiter found indirect support for the hypothesis that supplementation to eliminate iodine deficiencies improves mental performance.

Researchers working in Indonesia examined the effects of iodine deficiency on mental and psychomotor abilities and found significant cognitive performance differences among nine to 12 year olds. Similar differences were detected among six to eight year olds although these were not significant. However, when educational background was controlled, few significant differences were detected thus rendering this study's findings ambiguous (Bleichrodt and others as cited in Pollitt, 1990). A study in Java showed that iodine-deficient children over age nine performed markedly worse on tests of intelligence, motor skills, concentration, perception, dexterity and response orientation than a matched but iodine-replete group of children (Querido et al., as cited in Pollitt, 1990).

In his review of studies dealing with the consequences of iodine deficiency, Pollitt (1990) notes that a child's aptitude for formal education may be in jeopardy even prior to school enrollment if the mother suffered from maternal iodine deficiency during pregnancy. Furthermore, it appears likely that these children of iodine deficient mothers are also more prone to hearing impairment than the sons and daughters of iodine replete mothers. Poor hearing, of course, constitutes a major obstacle to satisfactory school achievement.

Evidence suggests different rates of school enrollment for children living in IDD endemic and non-endemic areas. Studies conducted in Indonesia and Spain, for example, report that the average number of school years of children in areas where IDD is highly prevalent is about three years less than that of children from comparison communities (Pollitt, 1990).

Thus, IDD is a significant risk factor for school achievement. The effects of iodine supplementation, however, while clear from a prevention standpoint, are not as well understood in the context of a therapeutic response to the condition. Additional studies are needed to determine the effects of supplementation on cognitive function and school performance for in-school populations.

**Iron deficiency anemia** is, along with PEM, one of the two most common nutritional deficiencies in developing countries. Approximately 1.3 billion people are estimated to suffer from iron deficiency of whom 210 million are school-aged children (Berkley and Jamison). The highest levels of anemia among school children are estimated to be in South Asia and Africa, where the prevalence rate extends to about half the cohort. The comparable prevalence rate for Latin America and East Asia is approximately one-fourth the cohort size (Israel and Hornsby).

Prevalence rates vary considerably within both countries and regions as well as by gender. Thus, for example, a study of children ages five to 15 in Baroda, India identified 73 percent of the boys and 67 percent of the girls as mildly to moderately anemic (Pollitt, 1990). For children between the ages of five and 14 in Bangladesh, prevalence was about 75 percent. In contrast, for Filipino boys the rate was 21 percent while for girls it was 32 percent (Pollitt, 1990).

An insufficient body store of iron leads to mild growth retardation and iron deficiency anemia. When the anemic individual is a pregnant woman, the result often is a low birth weight baby and prematurity or fetal mortality. In studies of infants and preschoolers with iron deficiency, lower scores were reported for iron-deficient subjects on tests of mental and motor development. These children also exhibited increased fearfulness, inattentiveness, and decreased social responsiveness (Landers).

A study of preschoolers in the Philippines demonstrated that preschoolers with iron deficiency were also handicapped in terms of their ability to engage in higher cognitive processes such as conceptual learning (Popkin and Lim-Ybanez, as cited in Pollitt, 1990). This same study concluded that, because of the inexpensiveness of iron supplements relative to food, it is more cost-effective to employ intervention strategies to increase a child's hemoglobin level rather than body weight.

Effective treatment and prevention of the condition in individuals whose diets are inadequate in terms of iron intake consists of daily oral supplementation with appropriate iron and compounds. Several studies on deficits in attention among preschool and school-aged children, for example, demonstrate that their attention deficits were reversed once iron treatment was implemented (Pollitt, 1990).

A study of Kenyan school children to assess the effects of iron supplements on physical growth showed significant increases in body weight after treatment (Lawless et al.). Kenyan primary school children were also shown to experience improved appetite and increased energy intake after iron supplementation (Latham et al.).

The human body is not able to maintain significant stores of iron. As yet, there is no cost-effective time release capsule on the market, suitable for developing country use, that would obviate the need for daily ingestion of iron supplements. Development of such a capsule, however, is underway (Berkley and Jamison).

Iron deficiency influences a child's ability to benefit from classroom instruction in several ways. School-aged children deficient in iron stores exhibit reduced levels of alertness, attention and concentration which influences their learning (Lockheed and Verspoor). They also display less aptitude for making appropriate selections from information presented in the classroom setting (Pollitt, 1990).

Evidence suggests that while iron-deficient children are apparently less attentive to environmental clues that facilitate problem-solving, they can process information as well as iron-replete children once they learn a task. However, iron-deficient children tend to exhibit less motivation to persist in intellectually challenging tasks as well as lower levels of overall intellectual performance than matched groups of iron-replete children

(Scrimshaw, as cited in Lockheed and Verspoor). While there appears to be a relationship between iron deficiency and behavioral changes that are a product of brain function alternation, the mechanisms that govern this syndrome are not understood.

Iron-deficient children tend to exhibit irritability and a low level of engagement with and interest in their immediate environment. These traits inhibit the development of a child's active learning capacity (ALC) and impinge upon school achievement. Poor performance on a variety of achievement tests by iron deficient children enrolled in school has been reported by several authors (see Pollitt, 1990). Based on this evidence, Pollitt (1990) concludes that where iron deficiency anemia is prevalent, the condition acts directly to impede educational efficiency.

Supplementation appears to be an effective tool for correcting cognitive function deficits caused by iron deficiency. Two studies reviewed by Pollitt (1990) concluded that when iron deficient anemic children first enroll in school, they are at a disadvantage in terms of their aptitudes. This disadvantage disappears once children become iron-replete through supplementation.

It should be noted, however, that iron deficiency anemia can be caused by other factors besides inadequate dietary intake. Alternative contributors to the condition include helminth infection and malaria. Thus, an intervention strategy must be sensitive to both the causes and consequences of the disorder. In many instances, measures to reduce helminthic infection must be taken to eliminate iron deficiency anemia. The relationship between iron deficiency anemia and helminthic infection underscores the need to conduct area-specific epidemiological studies prior to planning specific intervention strategies.

**Vitamin A deficiency** is often accompanied by protein-calorie malnutrition. In its most extreme manifestation it causes blindness. Depleted stores of vitamin A are also associated with acute respiratory infection, the severity of measles, and diarrhea. Vitamin A deficiency also contributes to night blindness and limited peripheral vision. Evidence also exists linking vitamin A deficiency to growth, including brain growth, which continues through age seven to ten (Lockheed and Verspoor). Prevalence among school-aged children is estimated to be 85 million (Berkley and Jamison; Sanghvi).

Oral supplementation every four to six months is an effective treatment for vitamin A deficiency. Purchase of capsules is estimated to be about $0.01 per child per year (Berkley and Jamison).

There is no research literature that directly examines the relationship between vitamin A deficiency and school performance outside the context of special education. This is because extreme deficiencies result in blindness and thus preclude school enrollment in most areas of the developing world. However, it is reasonable to expect that, under less extreme circumstances, student attendance would be directly linked to vitamin A stores.

In many countries, acute respiratory infection, a condition related to vitamin A deficiency, is the leading cause of school absence. The degree to which vitamin A deficiency also influences both the severity of measles and diarrheal disease also suggests a linkage to school attendance and, through school attendance, to school achievement.

*3. Helminthic Infection*

Among school-aged populations, helminthic infection generates very high levels of morbidity despite relatively limited consequences for mortality (Jamison and Leslie). This may explain why the condition has not received the priority attention it deserves. Yet large parasite burdens, particularly severe hookworm infection, are associated with impaired cognitive function as well as such educational outcome measures as absenteeism, under-enrollment, and attrition (Bundy and Guyatt). Thus, helminthic infection appears to constitute a very real barrier to children's progress in school.

Parasitic helminths are one of the most common infections in the world. The majority of cases occur in people living in developing countries and are usually common and most intense among school-aged children. Infections in children have been shown to affect their health, growth, nutritional status and cognitive development. School-aged children (five to 14 years old) are most likely to have the heaviest infections within a population and therefore to be most severely diseased.

Little or no protective immunity is stimulated by parasitic helminths. Thus, most people become reinfected after having been treated and have to be retreated on a periodic basic, usually at intervals of between six and 24 months. Regularized treatment serves two functions. It directly reduces infection in the individual and, by reducing the shedding of eggs in the environment, diminishes the source of infection for the community as a whole (United Nations Development Programme Interregional Project).

Roundworm and whipworm are estimated to infect one quarter of the world's population, and school-aged children have the highest prevalence rates and levels of intensity among those infected (Nokes et al.). Roundworm (*Ascaris lumbricoides*) is present in one billion individuals of whom 400 million are school-aged children. Whipworm (*Trichuris trichiura)* is found in 750 million people including 300 million children of school age. Hookworm infection affects 750 million, of whom 170 million are children. Schistosomes impair an additional 200 million including 90 million children (Berkley and Jamison).

Each of these parasitic infections is associated with a particular set of symptoms. Roundworm usually leads to malnutrition, impaired growth and development as well as abdominal obstruction. Whipworm is associated with growth retardation, chronic colitis, and iron deficiency anemia (Berkley and Jamison). A recent study conducted in Jamaica also found a relationship between whipworm and psychomotor development among children aged three to six (Unesco, January, 1990, b).

Iron deficiency anemia (and accompanying fatigue) is associated with hookworms while schistosomes contribute to decreased work capacity and severe disease (Berkley and Jamison). Clinical features of infection by schistosomes includes fever, weakness,lassitude, muscular pain, nausea, vomiting, diarrhea and fatigue (Pollitt, 1990). Although the research on the effects of schistosomiasis is flawed, it seems abundantly likely that such school-related outcomes as attendance and achievement are negatively influenced by this symptomology.

In general, geohelminthic infection is linked to poor cognitive function, educational attainment and learning ability. It is unclear, however, whether the relationship is causal or confounded by intervening socioeconomic variables (Nokes et al.). Nevertheless, roundworm, whipworm and hookworm are all considered to exert heavy negative influence on learning aptitudes and moderate negative influence on school attendance (Education Development Center).

Roundworm, hookworm, and whipworm can be treated with a single dose of an anthelminthic yearly, although in the case of hookworm this must be supplemented with ferrous sulfate in order to prevent morbidity. A single dose of praziquantel every few years will prevent significant infection levels of schistosomes (Berkley and Jamison). Treatment costs are low. A conservative estimate of operational program expenses suggests that, for a ten-year treatment program, cost per child would fall between $10 and $15, including administrative and complementary inputs (Berkley and Jamison).

A recent study in Montserrat, West Indies demonstrates that chemotherapy targeted at school-aged children can achieve an overall reduction in the prevalence and intensity of geohelminth infection. Equally important, the study shows that treatment can be implemented within an existing health infrastructure (Bundy et al., 1990).

Mass treatment of children in their schools is viewed as a powerful tool for improving health. It has the potential to reduce infection while simultaneously serving as a focal point for health education and the delivery of other interventions to improve health, particularly iodine and vitamin A supplementation (United Nations Development Programme Interregional Project). Several studies also capture benefits of in-school treatment programs that directly relate to school performance variables (United Nations Development Programme Interregional Project).

In Jamaica, the removal of whipworms in a sample of school-aged children led to a significant improvement in auditory short-term memory as well as retrieval of information stored in long-term memory. Indeed, after nine weeks, treated children were not significantly different from an uninfected comparison group in two tests of cognitive function. This investigation suggests that whipworm infection has an adverse impact on cognition. Treatment, however, can partially reverse these effects (Nokes et al.).

In Kenya, children with large parasite loads performed more poorly on tasks of visual discrimination and memory retrieval than a matched group of students treated with albendazole. The study was conducted as a double blind clinical trial (Pollitt et al., 1991).

There are multiple paths for whipworm to affect school performance. Heavy infections produce an inflammatory response that may affect children's arousal level through brain function alterations. Growth retardation, another concomitant of whipworm infection, also tends to be associated with poor levels of school achievement, although the mechanism by which this occurs is not understood. In addition, heavy infections lead to iron deficiency anemia with the adverse consequences to school performance discussed earlier (Unesco, January 1990, b).

As noted, helminths affect nutritional status in several ways depending upon type. Whipworms, for example, affect enzymatic digestion and cause bacterial overgrowth while competing for the host's nutrients. Roundworms impair the absorption of fat, protein, and Vitamin A. Hookworms are considered to be one of the principal causes of anemia due because of the blood loss they cause (Gopaldas, a). Moreover, the most common forms of malnutrition in the developing world (PEM, iron deficiency anemia, and Vitamin B deficiency) are all aggravated by helminth infection (Stephenson,a). The diarrhea produced by worms further reduces nutritional status while malnourishment, in turn, lowers the organism's resistance to infection by a whole range of infectious agents (Unesco, February 1990).

The impact of worm burden is often exacerbated by cultural practices. In many countries, mothers feed their children less during bouts of parasitic disease; a prevailing belief holds that the way to help children get rid of worms is for them to eat less (Tomkins, in The Imperial College of Science, Technology and Medicine Proceedings).

Research indicates that the growth of children with intense worm infections may be seriously impaired. These effects are primarily due to worm infections and can be reversed by deworming (Pollitt et al, 1991; Stephenson, 1987; Cooper et al, 1989 as cited in Unesco, February 1990). Although there is little direct evidence regarding the effect of helminthic infection on intellectual development, the physical consequences of worm burdens, such as anemia and stunting, are significantly correlated with cognitive development and educational achievement measures (Pollitt, 1990).

Recent investigations show that the treatment of intestinal helminths leads to improved physical fitness, growth, and appetite among students in areas where helminths and stunted growth are highly prevalent (Stephenson et al.). Treatment also results in improved performance on cognitive tests on tasks of vigilance and attentiveness. Such an effect would not be readily observed on cognitive exams that primarily test accumulated knowledge or school achievement (Nokes et al).

Pollitt (1990) notes that the task ahead lies in defining the effects of helminth infection on school learning variables independent from or in addition to those effects related to nutritional status variables. Other issues that still need to be addressed are the degree to which intensity of infection is important and whether some individuals display a propensity toward helminthic infection.

Yet, despite our imperfect knowledge concerning the impact of helminthic infection on school achievement, a key fact remains clear. The problem often peaks among school children who need to avail themselves fully of their scant educational opportunities. Significant impediments to school attendance, concentration, and cognitive development rob children of their potential to benefit from education.

*4. Sensory Impairment*

Prevalence data for hearing and sight impairment among primary school children are not available. However, a study in the Philippines (Florencio) found that 2 percent of students tested had vision impairment. This investigation also found that the largest proportion of students with poor eyesight were in the first grade. As the grade level studied rose, the percentage of children with normal vision increased. This finding provides strong evidence that children with poor sight have higher rates of attrition than their normal vision peers. Such attrition may well reflect higher rates of school failure although the study did not test this hypothesis. However, mental ability and eyesight were the two most robust predictors of academic achievement for the sample studied.

Florencio also examined hearing acuity in her sample and found that 13.5 percent experienced some degree of impairment. As noted earlier, hearing loss appears to be linked to mild iodine deficiency. Investigators in China found that the mean level of hearing for normal school children in an iodine-deficient, remote area was significantly lower than for a comparison group of children( Yan-You and Shu-Hua, as cited in Pollitt, 1990). Differences between the two groups disappeared after three years of iodine supplementation. As noted above, Nokes et al. found a correlation between presence of whipworms and impaired auditory memory and cognition.

A study conducted in Brazil established a relationship between visual acuity and on-time promotion of students. Researchers found that almost half the students suffered from some level of visual impairment. Students with good eyesight were, on average, 21 percent more likely to be promoted on time than visually impaired children. Visual acuity was the most important factor influencing student achievement (Batista Gomes-Neto et al, as cited in Israel and Hornsby).

Thus, while a comprehensive body of literature does not exist on prevalence and impact of sensory impairment on school performance, available studies strongly suggest that vision and auditory problems constitute significant educational risk factors for school-aged children. Sensory impairment limits a student's exposure to classroom stimuli and may interact with vitamin A or iodine deficiency to create negative synergisms for the child in school.

### 5. *Temporary Hunger*

Although reliable estimates on the number of children who come to school every day feeling hungry do not exist, short-term or temporary hunger is unquestionably a pervasive condition in developing countries. In the school setting temporary hunger commonly occurs when children come to school without having eaten breakfast. The result of this short-term fasting is a child more easily distracted by irrelevant stimuli (Pollitt et al., 1983). Because hunger appears to cause inattentiveness, it is likely to influence school performance and learning.

This is the rationale most often presented to justify the provision of school breakfast and lunch programs. Evidence from the Philippines suggests that "feeling hungry" in school is associated with poor attainment levels (Popkin and Lim-Ybanez, cited in Unesco, January 1990 a). While it has been established that temporary hunger has an effect on cognitive function, further research is needed to understand implications for school achievement (Unesco, 1989).

Several studies in the classroom have suggested that immediate improvements may occur in children's behavior following receipt of a snack or drink (Laird et al.; Keister; and Benton et al., as cited in Unesco, January 1990 a). Adaptive behaviors to temporary hunger appear to be short-term in nature and generally disappear when the child is no longer hungry (Pollitt, 1990).

Researchers in Jamaica found that the provision of school breakfasts to primary students had a significant effect on attendance and arithmetic scores but not on weight or spelling scores (Powell et al.). The difference in results obtained for the different measures may in turn be a reflection of the different problem-solving skills required to perform the tasks. Spelling is done by rote; arithmetic involves the application of rules to novel situations. Students who are easily distracted because of temporary hunger would be more vulnerable to low scores on arithmetic tests than their less hungry peers.

Temporary hunger is likely to constitute an educational problem for well nourished and malnourished children alike. It is not similar, therefore, to PEM with respect to either causes or manifestations. The severely malnourished child often is not hungry, and the very hungry child may or may not be malnourished. However, in terms of school achievement, malnourished children may be more susceptible to the effects of short-term hunger in light of other cognitive dysfunctions associated with their nutritional state.

Evidence to support the view that the effects of short-term hunger may be more damaging to children who have a history of malnutrition was found in a study of a school breakfast program in Jamaica (Simeon and Grantham-McGregor, as cited in Pollitt, 1990). The students who were affected detrimentally in most cognitive tests by missing breakfast were those who were wasted and either stunted or previously malnourished. When a history of malnutrition was combined with missing breakfast, the effect on cognitive functioning was even more profound than when either condition appeared singly.

Wilson (1983) addressed the issue of hunger and its impact on school work in his review of the literature on interrelationships among diet, physical growth, verbal development and school performance. He noted that the effects of current diet on school performance are not well documented. Several studies find, although a few fail to do so, that even in relatively well-nourished populations in the United States, temporary hunger (as opposed to malnutrition) may adversely affect attention, interest, and learning. Such findings are consistent with Latham and Cobo's hypothesis (as cited by Wilson) that low energy leading to inactivity has short-term effects on learning that can be cumulative, regardless of long-term nutritional status.

Additional support for this hypothesis was found in a study of diet and school performance in Guatemala. A child's total diet was found to be the largest and most significant factor affecting a teacher's assessment of performance when prior verbal attainment, size, and a large number of other variables were held constant. The investigator concluded that this clear finding provided strong support for the Latham and Cobo argument that current levels of energy have an important impact on learning and performance, even among children with comparable prior nutritional status and comparable levels of ability (Wilson).

Many of the studies examining the relationship between school feeding programs and school achievement fail to support the view that such interventions extend educational benefits to children at risk. This is largely a reflection of study design problems which yielded inconclusive findings rather than the presence of strong evidence to the contrary (Levinger). Where investigations have been carefully controlled (as in the case of Jamaica), results appear to favor this intervention.

## Conclusions

Vast numbers of school-aged children in developing countries face major health and nutrition problems that adversely affect their ability to take advantage of the limited educational opportunities available to them. Many of these children have a history of PEM as well as current nutritional deficiencies including deficits in body stores of iodine, vitamin A and iron. These conditions are exacerbated by helminthic infection which is highly prevalent among school-aged children and particularly inimical to their healthy growth, development and educational progress. Temporary hunger and sensory impairment are also widely prevalent conditions (despite the fact that exact numbers are unknown) that vitiate attempts made by children and their families to reap the benefits of classroom instruction.

Most of these educationally limiting conditions are amenable to relatively low-cost intervention strategies that can halt their negative impact on learning and school achievement. However, children who have experienced prolonged periods of malnutrition, infection or sensory impairment probably face accumulated learning deficits that must be addressed. Preschool programs, nutritional supplementation for at-risk infants, toddlers and their malnourished mothers, as well as patenting education will make important long-term contributions to school achievement. School snack and breakfast programs also appear to be important tools for overcoming problems associated with short-term hunger.

Any one of the health and nutrition problems discussed here constitutes a handicapping condition for the development of a child's ALC. All too often, however, the conditions exist not singly but in combinations that produce negative synergies. Consequently, compensatory strategies must be developed to improve child quality. In addition to such interventions as deworming, micronutrient supplementation, and the provision of school snacks or breakfasts, developmentally facilitative classrooms that foster ALC must be offered to children whose histories suggest that they will have difficulty in making satisfactory educational progress.

## IV. A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING HOW HEALTH AND NUTRITION FACTORS INFLUENCE SCHOOL ACHIEVEMENT: THE ACTIVE LEARNING CAPACITY MODEL

A comprehensive examination of how health and nutrition considerations influence school achievement needs to reflect some implicit or explicit theory regarding the factors that determine classroom learning. Such a theory must encompass both child and school characteristics as well as an understanding of the processes that shape the teacher-learner interaction. Surprisingly, in light of the evidence presented thus far, most studies of pupil achievement determinants fail to specifically address health and nutrition considerations (Pollitt, 1990).

One exception to this generalization is Pollit's (1990) review of literature on the relationships among school learning, malnutrition, infection, hunger, and sensory impairment. In that work, Pollit identifies four determinants of school learning: student aptitude; time-on-task (including attendance and enrollment considerations); perseverance (i.e. motivation, arousal, attention, vigilance); and, quality of instruction. He then assesses how malnutrition and infection affect school achievement in terms of each of these determinants.

This model is useful in calling attention to health and nutrition as important contributors to educational outcomes. Nevertheless, a more dynamic model is needed to capture relationships among variables. How, for example, do the effects of nutrition status interact with a child's access to school? How do a child's early social environment and nutrition status reciprocally influence each other? In short, causal relationships among independent variables must be analyzed in depth, given their potentially high significance.

A second requirement for a model seeking to depict the relationships among health, nutrition, and successful completion of basic education is that the model must reflect some of the higher order cognitive demands that active learning places on students. This is because, with the advent of basic education reforms, more active engagement in the learning process by primary school children is either underway or imminent. Will children have the cognitive and physiological capabilities to fulfill these new demands and expectations? Asked another way, the question is whether a new conceptualization of school achievement determinants is needed in order to capture some of the changes occurring in developing countries with respect to teaching-learning behaviors and expectations.

Earlier in this monograph, the notion of active learning capacity (ALC) was introduced as critical in understanding how child quality acts as a determinant of learning outcomes. ALC was defined as *a child's propensity and ability to interact with and take optimal advantage of the full complement of resources offered by any formal or informal learning environment.* If the quality of instruction (including the availability of teaching-learning resources and teacher quality) and quality of the school plant are held constant, then the following relationship is posited: **As a child's ALC increases, the child's school achievement will also rise** (assuming that the school does not penalize or discriminate against children with high ALC).

Three sets of variables influence ALC. **Primary variables** are those that significantly affect ALC both directly and, through their effects on the secondary variable set, indirectly. The variables within the primary set interact with each other, at most, to a *moderate* degree. *Primary variables are also influenced by the secondary variable set, although this relationship is not as intense as its reciprocal.* Among variables in the secondary set, the level of interdependence is *high.*

Both the primary and secondary set of variables focus on **child quality**, that is, those *characteristics the learner brings to the classroom* that play a significant role in determining school outcomes. *Mitigating variables*, the third set, have potential to alter, for better or worse, the impact of primary and secondary variables. The focus of mitigating variables are the processes and interactions that occur *in school* to determine ALC and, through ALC, school achievement. In other words, mitigating variables capture those moments when child quality and school quality encounter each other. The nature of this encounter – its content and processes – will largely determine whether a child completes basic education or be among those who are almost assuredly confined to the margins of society.

**Primary ALC Variables**

Three primary variables determine ALC: health/nutrition status; hunger level; and, psychosocial support. These factors are, to be sure, often associated with such family background indicators as family size, family social class, family income, birth order, and gender. Indeed, family background appears to be influential in determining school achievement in developing countries when the formal schooling is highly institutionalized, when class structures are clearly defined and for subjects that are linked to the parents' own knowledge (Lockheed, et al., 1989). However, the significance of these background (or environmental) variables in terms of ALC is that they are assumed to influence, co-vary with, or serve as a proxy for, the primary variable set (and, indeed, for several of the secondary variables as well). Thus, their effects are captured implicitly albeit not explicitly. Each of the primary variables will be now be defined and reviewed in turn.

**Health/nutrition status** refers to both *current* and *prior* bouts of PEM, micronutrient deficiency disorders, sensory impairment (particularly vision and hearing), helminthic infection, and other physically or mentally handicapping conditions that impede a child's propensity and ability to interact with and take optimal advantage of learning resources and opportunities. Numerous findings concerning the ways in which health/nutrition status influences ALC were presented earlier in this monograph. Among the most salient relationships and observations were the following:

With respect to **PEM**:

- Height-for-age (a measure of *prior* nutrition) is a strong predictor of school enrollment and is positively associated with grade levels. Taller children have higher levels of verbal development. Height-for-age is also positively associated with performance on reading, spelling and arithmetic tests.

- Both *current* and *prior* PEM correlate with poorer cognitive function, poorer school attendance, and poorer school performance.

- PEM *prior* to school enrollment retards physical and mental development and negatively influences age-appropriate school enrollment.

- Children *currently* receiving high energy diets perform better in school.

- Greater weight-for-height (a *current* nutritional status indicator) correlates with better performance on concentration tests.

With respect to **micronutrient deficiencies**:

- Vitamin A deficits are a leading cause of nutritional blindness and, where severe, preclude school participation. The link between vitamin A deficiency, diarrheal disease, acute respiratory infection and other vision problems (e.g., night blindness and limited peripheral vision) also directly influences school outcomes.

- Iodine deficiency in school-aged children is linked to cognitive function impairment and fewer years of participation in school. Maternal iodine deficiency can cause cretinism, less severe but irreversible mental retardation, and auditory impairment among infants who are then unable to enroll in school.

- Iron deficiency, whether caused by dietary inadequacy or parasitic infection, exerts a high degree of influence on aptitudes and moderately influences school attendance. Consistent, strong relationships for both preschool and school-aged children have been found between iron-deficiency anemia, impaired cognitive function and poor school performance.

With respect to **helminthic infection**:

- Heavy worm burdens are associated with impaired cognitive function and delays in psychomotor development.

- Helminthic infection adversely influences attendance, enrollment, and school completion.

- The presence of parasites leads to other health- and nutrition-related problems that have adverse consequences for school achievement and ALC. Specifically, PEM and iron deficiency anemia are brought on by severe helminthic infection.

With respect to **sensory impairment**:

- Vision problems constitute a significant barrier to learning unless corrected and appear to be associated with primary school completion rates.

- Mild to moderate hearing loss can significantly impede satisfactory progress in school.

The second primary variable that determines ALC according to the model under discussion is the child's **temporary hunger level**. As noted earlier, the malnourished child does not necessarily experience hunger, and the hungry child is not necessarily malnourished. Hence, a distinction is needed between health/nutrition status and short-term hunger for the purpose of determining how each contributes to ALC.

Hunger contributes to a child's distractibility, inattentiveness to environmental stimuli, and, adaptive behaviors of passivity and inactivity. These effects are more apparent when the child who is hungry is also malnourished. The response to hunger directly impinges upon the development of a child's ALC. Exploratory activity is likely to be shunned rather than sought after by the hungry child.

The final primary variable in the ALC model is **psychosocial support**. Encompassed in this concept are such traits as the degree to which parents, caretakers, community leaders, and other significant adults encourage child independence and inquisitiveness; promote play; and, hold expectations that favor learning as well as formal schooling. Psychosocial support also relates to the degree to which community institutions, values and norms promote the healthy growth and development of children. The extent to which parents and caretakers differentiate their behaviors and values on the basis of a child's gender will also play a role in establishing how much psychosocial support a child receives.

One dimension of psychosocial support is the quality of caretaker-child interaction – the level of stimulation and nurturance a child receives from primary caretakers, generally mothers or older siblings. Malnourished mothers and caretakers often provide limited stimulation to their children as an adaptive response to their low energy levels. Similarly, malnourished and hungry children often exhibit, depending on their condition, lassitude or irritability. These conditions often fail to elicit responses from caregivers that facilitate healthy growth and ALC development.

There is also a cultural dimension to psychosocial support. Research in Nepal, for example, demonstrated that modernity of parental attitudes and parental demand for their children's education were both significant determinants of children's schooling (Jamison and Lockheed, as cited in Lockheed et al., 1989). In Thailand investigators found that parents' aspirations for their children's education was the most important predictor of educational attainment for sons (Cochrane and Jamison as cited in Lockheed et al., 1989).

Just as the health/nutrition status variable interacts with hunger level so that the impact of temporary hunger is exacerbated in a malnourished child, the same type of interaction occurs with psychosocial support. Specifically, parental expectations for malnourished children appear to be lower; this explains the tendency among parents of malnourished children to delay school enrollment and to accommodate (and perhaps reinforce) such adaptive behaviors as low levels of exploratory behavior.

Despite this relationship between psychosocial support and a child's nutrition/health status, psychosocial support is considered to be a primary variable in the ALC model because, by itself, it is likely to account for a significant portion of the variance among children with regard to ALC. It should be noted that while psychosocial support is related to family class, it is a different, broader construct.

**Secondary ALC Variables**

Three variables are considered secondary in determining ALC: prior learning experience; a child's learning receptiveness; and, a child's aptitudes for learning. The first variable focuses on interactions the child has with others. The remaining variables are concerned with qualitative characteristics of the child. Each of these variables will be defined and examined in turn to establish patterns of relationship *between* the primary and secondary variable sets as well as *within* the secondary set.

**Prior learning experience** refers to the child's exposure to formal and informal situations conducive to the acquisition of new knowledge and skills. This experience may take place within the home, in a primary school, day care center or in a less formal preschool setting. Participation in preschool programs is known to improve significantly a child's subsequent school performance (see, for example, Landers; Lockheed and Verspoor; Haddad; McKay et al.).

A child's health and nutrition status unquestionably influences prior learning experience. As noted earlier, age of school enrollment, school attendance, and academic progress (all aspects of prior learning experience) are sensitive to insults to a child's biochemical makeup. It is because of these relationships that prior learning experience is categorized as a second tier determinant of ALC.

**Learning receptiveness** refers to a child's motivation, arousal, attention and vigilance. Health/nutrition status and hunger level primarily exert influence on this variable in ways that are either reversible or temporary. Prior learning experience and psychosocial support (particularly the quality of the caretaker-child relationship) also combine to further influence learning receptiveness.

**Aptitude** is frequently associated with IQ. More generally, it relates to the time a child needs to learn a particular task. Learning receptiveness, particularly those dimensions of it that relate to the child's ability to attend to stimuli and to concentrate, affects aptitude. Malnutrition (especially PEM and iodine deficiency) significantly depresses a child's aptitude although the effects may be reversible in some instances if the child's environment is highly facilitative. Iron deficiency anemia also has a direct bearing on aptitude although the effects of this disorder can also be corrected.

Studies have shown that students vary in the effort they expend on schoolwork. When children perceive themselves as performing efficaciously (i.e., "aptitudinally" ), the effort they put forth increases (Lockheed et al., 1989). Thus, aptitude influences ALC by increasing the intrinsic reward (and, hence, the level of positive reinforcement) a child is likely to reap from taking optimal advantage of the full complement of learning resources available.

**Mitigating ALC Variables**

Mitigating variables are concerned with processes and interactions that occur in the classroom. Included among these variables are quality of instruction, teacher quality, availability of learning materials, and the provision of direct services to school children that reduce hunger, malnutrition, infection and sensory impairment. They are described as "mitigating" because they have the potential to partially offset some of the ill effects to ALC caused by the primary and secondary variables.

Classroom instructional strategies that are developmentally facilitative and compensate for accumulated nutrition- and health-related learning and attention deficits constitute an important mitigating strategy. Little or no research has been done to date on whether malnourished, ill, hungry or impaired students elicit a less favorable response from their teachers than their healthy peers, However, such a negative interaction is highly plausible in light of evidence that suggests such a cycle between young children and their caregivers. Studies bear out that pupil performance is higher when teachers hold high expectations for student achievement. To the degree that malnutrition, infection and sensory impairment deflate teacher expectations of students, the full potential of the school to mitigate the effects of ill health and poor nutrition cannot be achieved.

Deworming, micronutrient supplementation (particularly with vitamin A and iodine), simple vision and auditory screening, and the provision of school breakfast or snacks, figure among those measures that are currently receiving increasing attention in light of the ambitious basic education goals agreed upon by international donors and developing country governments alike at the Jomtien meeting. Measures to improve environmental sanitation (e.g. provision of water and latrines) and nutrient intake through the introduction of school gardens are also viewed, under this definition, as mitigating variables as is the inclusion of health and nutrition-related content in the curriculum.

Figure 1 shows the relationship among the three sets of variables and ALC. The figure clearly depicts that interactions occur both *within* and *between* variable sets. The figure also reflects the theoretical assumption that gains in a child's ALC directly influence school achievement outcomes. Note that the primary and secondary variables describe characteristics that the learner brings to the classroom (assuming the child is enrolled in school) and thus focus on child quality. In contrast, the mitigating variables refer primarily to qualitative variables *exogenous* to the child that have a bearing on ALC. Also note that the variables in the primary set while somewhat interdependent, are less so than the variables included in the secondary set. Thus, within the primary variable set, interrelationships are shown with thin arrows; thick arrows are used within the secondary set. Similarly, the flow of influence from the primary to secondary set of variables is captured by a thick arrow, whereas the reciprocal movement is depicted by a thin arrow.

**Conclusions**

The ALC model responds to the need for a dynamic portrayal of the complex relationships among the determinants of educational outcomes. It represents a departure from previous analyses in that it captures the high degree of influence health, nutrition, sensory impairment, and temporary hunger exert on the quality of the child and, hence, on the child's learning outcomes. The model depicts relationships both within and between distinct sets of variables so that negative synergies that operate to impede school achievement can be readily understood.

In an excellent review of seven frameworks for the analysis of child survival, growth and care of the post-survival child, Myers (1992) offers several important insights concerning the characteristics that any highly explanatory model of child development must have. Each of these "essential characteristics" will be briefly noted and described in terms of how it relates to the ALC model under discussion.

*A useful model needs to link community, family, national institutions, programs and policies.* The ALC model attempts to capture community and family through discussion of psychosocial support. The influence of national institutions, programs and policies is addressed through the mitigating variables. Furthermore, an analysis of psychosocial support and prior learning experience would reflect programs in place that reach infants, preschoolers, and their mothers through parent education, nutrition, health, and other community-based interventions.

*A useful model is not linear. It reflects the processes, mutual interactions, or synergisms that occur over time and that are a regular feature of child development.* The ALC model depicts relative degrees of interaction among variables that operate over time to influence a child's capacity to take advantage of learning opportunities. The model reflects the view that health and nutrition affect growth and development through a two-way, interactive relationship.

*A useful model portrays the child as an actor who influences the development process.* In the ALC model, the child is not viewed as a passive recipient of interventions and classroom teaching. Indeed, the outcome variable, active learning capacity, suggests that the child is at the center of processes that include exploration, information-seeking, and involvement in community, home and school.

*A useful model captures cultural differences inherent in the process of child development.* The treatment of psychosocial support (with its cultural component) as a primary variable is consistent with this approach.

*A useful model integrates epidemiology, psychology and other social sciences into its explanation of selected child development processes.* The principal knowledge domains around which the ALC model is built are epidemiology, anthropology, and psychology.

*A useful model incorporates several levels of the child's environment into its explanation of the processes under discussion.* The ALC captures processes that influence (and are influenced by) the child at home as well as in the community and at school.

Three additional advantages of the ALC model should be emphasized. First, it gives renewed attention to the importance of child quality (as opposed to teacher or curricular quality) as a determinant of school achievement. Second, the model highlights the interplay between school quality and child quality. It holds out the promise that through well planned and well executed interventions, conditions detrimental to a child's ALC can be mitigated.

Finally, the model is consistent with the concept of **lifelong learning** that is so much a part of the basic education movement and many curricular reform initiatives. By placing ALC rather than school achievement as the outcome variable, the model highlights student ability to take optimal advantage of learning resources both in and out of school. It is precisely this skill, the ability to use learning resources wisely, that lies at the heart of whether school leavers avail themselves of such ubiquitous features of development strategies as health extension services, non-formal training opportunities, and community leadership formation.

Unfortunately, most citizens of the developing world have scant exposure to classroom instruction. Therefore, the development of an individual's ability and propensity to engage in post-school learning must be considered absolutely essential to any strategy designed to maximize returns on education sector investments. At the same time, however, comprehensive efforts to improve children's access to and success in basic education programs must be expanded.

## V. REFLECTIONS ON THE FUTURE

Educators frequently discuss the potential of a **child** to learn. However, when attempting to prophesy educational outcomes, the potential of a **school** to respond to the biochemical and biosocial organism sitting in the classroom is at least as important. Why? The very essence of the learning operation is interactive. The learner takes cues from the environment, responds to them, receives feedback, and develops insights, attitudes, knowledge, and behaviors based on an iterative process of thrust and parry. Such a dynamic belies the notion that a child's learning potential – the likelihood that a particular child will achieve defined learning objectives – is fixed in some immutable fashion. Unfortunately, in common parlance this is what the term "learning potential" has come to mean: an IQ score or some other defining indicator that establishes a blueprint for the child's future school experience.

From an educator's perspective, therefore, the challenge is threefold. First, we need to understand *how* such child characteristics as health and nutrition status impede learning.

Second, armed with such knowledge, we must understand *what to do* with this information both in the classroom and in the community at large. Third, we must *create the milieu* at the policy, school and community levels that will support these actions.

Despite the enumeration of these three tasks, they should not be viewed as sequential. Indeed, they are optimally carried out concurrently once a certain threshold of knowledge has been created and crossed. Thus, basic research is essential to establish the case for treating helminthic infection or micronutrient deficiencies, for example, as both *educational* and *health* problems. However, once the evidence achieves the status of "compelling," it is time to shift gears.

Efforts should then be directed toward the *identification and testing of specific classroom practices that address through remediation and compensation the cognitive handicaps carried into the classroom by children who are sick and malnourished.* We cannot allow ourselves to believe that current practices are writ in stone; nor, can we accept the notion the education sector's financial and human resources are too scarce to improve the efficiency of schooling.

**Creating a Favorable *Policy* Environment**

By way of illustration, here are some tasks that must be performed in conjunction with research on the relationships among infection, micronutrient disorders, and cognitive function if we truly care about what happens to children in schools. This listing is not in priority order, nor is it complete. Rather, it is intended to shed light on how the fields of cognitive psychology, epidemiology, anthropology, educational planning and pedagogy must each play a role in removing the health and nutrition obstacles children need to overcome if they are to participate in basic education.

> Task One: **Create mechanisms and processes to facilitate coordination between ministries of health and education.** The appropriate mechanisms will vary from country to country. In one case it may be a formal body of advisors, while in another situation the appropriate mechanism may be as simple as a liaison officer in each ministry.
>
> Task Two: **Identify and strategize around education sector points of resistance to school-based health and nutrition interventions.** It is a truism that all bureaucracies resist change. This is especially true for ministries of education that face burdensome challenges with scarce resources to meet them. For a health-based innovation to be successfully assimilated into a ministry of education, two conditions must prevail. The innovation must be seen as *directly* contributing to the achievement of *educational* outcomes, and implementation of the innovation must not be seen as constituting a drain on education sector resources. The identification of specific classroom practices that are demonstrably efficacious in responding to the learning needs of sick and malnourished children is an

important tactic for overcoming education sector resistance to health-related interventions.

Task Three: **Design school-based management systems that assist teachers in responding to the learning needs of children with health and nutrition problems.** Programs of remediation and compensation are urgently needed by children whose learning has been impaired by health and nutrition problems. Conditions must be created favorable to such program. Teachers are likely to modify their classroom behaviors when they are supported in their efforts to change by colleagues and supervisors; when they know precisely what is expected of them and have the requisite skills to meet these expectations; when they can see positive results that are attributable to their changed practice; and, when change is not overly burdensome. Management systems may include diagnostic tools for teachers to use in the classroom, curricular materials that are keyed to the diagnostic tools, and student profiles that can be used to individualize instruction. The introduction of such systems must be accompanied by training for teachers and supervisors alike.

Task Four: **Design and implement educational impact evaluation studies.** More research is needed to link micronutrient- or health-induced cognitive dysfunction to such important school variables as attendance, enrollment and promotion. The establishment of such linkages is a critical first step in creating the policy environment needed if theoretical research is to be translated into classroom practice. Particular attention must be given to society's most marginal groups (girls, ethnic minorities, the poor of rural or urban slum communities). To design and implement educational impact evaluation studies of worth, some important methodological issues must be addressed. For example, what indicators are most suitable for determining academic achievement? Will these indicators be sensitive to differentiated impacts among students most at-risk?

Task Five: **Gather data on educational trends in developing countries and how these trends either facilitate or hinder efforts to improve the health of children in school.** The Basic Education movement, with its promise of "education for all," has created a new policy environment for attempts to improve school enrollment, achievement, and student retention. Manifestations of this changed environment include shifts in budget outlays for education, the introduction of new curricula, and innovative approaches for bridging the gap between school and family. Each of these changes has significant ramifications for attempts to improve the health and nutritional status of children in school.

Task Six: **Design and test appropriate strategies for achieving a high degree of community participation in matters that bear directly on school-based strategies for improving the health and nutritional status of children.** A prerequisite for exploring this matter is the identification of areas in which community involvement and participation would be especially beneficial in creating the health conditions most favorable to school-age children. Improving the health of children in school requires community involvement in such programs as latrine construction, potable water system development, and a host of nutrition-based interventions including local food fortification and nutrient-dense food production. Community awareness and support are also necessary to facilitate the introduction of school-based chemotherapy and any curricular changes designed to support the learning needs of children who are infected or malnourished.

Task Seven: **Design and test promising approaches for linking maternal-child health service delivery programs to school-based interventions.** Primary health care represents a significant emphasis in most developing country health sector strategies. In practical terms, however, this has come to mean that priority has been given to such maternal-child health issues as growth monitoring, inoculation against targeted diseases, promotion of breastfeeding, and oral rehydration therapy. What other priorities relevant to the improvement of school-age children's health might be incorporated into ongoing maternal-child health programs? What investments and strategies would be necessary to achieve an integration between the aims of maternal-child health programs and efforts to remove the health and nutrition obstacles school children face in their quest for an education? Effectively, the challenge that must be addressed is how to create a seamless array of interventions that enhance the learning potential of children without having to wait until primary school enrollment occurs.

The seven tasks described thus far primarily relate to the creation of a **policy environment** propitious to programs of school health and nutrition. However, technical issues must also be resolved through a comprehensive program of coordinated research. Examples of six future research initiatives that are critical for the development of the appropriate **technical environment** will now be explored.

## Creating a Favorable *Technical* Environment

### *1. Research on Criteria for Selecting Interventions*

Not enough is known about the relative efficacy and impact of the range of available health and nutrition interventions that can improve the educational performance of children. Thus, it is difficult to answer convincingly for an often skeptical policy-maker the question of whether the costs of a deworming and micronutrient supplementation program could be offset by a reduction in the costs associated with producing a primary school graduate. A related – and unasked – question is whether governments would have the resources necessary to support the enrollment and retention of significantly higher numbers of children if in fact health and nutrition interventions achieved their potential for improving access to and success in school.

Another issue linked to the selection of interventions is whether the target population should be *all* children of school age or only those school age children who are enrolled in school. Little is known about the relative advantages and disadvantages of working with children not enrolled in school in terms of educational outcome measures. For example, are such children more likely to enroll later on if the school is linked to services for which there is perceived value? Conversely, if services are made available to children not enrolled in school, would this practice reduce the motivation of some students to remain in school since some of the desired benefits of school participation would be available to them regardless of their enrollment status?

We also know very little about "best intervention packages," that is, the relative cost-effectiveness of differing approaches and the complementarities that work best with each. Clearly, in order to assess the relative priority of interventions, some general criteria must be applied. In the absence of any field-tested and validated set of criteria, the following items are probably the most useful *at this time* for the selection of interventions: magnitude of the problem; amenability of the problem to remediation or amelioration through treatment; relative cost of treatment in relation to anticipated educational benefit; sustainability of the anticipated educational benefit flow; absorptive capacity of existing infrastructure to accommodate the intervention; level of investment required to create additional infrastructure; ease of targeting; and, likelihood of achieving a high degree of congruence between targeted and actual participants in an intervention program.

The application of these preliminary criteria to five of the most common intervention strategies for improving the educational achievement of children through health and nutrition programs would yield the conclusions noted below. These conclusions, however, must be validated *once the criteria themselves have been validated in terms of their ability to discriminate among interventions on the basis of overall efficacy.*

- **Supplementary feeding for PEM alleviation.** Relative priority for this intervention would be *low*. The limited number of feeding days in the school year makes it difficult to treat PEM through school feeding. Most evaluations have failed to uncover benefits that warrant the relatively high costs (Levinger). Benefits flowing from the intervention are not sustainable since when feeding is suspended, gains are often reversed. Given the logistical demands made by the program, absorptive capacity problems abound. While targeting is easy, leakage and substitution problems are frequent thereby reducing the congruence between targeted and participating individuals in the program. School feeding also requires a well developed infrastructure for commodity delivery.

- **Supplementary feeding for short-term hunger alleviation.** The relative priority for this type of program would be *moderate*. Temporary hunger is immediately alleviated (high amenability of the condition to treatment). Cost is high, but the benefits may also be high, especially among nutritionally deprived populations who are engaged in cognitively complex tasks (e.g., arithmetic) early in the day. Benefit sustainability stops when the feeding stops, and, therefore is low. Absorptive capacity and infrastructure demands are low if a snack is involved; they are higher (probably too high) for a full meal. Targeting is difficult unless it is assumed that all children are coming to school hungry. The likelihood that children not targeted by the program will partake in it is low if all children in a given school are assumed to experience temporary hunger.

- **Iron and iodine supplementation.** The relative priority for this intervention is *high* where deficiencies of these micronutrients are prevalent. Supplementation results in the reversibility or remediation of several educationally handicapping conditions. Cost-benefit ratios are favorable and benefits are sustainable. Absorptive capacity and infrastructure requirements are not very onerous. Targeting is relatively simple since it is not done on an individual level. Thus there is a high degree of congruence between populations of targeted and participating individuals.

- **Deworming.** For programs of this type the relative priority is *high* where epidemiological data indicate that the prevalence of helminthic infection is high. The rationale underlying the assignment of deworming to the high priority category is identical to that given for iron and iodine supplementation. There is, however, a greater need for investment in teacher training. Additional investment in the provision of water and basic sanitation services along with the integration of health education into the curriculum would greatly enhance benefit flows.

- **Visual and auditory screening.** The relative priority for this type of intervention is *moderate*. Given the limited resources available in most schools, screening will most likely result in mediation rather than correction of the impairment. Cost-benefit ratios are favorable when screening is followed by the application of such classroom management techniques as moving children who are impaired to the front of the room. There are no absorptive capacity or infrastructure barriers other than the challenge of providing teachers with the necessary training to perform the screening.

*2. Comprehensive Epidemiological Studies*

Data on the prevalence of micronutrient deficiency disorders and the incidence of helminthic infection is still incomplete. It is difficult if not impossible to target communities on the basis of what is currently known.

*3. Identification of Facilitative Classroom Teaching Practices*

If large numbers of children in developing countries come to school educationally handicapped because they are malnourished and carrying heavy worm burdens, how must classroom teaching strategies be adjusted to make certain that every child has the opportunity to experience academic success? The research agenda on how cognition is affected by micronutrient deficiencies and parasite infection will achieve its true potential to contribute to the well-being of children when the lessons learned are translated into specific teaching behaviors. For example, should instructional periods be adjusted to cope with presumed attention deficits? Perhaps three short lessons of 20 minutes each would accomplish a great deal more in helping a child master arithmetic skills that one 60 minute class. Other classroom techniques that might similarly be responsive to such students include the use and manipulation of concrete learning materials; frequent reinforcement of correct responses; the pre-digestion of curricular content into smaller, bite-sized pieces; more frequent assessment of student performance by teachers; the use of teaching techniques that are kinesthetic and multi-sensory; and, multiple and alternative opportunities for students to master "missed" curricular objectives.

*4. Validation of the ALC Construct*

What are the best techniques for measuring ALC? Is there a relationship between classroom strategies to develop ALC and a child's propensity to engage in lifelong learning? Is there in fact a direct relationship between a child's ALC and school achievement?

*5. Development of Effective Targeting Techniques*

When is it most cost-effective and appropriate to engage in targeting at the individual level? What are some of the risks and disadvantages inherent in targeting at the community level? Are there some simple, low-cost techniques that represent a compromise between individual and community targeting?

*6. Pharmacokinetic Issues*

Concomitant therapy with the drugs used in deworming has not been well studied (Berkley and Jamison). Studies need to be done to understand the effects of using various anthelmintics in differing combinations as well as with and without micronutrient supplements. Research to further the development of a time-release iron capsule is another priority. The toxicity of deworming agents has not been well established. Therefore, some level of risk is involved in administering chemotherapy to young women of reproductive age (Berkley and Jamison). What targeting practices should be followed for this group? More must be known concerning both the benefits and risks of treating young women.

**A Final Comment on Future Research Needs**

At the First Technical Meeting of the New Unesco Project to Increase Primary School Performance Through Improved Nutrition and Health (Stockholm, 1989), participants identified some additional studies that would be useful in clarifying the relationship between school performance and the conditions described in this monograph. Some of their most salient suggestions include the following.

- **Short-term hunger**. Research is needed to establish effects on *school performance* (in contrast to cognitive function).

- **PEM**. Additional investigations are needed to determine the relationship between wasting/stunting and *enrollment* (in contrast to school performance).

- **Iron deficiency**. An experimental intervention study is needed to determine the effects of iron treatment on students with anemia (in contrast to the work already done in determining effects on individuals without anemia).

- **Vitamin A**. Observational studies are need to determine the relationship between vitamin A deficiency and school enrollment, absenteeism, as well as school performance.

**In Conclusion**

Achieving a "post-child survival revolution" of educational opportunity must be a priority for all people concerned with the creation of a just and equitable world. This monograph has argued that a four pillar strategy is required to eliminate the health and nutrition roadblocks that stand between vulnerable children and the schoolhouse door. Two of the pillars – policy and technical matters – have been discussed in detail. It is now time to say a word or two about the two remaining pillars: investment and consensus.

The two go hand in hand. Thus, investment in crucial initiatives will not be forthcoming until there is consensus on the criticality of these programs. What is called for is a major effort to influence opinion-makers of all stripes from health and education ministry leaders to those who establish donor priorities. New mechanisms for information dissemination will have to be created and new networks formed.

Today, we are poised to accomplish in the field of education what the "green revolution" augured for agricultural production. New technologies including chemotherapy can significantly reduce helminthic infection and micronutrient deficiency among millions of school-age children thereby eliminating a major obstacle to learning.

Unfortunately, the green revolution has yet to fulfill its promise. This is because its technologies were never put into the hands of those who needed them most – the front-line small farmer who accounts for most of the developing world's food supply. Let's not repeat this mistake and permit a unique opportunity to slip away. We need to respond to a dual challenge. To be sure, we must uncover new insights into the relationships among schooling, malnutrition and infection. But we must also do everything possible to translate and popularize these findings so they can be applied by the host of "front-line workers" in whose hands our hopes for the next generation rest: parents, educators, community extensionists and the children themselves. New alliances, coalitions and networks will become indispensable tools as we seek to erect the pillars of a structure that will eventually shelter the dreams and aspirations of our children.

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