Contents

Proceedings of the International Workshop on Articulating the Impact of Nutritional Deficits on the Education for All Agenda

Osman M. Galal, Charlotte G. Neumann, and Judie Hulett, guest editors

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Preface

Background

Many developing countries have signed on to the United Nations declarations on Education for All promising basic education for all citizens by the year 2015. Together with international organizations, these governments are making massive efforts to increase quantity and improve quality of basic education within their national educational systems. These educational efforts raise urgent questions regarding the impact of the health and nutrition status of the school-aged population on the education systems in developing countries. The important role of school-based health services and school feeding programs in the cognitive development and school performance of children is well recognized and documented. During the last two decades, child survival programs orchestrated by UNICEF have been very successful in fulfilling the above UN declarations' objectives. These programs were mainly a response to the high morbidity and mortality among infants and preschool children all over the world. By successfully decreasing the infant mortality rate by half, the effort was considered revolutionary. As a result of the child survival program, the number of children eligible to enter school has increased by approximately 10 million per year, to a total of just under 800 million [1]. However, approximately 25% of these children remain undernourished [2].

Malnutrition affects schoolchildren's scholastic performance, age of enrollment, concentration in class, attendance, and infection rates [3–5]. Recent available data detail the strong association between nutritional insults and the health and school performance of children [4]. Further studies in Guatemala [6], the Philippines [7], Jamaica [8], Kenya [9], and Egypt [10] have come to similar conclusions. Children who are already at risk due to health nutritional problems come to school tired, hungry, and unable to cope or to benefit from their lessons [11]. Absenteeism, delayed enrollment, lowered cognitive capacity, and reduced academic achievement are all associated with an under-supply of important nutrients [12]. If children are in poor health and undernourished at school, the synergistic relationship between deprivation, poor health and malnourishment erodes the benefits of any investments in education [13]. Efforts are needed to eradicate malnutrition and protect the potential of schoolchildren to become productive adults [14].

Schoolchildren's health and nutrition

Resources and international focus have been centered on reducing infant and child mortality, but interest in schoolchildren has often been neglected [15]. Health and nutritional deficits constrain the success of development and prevents poverty alleviation, which could be achieved through education. Although there is a growing body of knowledge on the health status of children of school age, limited attention has been given to the nutritional well-being of these children. Furthermore, clear articulation of health and nutrition issues is largely absent from the education policy agenda in many countries.

International commitment to improving educational access in developing countries is not lacking. UNESCO and many non-governmental development agencies are actively engaged in projects and programs toward this end [16, 17]. Governmental commitment is also evident from the significant percentage of national public expenditure allocated to the education sector, even in countries with demonstrably declining economic performance [18]. However, the nutrition and health status and well-being of schoolchildren around the world is seldom articulated in planning for the current goal of Education for All, except for attention given to deworming and HIV/AIDS prevention in school curricula, which is a recognized international agenda [1]. Although there is a substantial body of literature attesting to the causative links between health problems, particularly malnutrition, and school performance [19–21], this research focus is largely missing from the Education for All agenda in international development [22–24]. The disconnect may be attributable to the fact that health and nutrition are perceived as problems to be dealt with in the health sector by health organizations and ministries rather than as integral to the education sector [25].

The present workshop focused on one of the most important issues facing global development today, namely the quality of the human capital being developed through educational systems for the future. Even as we recognize the impact of the HIV/AIDS pandemic on the education sector through the loss of teachers and students who drop out to take care of siblings at home [1], we need to acknowledge and act upon the demonstrated negative impact of malnutrition on a far larger proportion of children's educational outcomes. The present workshop intended to bring to the forefront evidence demonstrating the role of malnutrition in the educational outcome indicators in developing countries, where nutrition inadequacy and infections prevail.

Scope and goals of the workshop

The workshop compiled and presented data from various health and education agencies, ministries, and organizations (as well as data that are available and unpublished in literature) on the health and nutrition status of schoolchildren. Some presentations documented the interactions between poor health and nutrition and educational outcomes. Moreover, the workshop participants presented information on the nature and magnitude of global efforts implemented to improve the educational situation of schoolchildren in developing countries.

The workshop was the first step toward the long-range goal of projecting the impact of health and nutrition status on the success of investments in education. In addition, the workshop provided information for the development of educational and health policy recommendations and helped advocacy efforts to encourage international organizations to buy into improving the nutrition status of schoolchildren worldwide to enhance their school performance and potential capabilities to be productive adults.

By bringing together an international research group of scholars in economics, education, and public health from Africa, Asia, Europe, Latin America, the Middle East, and North America, the workshop was able to move the role of poor health and malnutrition as an intervening factor in education from the margins of scholarly discourse to the center. Although common sense tell us that poor health, particularly malnutrition, contributes to poor school performance, and although there is a substantial body of literature backing up this common sense, there has not been adequate dissemination of the research findings or implications nor adequate application of the research to establish policies and programs to combat poor health and malnutrition among school-age children. The workshop addressed all these issues.

The workshop

The papers presented in the workshop were in five sessions and ranged from comparatively abstract and theoretical considerations of, for example, strategies to estimate child nutrition and school performance, to concrete reports on school feeding programs in, for instance, Makueni District, Kenya. The first session, chaired by Dr. Paul Glewwe (Department of Applied Economics, University of Minnesota), explored nutrition and schoolchildren performance. The second, chaired by Dr. Sally McGregor (Institute of Child Health, UK), presented six papers on evidence-based nutrition and educational outcomes. The third, chaired by Dr. Charlotte Neumann, discussed the positive impact of animal source foods and improved diet quality in school feeding-intervention studies in Kenya. The fourth, chaired by Dr. Donald Bundy of the World Bank, evaluated "Food for Education" programs, funded by the United States Department of Agriculture. The fifth, chaired by Dr. Beryl Levinger (Education Development Center), dealt with micronutrients and food programs. And the sixth and last session, chaired by Dr. Osman Galal (UCLA School of Public Health), consisted of a panel discussion, entitled "The Way Forward," of what may be the most important question facing researchers and policy makers in the area of school child nutrition—what do we do now?

As one would expect, the workshop did not yield easy solutions to malnutrition and poor health among schoolchildren. Instead it helped identify questions and dilemmas that policy makers must confront and it presented the results of research that can help in designing optimal policies and programs. For example, because funding is always limited, how should it be allocated to achieve the best results, however one wishes to define that? Is it more important to feed younger (perhaps pre-school) children, and thus head off the stunting and wasting that would result from poor nutrition, or is it more important to feed older children, or the mothers who share responsibility for caring for younger siblings and thus can do a better job if they are adequately fed? If one can provide only a single daily meal for schoolchildren, should it be breakfast or lunch? What should children be fed? How important is it to supplement vegetable-source foods with meat? (Multiple micronutrient deficiencies are highly prevalent with even moderate amounts of meat, fish, or fowl). What approaches to food and nutrition education are most effective in combating the obesity that plagues children in much of the developed world? These are only a handful of the multitude of questions addressed by the workshop.

The workshop was especially significant in that it covered numerous regions of both the developing and the developed world that have grappled with malnutrition.

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Introduction

Ernesto Pollitt

This supplement to the *Food and Nutrition Bulletin* includes a selection of papers presented at an international meeting held from February 18–20, 2004, at the University of California, Los Angeles, titled "School Children: Health and Nutrition." The research data presented and the questions that arose about the effectiveness and efficiency of interventions presently available (e.g., nutrition education, school feeding, deworming) are at the forefront of this field of work. Although health and nutrition interventions in schools have a long history, the recognition of their potential educational benefits to schoolchildren in low-income countries has never been stronger than it is today [1]. The research work of many investigators, the leadership and funding of various international agencies, the motivation and actions of several countries, and the advocacy of interested parties have unleashed an unparalleled movement to improve the well-being of schoolchildren and their learning of the competencies required by a modern economy.

Contemporary theories and research in developmental science have shed new light on old and new data on the developmental effects of poverty and malnutrition as well as on the impact of health and nutrition interventions at different periods of children's development. These advances explain, in my view, part of the recent growth in the assessment and implementation of health and nutrition policies and programs targeted toward schoolchildren. While there is no consensus, there is wide recognition today that the psychobiologic development of children is plastic and it follows a course that uninterruptedly depends on the interplay between the changing organism and its changing environment [1–5]. The development of a child is sensitive to the influences of adverse biophysical and social-cultural factors and the long-term outcomes will generally depend on the life course events [6]. Under conditions in which populations generally live (e.g., endemic poverty), these factors do not operate as independent agents that cause particular quantifiable changes in one specific developmental domain. Rather, the effects of such factors (e.g., iron deficiency anemia) are, or can be, moderated by developmental stage (e.g., early infancy), health (e.g., infection), ecology (e.g., altitude above sea level), and sociocultural (e.g., quality of caretaking) and economic conditions (e.g., level of poverty), and together they influence the course of child development [7]. The strongest influences are generally observed during infancy and the early years of life [8–10]. Further, the effects detected in one particular domain (e.g., cognition) are rarely isolated from other domains (e.g., motor, socio-emotional) because one of the characteristics of development is precisely the reciprocal influences among subsystems within the organism [11, 12].

In agreement with the above considerations, young children could follow two different developmental courses in populations where poverty and malnutrition are typical. In one case, the psychobiologic development of children will be continuously at risk whenever poverty, illness, and malnutrition characterize their life course and their effects join. Recall that it is the number and relationships of socioeconomic and biologic stress factors and their cumulative effects that determine the developmental course rather than any one particular factor [11–15]. In the other case, with some important exceptions (e.g., cretinism, extreme deprivation), there will be a significant shift of the developmental course whenever there is a lasting improvement in their social and economic status as well as in health and nutrition [16]. This shift allows the reorientation of the developmental course toward a comparative better level of well-being.

There are no studies, to my knowledge, that have followed children from birth to adulthood and have measured the independent and cumulative effects of poverty,

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poor health, and malnutrition on intellectual development and education through the generally recognized developmental periods, across a variety of eco-cultural settings. Nonetheless, several studies in developed and developing countries have looked at selective aspects of the overall perspective presented above. These studies, which can be characterized as partial approaches to the overall picture, have focused on different degrees of poverty, poor health, and malnutrition; have looked at different developmental domains and periods; have used different definitions of intellectual development and widely different methodologic approaches, and have been conducted in a myriad of widely different eco-cultural contexts. This state of affairs in a specific area of research parallels the vast difficulties faced by social and behavioral researchers to develop universally valid, widely accepted conceptual and methodologic approaches to study complex problems in different cultures. However, owing to the social relevance of the issue at hand, it is important to scrutinize findings from available research that are well established. With careful consideration for basic issues of external validity [17], the generalizations presented in the next paragraph regarding the cumulative effects of poverty and malnutrition are efforts in this direction.

In the different ecologic settings inhabited by economically impoverished families in the developing world, 2- to 3-year-old children who are ill and malnourished carry an acquired initial disadvantage, compared with children of the same age of middle-class parents in the urban centers, for the later learning of the competencies taught in formal schools [18]. This initial reduction in the chances for success to deal effectively with problems considered important in school settings will increase up to the time when they enter primary school even though their attendance in a preschool might assuage somewhat the magnitude of the disadvantage [17]. Even larger differences will set in during primary schooling. The disadvantaged children will continue to experience the cumulative adverse effects of their poor socioeconomic background [19] and, in addition, the schools they will attend will be of a lesser educational quality than the schools available to children who are well off economically [20, 21]. Such a difference will endure if, before or at the end of primary school, the disadvantaged children drop out of school. In the absence of major social and economic changes, this one event generally prevents the acquisition of the competencies presently required by fast changing societies and modern technology [22]. In this sense, schooling is a unique window of opportunity. Consider, however, that this view is heavily influenced by the notion that there are certain competencies, valued in Westernized societies, that are, or should be, taught in schools so that the students will be eventually competitive in that kind of context [23].

Studies conducted in a span of about 40 years have tested the functional effects of improving the health and nutrition of children in early life and during the school period [24–27]. A body of information is now available that might not be complete to meet the stringent criteria of established knowledge but is sufficiently strong to allow for responsible interventions and policymaking [28]. Supplementary feeding during infancy and the preschool period led to significant improvements in performance in school achievement tests administered in adolescence [29]. Within this same study, a subsequent follow-up of the women when they were young adults showed a significant effect on similar indicators of educational attainment [30]. Of critical importance to education are the data from recent studies, which show that the cognitive and school competence of schoolchildren will benefit from health and nutrition interventions during school even though they experienced multiple and continuous biologic- and socioeconomic-induced stress in early life [25, 27]. Qualitative and quantitative improvement of the diet of rural schoolchildren led to significant improvements in their educational performance and social behavior [31, 32]. True, the health/nutrition intervention in schools is not likely to compensate for the educational loss over years of disadvantage; nevertheless, school competence will improve. In some cases, depending on the intervention, the effects will probably be restricted to improvement of school attendance [33]. Nonetheless, the benefits of school programs are such that the educational system should consider health/nutrition interventions as one way of improving the educational competency of schoolchildren.

There is need for further understanding of the cultural and economic influences in the variability of the responses of parents and teachers to some of the effects produced by nutrition and health interventions. In some situations, these responses will moderate the effects of the interventions and such an understanding helps wise policy decisions. For example, early supplementary feeding improves physical growth in populations where poverty and malnutrition are endemic [34]. While in some communities taller children were less likely to enroll late in school and drop out early [35], in other communities, comparatively taller children were more likely to drop out from primary school to help their parents at work [36]. This latter case suggests that the parents attributed greater value to the contribution of the child to the family's economy than to the educational benefits from elementary schooling [23]. In these latter communities, other indicators of nutrition status (e.g., energy intake) among adult men were related to work productivity [37].

One concern is that studies on health/nutrition interventions on schoolchildren are often guided by definitions and values of Westernized societies given to health/nutrition (e.g., stature, activity) [38] and educational (e.g., competencies) outcomes [23]. For example, researchers usually value the increments in activity that follow the administration of supplementary micronutrients [39, 40] given to poorly nourished children. However, such increment in activity among schoolchildren might explain why iron supplements given to schoolchildren in Zanzibar were associated with an increment in the repetition of grades from first-to-second-to-third grade [41]. Mothers in Tanzania [42] and teachers in other sub-Saharan communities [43] value students with a receptive disposition and listen quietly without interrupting the transmission of information. In that context, teachers might have a low tolerance for increments in physical activity. How should the educational system proceed?

The large numbers of poor children in the developing countries, the limitations of the funding for the social sector, the problems of organization and administration of large-scale health and nutrition interventions, and the ideologic differences associated with any social-political problem will challenge the implementation and maintenance of health and nutrition interventions. However, by any measure or standard, the progress made during the last 5 years in the implementation of school health and nutrition policies and programs and in the understanding of the effects of these programs has been remarkable.

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Children's healthful eating: From research to practice

Anthony Worsley

Abstract

This paper provides a brief overview of some of the challenges facing the world community in promoting the nutrition status of schoolchildren. It begins by describing the main objectives and aims of children's nutrition promotion and then moves to consider the needs and environments of schoolchildren, the purposes of education and food and nutrition promotion, and the domains of schools and teachers. In the second part of the paper the evidence bases for food and nutrition promotion are considered, especially the gaps in current knowledge. This leads to a discussion of useful practice models as well as a case study of a school health promotion program in Australia. The final part of the paper examines some proposals for schoolchildren's food and nutrition policies, which might be implemented in local schools as well as nationally and internationally. The main theme underlying these proposals is that policies must be created and their effectiveness monitored regularly and reported back to schoolteachers, health workers, school communities, and governments.

Key words: Schools, education, promotion, systems, policies

Introduction

Other papers in this supplement to the *Food and Nutrition Bulletin* describe some of the research and intervention work that is being conducted around the world to promote schoolchildren's nutrition and educational performance. The International Union of Nutrition Sciences' (IUNS) objectives in this area have been described in detail by Galal [1]. This paper aims to review, summarize, and disseminate evidence relating to children's food security in terms of its prevalence and causation; document the evidence bases about the relationship of children's nutrition status to cognition, learning, and educational achievement; identify better ways to promote healthful eating and optimal nutrition (and health) status among schoolchildren; and document the costs of nutrition deficits on educational outcomes. It is hoped that these activities will help to foster the following:

» The promotion of schoolchildren's health and nutrition worldwide.
» The identification and promotion of best practice nutrition promotion in schools.
» The review and revision of teacher-training curricula to elevate the status of schoolteachers and associated health personnel as community advocates for healthful eating.
» The implementation of school food policy guidelines via international collaborative networks (such as the health promoting schools movement).

Schoolchildren: Who are they?

Most of the world's children between 5 and 15 years of age attend schools, although many do so under difficult circumstances [2] and many cease schooling before the end of high school. A large group of children, perhaps over half, are underfed, poorly nourished, and exposed to a range of parasitic and infectious diseases [2]. Micronutrient deficiencies, such as deficiencies of iron, iodine, and vitamin A are common in many parts of the world (including affluent societies) [3, 4, 5] and overweight and obesity associated with excessive energy intakes and sedentary lifestyles are becoming serious problems for children in all countries [6]. In

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many countries in Africa, Latin America, and south Asia substantial numbers of children do not have living parents because of the impact of HIV/AIDS or other epidemics including violence. Many schoolchildren live in material poverty and in substandard or no housing with poor water supplies and little or no sanitation, and are also often exposed to violence and exploitation. Schools represent one of the few opportunities to provide children with material resources (such as food, clean water, sanitation, and shelter) on a daily basis as well as to provide them with education for their future lives. The complexity of the likely interactions between nutrition and socioeconomic causes of poor health have been well illustrated by Grantham-McGregor and Ani in their review of the effects of iron deficiency on cognition [3].

If school staff are to provide useful services for children, they need first to consider the nature of children. In most societies in the past children were not only the light of parents' lives, but they we also economic players who provided material help for their families not many years after birth, for example through assistance in agricultural labor. After "the age of reason" or equivalent, children were (and are) regarded as mini-adults sharing many of their sanctions and duties. The rise of mass education marks a significant change in this view, with children now regarded as substantially different from adults and they are required to attend primary school and now secondary school, largely for the purposes of the state (for example, to aid industrialization or militarization). Childhood, then, is a special time when children are expected to learn to prepare themselves for adult life. Liberal educationalists emphasize the value of play, experience, and exploration [7], and conservatives emphasize the vulnerability of the child. The varying views are well represented in Archard and Macleod's recent book [8]. The prevailing (but not universal) view of children is that they are legal minors who cannot make binding legal contracts and who live in another form of existence—childhood with its play and fantasy—thus requiring the care and protection of adult society.

Children have always been seen as investments in the future, but today this investment is challenged by short-term libertine philosophies that regard childbearing as a "life choice" and not as a major economic investment in the future of society [9]. The views that education and health workers hold about the nature of children and childhood will inevitably affect the vigor and ways in which they approach education and health care. Therefore, it is important for professionals in nutrition promotion and education to be very clear about the views of childhood that they espouse (see Gussow and Contento, [10]).

The child's environments

Educators and health workers must care for children and teach them within the contexts in which they live. There seems little point, for example, to teach cooking skills when children have no cooking utensils and limited access to food. A simplistic adherence to the notion that schools are places only in which basic curricula are taught ignores the complexity of environments in which children live and which create daily challenges for teachers and health workers. Schools are more than teaching centers; they are places in which children and their families come into contact with society and where services in addition to education must be provided if education is to be effective. There is little point in providing lessons in maths, science, and languages if children are too malnourished to concentrate. It is in the classroom and school yard that the effects of adverse environments are seen (by teachers and other staff) and so they are in a good position to recruit additional services (if these are available), such as additional food, anti-helmintic drugs, clean water, safety, etc. The sorts of environmental forces that affect children and their families include the following:

» Social influences: family, siblings, peers, adults; for example, if the parents smoke, the children's health is likely to be adversely affected; if parents eat poorly their children are likely to do so also.
» Financial restraints caused by unemployment and poverty, may be associated with malnutrition, child labor, and non-attendance at school, all of which affect children's educational prospects.
» The physical environment, such as the state of housing, sanitary conditions, food supply, location, and transport facilities can all affect children's health and nutrition status and ability to learn.
» Similarly, children's and their families' health status will also affect learning; for example, the prevalence of HIV/AIDS or iron-deficiency anemia will affect children's material and emotional status and their ability to profit from (or even to attend) school.
» Finally, exposure to the mediated environment can have both positive and negative effects. It may provide the benefit of stimulating curiosity and, therefore, motivate learning, but all too often it exposes children to unhealthful food products, cigarettes, and alcohol as well as materialistic, sedentary lifestyles. This is particularly evident in countries that adopt the implicit view that children, like adults, are consumers who can be exposed to marketing campaigns.

Educators have to deal with all these influences.

Children's needs

Parents, philosophers, psychologists, and educators have all considered the nature of children's needs. Many of these are similar to those of adults in that children and their families must satisfy a variety of biologic, psychologic, and social needs [11–14]. In different cultures people may place greater emphasis on some needs than others; my own list includes the following:

» Sound material environments: water, food, shelter, transport
» Love, care, and safety
» Positive social interactions
» Cognitive consistency, stability
» Stimulation, information, knowledge, and activity
» Learning support and motivation
» Healthy, positive adult models
» Hope for the future

The point is that schools are custodians of children for substantial periods of their lives and so they have a duty of care to provide for a variety of children's needs in addition to their learning requirements. For example, in societies in which children are regarded as minors, schools may be responsible for the quality of food fed to their students; if the food inhibits learning (e.g., because of insufficiency [15]) or if it contributes to unhealthy states such as obesity (because of excessive energy content [16]), school and education administrations may be liable to future legal redress by the children or their families.

Duty of care of children's health and education systems

Several systems may be responsible for children's education and welfare including their families, pre-school centers, schools, health facilities such as mothers' and children's health services, religious organizations, and local communities and local government facilities. In addition, the mass media may provide special programs tailored to the interests and needs of children. These agencies may need to be considered within the contexts of individual cultures when considering the range of educational services provided. From the point of view of health and nutrition, if children spend more than a few hours in any institution we have to ask whether these agencies are accountable for food, nutrition, and health. The answer will vary from country to country but there should be clear policies about the responsibilities of all agencies in which children spend substantial amounts of time. Children need feeding regularly—Does the agency provide good food, and, if not, what arrangements has it entered into to ensure that children are well fed?

The purposes of education

Schools provide children (and their families) with a number of education services. These have been debated by many educationalists such as Dewey and Skemp [7, 17]. Most note that schools should meet the needs of individual children and of the wider society; for example, schools may be good places to teach children hygiene principles to curb the spread of infectious disease in the wider society (this is sometimes called "schooling"). By contrast, there are more individual benefits that may accrue to the child from a broader education [17]. Some of purposes of education include the following:

» Self actualization—learning how to be happy and good
» Cognitive—learning about the world so that it is more predictable/controllable. Cognitive learning is often assessed in nutrient supplementation programs, but it is only one (important) aspect of education.
» Socialization—learning the rules of the culture and learning how to get along with others
» Emotional—learning how to control one's emotions
» Life skills—acquisition of life skills such as reading and arithmetic, cooking and shopping, and job-related functions such as learning to use a keyboard

The attainment of these goals depends on the creation of a happy learning community in the school. This depends on management and organizational and teaching skills and on material resources such as adequate buildings, clean water, sanitation, and healthful food supplies. Summaries of what schools can do

TABLE 1. Suggested roles and requirements of schools

What should schools *do*?	What do schools *require*?
Care for and protect children	Infrastructures
Act for parents	Organization and management
Socialize children into "culture"	Physical infrastructure (e.g., buildings and equipment)
Expose children to new experiences	Resources to care for children
Teach about the world and people	Trained, learned, experienced teachers
Instill lifelong learning schema	Well-designed curricula and pedagogies
Model healthful behaviors	Peace and harmony
Motivate learning	

for children and the requirements they need to do so are listed in **table 1**.

The effects of education

The effects of education are well established but worth summarizing. First, education gives people a sense of control over their lives and a future orientation that encourages investment in the future, such as saving for old age [18, 19]. Second, it fosters life-long learning and the socialization of children into active citizens. Third, it clearly promotes higher standards of health when girls as well as boys are educated [20]. Fourth, it promotes the economic well-being of society.

The aims of food and nutrition education promotion

There is a substantial body of literature that deals with the aims of food and nutrition education promotion [10]. The key aims include the following:

» The provision of healthful food now and in future. This raises the issue of ecologic sustainability and thus of education about nature and ways to maintain the ecosystem. It also implies that before any learning can occur children must be well-fed.

» Provision of procedural knowledge and skills associated with exposure to a variety of healthful foods and the development of preferences for healthful foods as well as the ability to acquire and prepare healthful, tasty foods. The idea is that food consumers should be active participants in food preparation and consumption rather than passive purchasers of mass-marketed, poor quality foods. The "Slow Food" movement is an example of an active consumer approach [21].

» Acquisition of knowledge framework (core schema) for interpretation of food and nutrition information [10, 22]. This equates to an understanding of key nutrition principles such as energy balance, the importance of food variety, etc., which will enable learners to interpret and assimilate future information, i.e., to know what they are doing in relation to food and nutrition. If effective, this helps consumers defend against quackery and marketing of foods of dubious quality.

» To emphasize the salience of food and nutrition to the individual and in the community. Food is important but many consumers do not know it. School education can impart life-long motivation to eat healthful foods. Educators are also in a good position in the local community to advocate for good nutrition. For example, home economics teachers may call for reduction in the supply of poor quality foods to children at school. At present, good nutrition has few effective advocates in many countries.

» Provision of environments and resources that maintain healthful food supplies. The aim of nutrition promoters is to feed children (and their families) well. Therefore, it is important that all places in which children usually eat are provided with healthful food. This often requires the development of local food policies by schools, preschool centers, religious organizations, and health facilities, as well as guidance on food advertising and marketing.

Stakeholders in schools: Who has interests in the school?

Many groups have interests in what goes on in schools. They all must be involved in the promotion of healthful eating and children's nutrition status. Chief among them are the children, who are usually divided in groups with differing interests (e.g., boys and girls, juniors and seniors). Effective school food policies usually allow children a say in the management of food programs. The children's parents and families often play key roles, from actually building the school (as in Tanzania), to assisting with reading and other teaching, to serving in school canteens. But are they really involved in the management of the school? Examples of adults' views of some of the aims of school food education are given in **box 1**. The local community in the form of religious or business organizations may have strong influence. For example, in the United States it is not uncommon for companies to market their foods directly to children.

BOX 1. Adults' views of what children should learn about food, Victoria 2003 (n = 430)

Children should learn to cook while at school	87%
Children should be taught how to deal with advertising and marketing in school lessons	80%
Children should learn how to shop for healthful foods	93%
All boys and girls should learn how to shop and cook	94%
School canteens should sell fresh fruit	98%
Primary schools should have fruit and vegetable gardens	70%
All soft drink and confectionery vending machines should be banned from schools	71%
Food companies should not market high-energy/high-fat products at school	77%
All schools should have school food policies to control types of foods sold	73%
Governments need to spend more on nutrition and physical activity in schools	82%

Teachers clearly play pivotal roles but are they well trained in food and nutrition? In many countries they are poorly or infrequently paid, affecting their ability to perform well. School administrators may play major organizational roles in the running of school food policies, but they may be poorly trained or absent from many schools. The government or ministry of education is usually involved in setting national curricula and in training teachers, but in many countries, including affluent countries, it may have only weak influence and insufficient resources. Finally, local health agencies may be involved in the delivery of health services to children at school. These personnel are often in a good position to support the efforts of teachers in providing food and nutrition services for children. It is important that the activities of all these stakeholders are coordinated through a school-based food and health policy (see health promoting schools network).

Adult (and parental) views about the need for strict control over foods sold at school, and the need for life skills training at school, appear to depend mainly on their degree of confidence in government and school authorities (**figs. 1 and 2**) and upon the strength of their equity and harmony values. The more they believe that equity and harmony are good end results, the more they think there should be strong school food control policies (**fig. 3**). The creation of trust in school and government agencies on the part of parents and adults is a key task for promoters of schoolchildren's health and nutrition status.

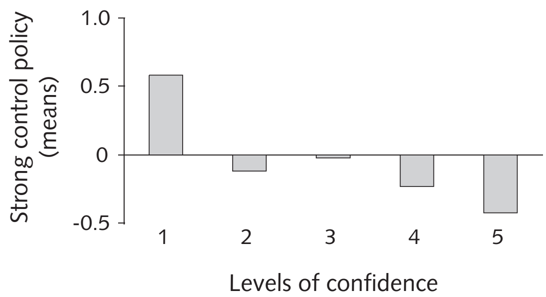

FIG 1. The relationship between adults' confidence in government and school authorities and their desire for strong control food policies in schools (n = 430; Victoria, Australia, 2003)

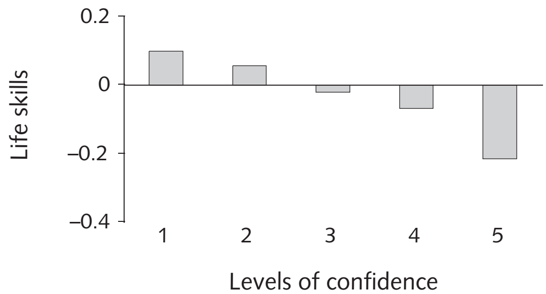

FIG 2. The relationship between adults' confidence in government and school authorities and their desire for life skills education in schools. (n = 430; Victoria, Australia, 2003)

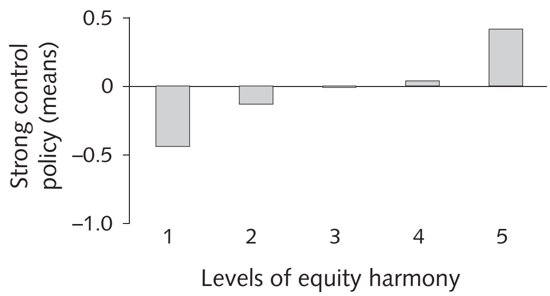

FIG 3. The relationship between adults' equity-harmony values and their desire for strong control food policies in schools. (n = 430; Victoria, Australia, 2003)

The evidence base: What do we know?

There are at least two major evidence bases that are relevant to the taskforce's aims. The first concerns the links between food and nutrition status and children's health status and learning abilities. This will be discussed further in related papers. However, it is fairly certain that children require several types of resources for optimal learning and health, including the following:

- » A variety of foods
- » Breakfast and lunch
- » Perhaps fortified food and supplements
- » Perhaps anthelmintic treatment, depending on the situation
- » Clean water and sanitation
- » Integrated programs to offset poverty
- » Sound teaching skills and educational delivery

The second evidence base concerns findings from healthful eating interventions, many of which have been conducted during the past century. My comments below are based on a review of children's healthful eating interventions in western countries [23]. (There is also a large database, with similar lessons, from developing countries.)

It is quite clear that school-based healthful eating programs can improve children's eating and nutrition status. There are many examples of evaluated effective programs (as illustrated in this supplement). Our review, however, showed that most interventions have not been evaluated, were aimed mainly at primary schoolchildren or at mothers and babies in the perinatal period, were of less than 3 months duration, and were not sustained in the long term. The effectiveness of particular intervention methods (e.g., changes to the school food service, parental involvement, classroom lessons) remains unclear. The main problems or gaps in the intervention literature are shown in **box 2** [30–42]. The main lessons we draw from the review include the following:

» All interventions should be evaluated (or at least the methods and observed effects documented), so that the case for interventions can be strengthened.
» Long-term evaluations should be conducted.
» Sustainability of programs is difficult to maintain, suggesting that long-term local (and regional) school food policies focusing on management and resource issues are required.
» Clear goals, monitoring, and feedback of attainment of policy goals are needed.
» Teacher training, participation in design, and support during program delivery is essential.

BOX 2. Gaps in children's healthful eating intervention research

1. Healthful eating is often poorly defined and measured
» An overemphasis on biomedical and nutrient outcomes rather than food consumption and skills acquisition outcomes
» Studies of the promotion of the whole diet are largely absent
  – Meals and meal timing have been ignored
  – Physical activity habit learning has often been absent from health eating interventions

2. Limited theoretical basis and ignorance of several evidence bases
» Most behavioral theories are inadequate [30]
» Psychophysiology of eating is largely ignored, for example:
  – Timing of food consumption [31]
  – Satiety and appetite regulation [32]
  – Food, mood, and cognition systems [33]
  – Food choice motivation, consumer behavior, and marketing theory [34, 35]
  – Learning and cybernetic theory has been underutilized [36–39]
» Social and family theory [40]
» Food policy research [41]
» Health promotion theory e.g., PRECEDE/PROCEED [42]
» Practitioners' experiences are crucial but often ignored

3. There are few evaluated studies of:
» Parental behaviors and family influence
» Preschoolers
» Teenagers
» Child-oriented community programs
» Long-term interventions
» Food consumption outcomes
» Broad health outcomes
» Effects of local food policies

4. Failure to deal with organizational and social contexts, for example:
» Lack of material resources (e.g., finance, housing)
» Behavioral problems (e.g., physical abuse, drug abuse)
» Lack of parental knowledge and skills (e.g., how to deal with feeding problems)
» Poor social and economic support
» Negative effects of government policies (e.g., employment, technology, and transport policies)

Useful examples of healthful eating interventions include the following:

» **Food Dudes** (UK) shows parents how to feed children [24].
» **Start Right Eat Right** (Australia) is a 12-hour healthful eating and nutrition education program for child care workers, which led to the development of accredited training programs [25].
» **FoodCent$** (Australia) used the healthful eating pyramid to promote inexpensive eating strategies (and, indirectly, healthful eating) to low-income families [26].
» **The Focus on Educational Resources for School Health** (FRESH) is a program described in **box 3** [27].
» **Maribyrnong Fruit Breaks and Water Bottles** (Australia) sets times for consumption of fruit during school day and for unrestricted use of water bottles in class throughout the day [28].
» **The Women, Infants, and Children (WIC)** program (USA) meets food needs of financially disadvantaged people.
» **New Information System Approaches** include **Kidsfood Club** (Australia), which provides information and exercises for primary children [29], and Humanrace.com (Australia), a website that provides self-monitoring of self-selected physical activity and food consumption targets for primary children.

A brief case study

In South Australia in 1978–85 two school-based "lifestyle" intervention studies among 10-year-olds, namely

BOX 3. The FRESH framework [27]

Four key components
» Health-related school policies
» Provision of safe water and sanitation, for healthful physical, learning environment
» Skills-based health education
» School-based health and nutrition services

Benefits of a school health, hygiene, and nutrition program
» Response to increased enrollments
» Increases the efficacy of other investments in child development
» Ensures better educational outcomes
» Achieves greater social equity
» Is a highly cost-effective strategy

the SHAPE and Body Owners programs [43–45] led to the adoption of daily physical education and nutrition programs by most primary schools in the state. This brought about the following in the study participants:

» reductions in body-mass index (BMI), blood pressure, serum cholesterol levels
» improved nutrition knowledge and behavior
» participation in daily physical education by most primary children in the state
» probable long-term effects, such as less smoking and more exercise in adulthood*

However, today Australia faces the following challenges:

» Twenty percent of 10-year-olds are overweight or obese (16).
» Children's energy intake has risen by 20% over 20 years*
» Only one-third of primary school children do daily physical education at school.*
» About one-quarter do not have breakfast on any given school day.*
» There is general ignorance in the community regarding of the nutrition status of children.*

What happened?

What caused these shifting trends? Basically there were policy failures at both the school and government levels.

At the school level there were the following:

» Failure to train new teachers
» A difficult-to-manage curriculum—the program took time and effort away from other areas of the school curriculum
» The health curriculum was too narrow, focusing too much on biomedical outcomes to the exclusion of social and food consumption skills
» There was a lack of regular monitoring of children's health status. This weakened schools' abilities to defend their programs since there was little evidence of effectiveness. This enabled government to withdraw its support.
» There was a prevailing limited view of the role of schools. Schools were seen as being only for "education," not as a child and community resource.

At the government level there were the following:

» Lack of coherent state or federal government policy regarding the promotion of children's health.
» Failure to influence teacher training and curricula, resulting in a lack of long-term advocacy.
» Weak advocacy—other lobbies were more successful than health lobbies at influencing government agendas.
» Widespread adoption of neo-liberal policies throughout Australia, resulting in withdrawal of resources from schools, failure to control food marketing, the promotion of the view that "government has no role in public life," and lack of content expertise in government as content specialists were removed from government service.

Two key conclusions are that programs must become institutionalized policies at both the local school level as well as at the government and community level, and governments must be made accountable for their actions.

Proposals for new initiatives at local, national, and international levels

Below are some proposals for the implementation of schoolchildren's food policies. These include recognition for monitoring of chosen policy goals. This will allow for the development of advocacy and responsibility within schools and within government and NGOs.

1. Form/link advocacy groups.
2. Set up school accreditation systems.
3. Define roles of school and link schools with health sector agencies.
4. Define roles of teachers as community advocates.
5. Design food and nutrition policy templates for schools and governments.
6. Create codes of practice and standards.
7. Promote model curricula in schools.
8. Set up monitoring and feedback systems.
9. Provide international exchange of experiences by teachers and health workers via the Internet and regional meetings.

Three of these suggestions merit further discussion:

1. Monitoring. School performance could be self-monitored by the school and might include estimates of the degree of compliance with the following criteria:

» The FRESH criteria.
» National dietary goals for children.
» The provision of healthful food and beverages at school at reasonable prices.
» Optimal standards of nutrition and health status.
» The teaching of food skills, e.g., purchasing and preparation.
» The teaching of relevant nutrition knowledge and attitudes, e.g., knowledge of ways to prevent iron-deficiency anemia.
» Teachers' levels of knowledge and skills, and advocacy activities relating to health and nutrition.
» The school's responsiveness to parents' concerns and its nutrition promotion among them.

Such information should be fed back by school or education service administrations to teachers,

* Details of recent research available from the author.

parents, local health practitioner schools and other stakeholders regularly.

2. **Accreditation programs**. Monitoring and promotion programs could be accredited by government or NGOs (e.g., Ministry of Education or community and teacher groups). Accreditation programs have several advantages:
  » They hold government accountable for implementation of policy goals.
  » They can be run by local and national teacher associations.
  » They allow for flexible local initiatives.
  » They set quality criteria that are appropriate to local conditions.
  » They allow for entry/progress at all levels.
  » They can be financially self-sufficient and independent of industry and government.
  » They can shape market forces, e.g., by setting rules about types of foods permitted to be sold on school premises.

  The Start Right Eat Right program [25] is a useful example of accreditation program (although it was government sponsored). An outline of the criteria that an accreditation program might employ is given in **box 4**.

3. **Teacher-training curriculum**. There is a need to develop the roles of teachers as educators and as community advocates and leaders. To take such roles, teachers will require training that will accomplish the following:
  » Develop pro-nutrition attitudes and motivation.
  » Provide them with basic nutrition knowledge.
  » Provide knowledge of key health issues, e.g., anemia, HIV/AIDS, obesity.
  » Provide knowledge of human (eating) and learning processes (e.g., Food Dudes).
  » Develop their understanding of social forces and trends relating to food, nutrition, and health.
  » Develop their social, organizational, and management skills.

BOX 4. Accountability issues for nutrition promotion accreditation systems in the school sector

1. What percentage of children attend primary and secondary schools?
2. How many children attend preschool centers?
3. How many primary and secondary schools provide healthful food for children (e.g., breakfast, lunch). How is school food paid for?
4. How many foods supplied at school comply with national dietary guidelines?
5. What percentages of preschoolchildren in primary and secondary are regarded as being malnourished?
6. What percentage of children are overweight or obese?
7. Do maternal and child health services provide information to parents about the nutrition care of children?
8. Approximately what percentage of mothers are reached by maternal and child health (MCH) programs?
9. What percentage of primary and secondary schools have a food policy?
10. What percentage of primary and secondary schools teach a nutrition education curriculum? How adequate is the curriculum content and frequency of teaching?
11. What percentage of primary and secondary schools provide physical education lessons? What is the frequency of these lessons?
12. What percentage of schoolteachers receive training in nutrition education?
13. Are continuing education courses in nutrition promotion widely available?

Special food policies for the education sector, with their inherent accountabilities and responsibilities are required. They will require financing and substantial commitment by national and international stakeholders along with collaboration between governments, universities and school education and health systems.

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Can the provision of breakfast benefit school performance?

Sally Grantham-McGregor

Abstract

Studies of an association between school performance (enrollment, attendance, achievement, classroom behavior, and school drop-out) and nutritional status are discussed and the evidence of an effect of school meals evaluated. Many studies have shown associations between hunger, poor dietary intakes, stunting, underweight, and poor school performance after controlling for socioeconomic conditions. However, it remains possible that unmeasured socioeconomic variables could explain the relationship. Rigorous short-term studies of missing breakfast have generally found detrimental effects on children's cognition whereas studies of providing breakfast have shown benefits particularly in malnourished children. Classroom conditions may modify the effects of breakfast on behavior. There are extremely few longer term studies of the effects of giving school meals. Nearly all involved breakfast and very few had randomized controlled designs. Studies comparing participants with non-participants or comparing matched schools have found benefits (but bias due to self-selection) of receiving breakfast; inadequate matching of schools also remains possible. One longer term randomized controlled trial found benefits associated with attendance and arithmetic performance. In conclusion, most studies of giving breakfast have found benefits to school performance but many had serious design problems, were short-term, and were not conducted in the poorest countries. In order to advise policy makers correctly, there is an urgent need to run long-term randomized controlled trials of giving school meals in poor countries and to determine the effects of age and nutrition status of the children, the quality of the school, and the timing of the meal. The special needs of orphans should also be considered.

Key words: School performance, breakfast, cognition, nutrition status

Introduction

It is accepted that access to both food and education is a basic human right and in 2000 all member states of the United Nations committed themselves to attaining universal primary education and eradicating hunger. Furthermore, primary education, especially for girls, is considered the most effective development tool [1]. Despite the international acknowledgement of the importance of education, it is estimated that in developing countries as many as 26% of boys and 30% of girls of primary school age are not attending school [1]. A further 11% of children attending school do not reach grade five [2].

Children's academic performance is affected by the three main areas of influence: the quality of the school (for example, facilities, teaching quality, and allocated teaching time), family characteristics such as socioeconomic status, parents' educational level and attitudes toward school [3], and child characteristics. Children's aptitude, motivation, and behavior can all affect attainment levels. For many years it has been recognized that child health and nutrition status may also be important [4].

There is reasonably good evidence that early childhood severe clinical malnutrition, moderate and severe stunting (low height-for-age), and underweight [5] and iron-deficiency anemia [6] are associated with poor cognitive development, behavior, and academic attainment in later childhood. In this workshop we are concerned with whether lack of current food in quality, quantity, or timing of eating contributes to the apparent failure of education in many school-aged children.

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More importantly, can the provision of food improve school performance?

In this paper I will review the literature concerning the effect of school meals on children's school performance. I will not discuss studies on take-home food. I will consider the following as school performance measures: enrollment, attendance, tardiness, classroom behavior, cognition, grade repetition, attainment levels, and drop out. I will not discuss studies on the effect of supplementation on children's nutrition status or studies of micronutrient supplementation [7–9] because they are being reported elsewhere in this supplement. I will restrict the review to papers published in English in peer-reviewed journals, concerning children under 16 years. I will first discuss associations between school performance and nutrition and then possible mechanisms linking school meals to school attainment levels. I will then outline the problems with much of the research into school feeding.

Associations with nutrition status

We previously reviewed studies showing associations between current nutrition and school performance [10]. A large number of studies were found that showed children who were stunted, anemic, or iodine deficient had poorer school achievement levels and attendance than other children. Fewer studies examined the experience of hunger, missing breakfast, or poor dietary intakes but most found associations with school performance. Since then further associations between hunger and academic achievement have been reported from Bangladesh [11] and Malaysia [12]. Associations have even been reported from the USA, one of the wealthiest countries, between experience of hunger and children's psychosocial function or behavior [13–17], academic attainment [14, 16], and attendance [15] (see **table 1** [13–25]).

Poor nutrition and experience of hunger are inevitably associated with many other socioeconomic disadvantages, which are likely to independently affect children's school performance. Many of the above studies failed to control adequately for socioeconomic background variables so that hunger may be no more than a marker for disadvantage. Although a few studies controlled for a number of covariates [11, 13] it is unlikely that all possible covariates were controlled. We therefore cannot infer causal relationships between current nutrition status and school performance from the above associations. As with other areas of research on nutrition and child development, the only way to determine the true effect of current nutrition status or hunger is to run randomized controlled trials of giving food or supplements.

Mechanism linking school meals to school performance

Many possible ways in which school meals could affect school performance have been hypothesized and some are shown in **figure 1** [26] taken from a previous meeting. I will discuss them briefly.

» *Time in school*: School meals could increase children's time in school or allocated time. Enrollment at the correct age, good attendance, and punctual daily arrival at school all contribute to time in school,

TABLE 1. Studies showing concurrent associations between hunger or missing breakfast and functional outcomes in children

Outcome variable	Correlate	Country	Study
Academic achievement	Hunger rating	Bangladesh	Huda et al. 1999 [11]
	Hunger rating	USA	Klienman et al. 2002 [16]
	Feeling hungry	Philippines	Florencio 1988 [18]
	Missing breakfast	Jamaica	Clarke et al. 1991 [19]
	Missing breakfast	Malaysia	Boey et al. 2003 [12]
On task/concentration	Missing breakfast	Philippines	Florencio 1988 [18]
Attendance	Hunger rating	Jamaica	Walker et al. 1998 [20]
	Feeling hungry	Philippines	Popkin et al. 1982 [21]
Psychosocial function	Hunger rating	USA	Weinreb et al. 2002 [13]
	Hunger rating	USA	Murphy et al. 1998 [15]
	Hunger rating	Tanzania	Makame et al. 2002 [22]
	Hunger rating	Mozambique	Libombo, personal communication
Cognition	Dietary intake	Kenya	Sigman et al. 1989 [23]
	Dietary intake	Egypt	Wachs et al. 1995 [24]
	Dietary intake	Guatemala	Wilson 1970 [25]

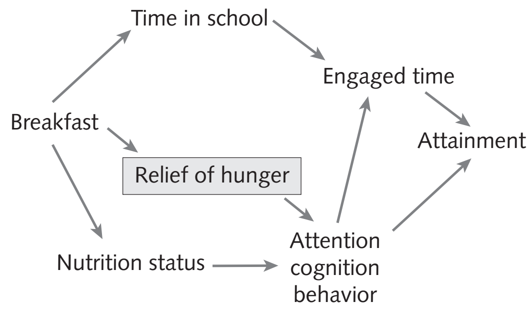

FIG. 1. Hypothesized pathways whereby school meals could affect attainment levels [26]

which is a critical predictor of attainment levels. In areas where poverty is severe, providing school meals may reduce the cost to parents of sending children to school and thus increase enrollment and attendance. Providing food to take home is likely to be an even greater incentive to extremely poor communities and in some countries it has been used successfully to get parents to send girls to school [27]. If breakfast rather than lunch is provided children are likely to get to school earlier.

» *Behavior and cognitive ability*: Although children may be in school they may not pay attention to a learning task if they are hungry. Holding constant the teaching quality and child's aptitude, the actual time spent concentrating on the task is probably the most critical component of learning. The relief of hunger may improve a child's ability to concentrate, which should facilitate learning. Children's memory may also improve so they are more likely to learn.
» *Improved nutrition status*: If school meals are of a good nutrient quality and quantity and the supply is efficient and continues for some time, the children's underlying nutrition status such as wasting and iron deficiency should improve. It is more difficult but possible to improve stunting [28]. Improved nutrition status may lead to improved cognition and alertness over time.

Study design problems

Unfortunately, it has proved extremely difficult to run scientifically robust trials of school feeding. One reason is that feeding children tends to be an emotional and politically sensitive topic. It is therefore difficult to have children in control groups. There may also be other interests apart from child welfare. Local people may be employed to prepare meals and local farmers may be able to sell their produce to the schools or school feeding programs.

Many investigators have "piggy backed" school-feeding programs but this approach has many problems as the investigators often do not have sufficient control over the study design. It is sometimes not possible to get pretest measures or adequate controls, and, furthermore, the evaluations often run for too short a time. The duration of providing school feeding is particularly important when assessing school attainment levels. If a child's state improves he may begin to learn faster but it will take some time before his school achievement levels improve. Furthermore, if schools provide poor teaching conditions, it will take longer or it may not even be possible for children to catch up without extra tuition.

Some investigators have compared participants with non-participants but this could give spurious results, as children who choose to eat breakfast at school are likely to be different from those who do not. Other investigators have used matched schools as controls but this approach may also be unsatisfactory because even schools in the same region vary in many different ways (see [29] for an example of differences) and are unlikely to be well-matched. Randomizing schools to treatment is probably the best approach but is expensive and difficult to run. Large numbers of schools are needed and the studies require considerable cooperation from the schools and probably the appropriate government department. Randomizing children to control or breakfast group within the same school is a robust design but is also difficult to organize and may give rise to ethical concerns.

Outcome measures may also be a problem, school grades may not be sensitive to small improvements, and group testing is unlikely to be as sensitive as individual testing. Teachers may not be blind to the treatment so that the use of teachers' ratings of behavior is likely to be biased. A further point is that the choice of measures has usually been very narrow, focusing on cognition or school grades. There has been little attempt to measure such things as psychosocial function, behavior, attitudes to school or even hunger itself. The age range of the children has also been narrow. Nearly all investigators have excluded preschool and grade 1 children and yet the biology of child development would suggest that younger children are most likely to benefit. I would hypothesize that grade 1 may be particularly important because it provides the foundation for schooling. Children's self-confidence concerning their academic ability and their attitude to school will be formed as well as the teachers' expectations. If they do poorly in grade 1, it might be difficult to catch up. Lastly, there needs to be more interaction between researchers and policy makers. For example, most studies have focused on providing breakfast but many schools in developing countries provide lunch.

For the rest of the paper I will discuss studies according to their design. I will begin with studies of the effect of missing breakfast on cognition in the laboratory or in schools, followed by short-term studies in schools of providing breakfast on cognition and behavior, then evaluations of breakfast programs using the approach of matched schools or participants versus non-participants. Finally, I will discuss longer term randomized trials of school breakfast provision. At the end of reviewing school feeding, I will briefly highlight an emerging problem which has particular relevance to this meeting: that is, orphans in sub-Saharan Africa.

Studies of the short-term effects of missing breakfast on cognition

There are many studies showing benefits to cognition, especially memory, from early morning glucose drinks or breakfast in elderly and young adults [30, 31] although some studies found no benefits [32, 33]. The effect of glucose is complex and varies by age of subject, difficulty of task, and level of glucose. It has also been shown that some cognitive functions improve with either breakfast or glucose but breakfast benefits additional ones [30, 33]. There are fewer studies in children. In an English study [34], investigators gave a glucose drink to 6- to 8-year-old children at 2:30 in the afternoon. The children were subsequently tested and showed improved reaction time and reduced frustration when doing a difficult task. It may also be relevant to school feeding programs that studies in adults have shown that lunch causes a decline of cognitive function [35] and this needs to be explored in children. Studies with adults or glucose drinks will not be further discussed.

Details of studies of missing breakfast and cognition in children are shown in **table 2** [36–38] and **table 3** [39–44]. In Chile [36] and India [37] investigators failed to find effects of missing breakfast. Two other studies from Denmark [38] and the United States [44] randomized children to high- or low-calorie breakfasts. No benefit of higher calories was found in one [44] whereas benefits on a test of creativity (fluency) and voluntary exercise were found in the other [38].

Four laboratory studies have examined the effect of missing breakfast on children's cognition in the late morning using a similar crossover design, two in the United States [39, 40], one in Jamaica [41], and one in Peru [42]. The children were admitted to residential facilities where they could be observed for one night on two occasions, one week apart. They were given a standard meal that evening and in the morning were randomized to having breakfast or not. On the second admission the breakfast treatment was reversed. They were given a set of cognitive tests at 11:00 a.m. In all four studies missing breakfast had some detrimental effect on cognition although the effects were not identical. The two studies in Jamaica and Peru had groups of nutritionally at-risk children and adequately nourished children. In both studies, the undernourished groups were detrimentally affected in cognition but the adequately nourished were not. Both stunted and wasted children were affected in Jamaica. Interestingly, the adequately nourished groups actually did better in the no breakfast state in one test in Jamaica and two in Peru.

Conners and Blouin [43] tested a small number of children at different times during the morning after missing breakfast and found that the detrimental effect on cognition increased with duration of the fast. Differences in the duration of the fast may contribute to differences among studies.

Comments on studies of missing breakfast

Of the nine studies reviewed, six found detrimental effects of missing breakfast on cognition [38–43]. In two of these studies it was only undernourished children who showed effects. Three studies failed to find effects of missing breakfast [35, 36, 44]. Possible explanations for failure to find differences are that two of the three studies [36, 37] did not observe the children from the previous night so that control of fasting was questionable. Also two [36, 44] did not have crossover designs. The Indian study [37] had a crossover design but some children were tested at home and some at school. When looking for small differences in cognitive function, a crossover design, in which children are compared with themselves with and without breakfast, is probably the most sensitive. It is also important to control for the order of treatment and test under carefully standardized conditions.

Studies of the short-term (< 1 month) effect of eating school breakfast on school performance

Laboratory studies of missing breakfast establish that breakfast affects cognition and these differences can be detected in carefully controlled studies, but this finding may not be relevant to the every day situation in schools. Children may eat different types of food at home, at different times and do different amounts of work before arriving at school. A few studies have looked at the short term effects of providing a school breakfast on children's cognition or behavior with randomized designs and the details are given in **table 4** [29, 45–47].

In Israel [47], children were tested on one occasion and were then randomized to receiving a school breakfast or not for 2 weeks. They were then given a repeat battery of cognitive tests. It is interesting that the children who ate a school breakfast performed better on tests of memory compared with children who did not eat a school breakfast, regardless of whether the latter reported they had eaten breakfast at home or not. This study did not have a crossover

TABLE 2. Trials of missing breakfast or giving low-calorie breakfast in schools

Study	Sample	Study design	Measurements	Results	Comments
Lopez et al. 1993 Chile [36]	12 public schools grades 4–6 10–13 years old three groups: nutritionally normal (n = 106) wasted (WHZ < 91% (n = 73)] stunted (HAZ < 92% (n = 100)]	Asked to skip home BKF At school given BKF or not, then tested 1 hour later Tested between 9 and 11 a.m.	Computerized tests given at school: short term visual memory, problem solving test (domino test), attention (search)	Rx effect not significant	Not crossover Method of assignment not given Children admitting to a home BKF were assigned to BKF group; this could lead to bias Control of fasting condition poor Early testing
Upadhyay et al. 1988 India [37]	34 boys and 16 girls, aged 6–8 years, primary schools	Crossover: half had BKF and half no BKF first time; treatment reversed a week later	Tested at 10 a.m.: digit span, arithmetic, free recall Thirty children given reaction time test	Rx effect not significant	Method of assignment to treatment order not given No control over fasting Tested at home or school
Wyon et al. 1997 Denmark [38]	200 10-year-olds from 10 classes 195 participated	Randomly assigned to different BKF for 3 days Mothers supplied with either low-or high-calorie BKF to give at home Tested only once in classes	Tested in two 40-minute sessions before lunch: addition, multiplication, grammatical reasoning, number checking, creativity (fluency), and voluntary exercise	Creativity significantly different in boys $p < .02$ Reduced voluntary exercise with low-calorie BKF Other tests not significant	Not crossover Control over home BKF not good

BKF, breakfast; WHZ = weight for height; HAZ = height for age; Rx, treatment

TABLE 3. Laboratory trials of the effect of missing breakfast or having a low-calorie breakfast on cognition

Study	Sample	Study design	Measurements	Results	Comments
Pollitt et al. 1981 USA [39]	n = 32 9–11 years old middle-class children	Crossover trial, two times one week apart, fasted overnight under observation, randomized to treatment order BKF or no BKF	MFFT, Hagens central incidental learning CPT (tested at 11:15 a.m.)	More errors in MFFT in low IQ children with no BKF	
Pollitt et al. 1982 USA [40]	n = 39 9–11 years old middle-class children	Crossover trial, fasted overnight under observation, randomized to Rx order	MFFT, Hagens central incidental learning (tested at 11:15 a.m.)	More errors in MFFT with no BKF in all children Higher incidential learning with no BKF	
Simeon, Grantham-McGregor 1989 Jamaica [41]	n = 90 9–11 years old well-nourished: n = 30 stunted: n = 30 severely malnourished in early childhood: n = 30	Crossover trial, two times one week apart, fasted overnight under observation, randomized to treatment order	Fluency, MFFT, coding, digit span, Hagens central incidental learning, arithmetic, comprehension (tested at 11:00 a.m.)	Undernourished children detrimentally affected in fluency and coding Well-nourished improved in arithmetic in no BKF	Wasted children significantly worse in MFFT and digit span with no BKF
Pollitt et al. 1996 Peru [42]	n = 52 9–11 years old lower-middle-class undernourished: n = 23 well-nourished: n = 29	Crossover trial, fasted overnight under observation, randomized to treatment order	Number discrimination, Peabody vocabulary test, Raven's matrices, reaction time, stimulus discrimination, Sternberg memory	Undernourished slower in Sternberg memory scanning time and stimulus discrimination decision time with no BKF	Well-nourished improved in two tests with no BKF
Conners and Blovin 1983 USA [43]	n =10 9–11 years old well-nourished	Crossover trial, BKF or no BKF on 4 different days Tested 3 times during morning	CPT, arithmetic, visual evoked potential, cardiac response	Better with BKF in arithmetic and CPT BKF changed visual evoked potential and cardiac response Differences more marked later in morning	Small sample Significance not given

Cromer et al. 1990 USA [44]	9th grade in middle-class high school, 34 children mean age 14 years, BKF $n = 18$, no BKF $n = 16$ Children with low IQ excluded	Admitted overnight to research center (random assignment to BKF or very low calorie meal)	Tested at 8:00 and 11:00 a.m. Rey auditory-verbal learning test, MFFT Continuous performance test Anxiety inventory Blood glucose and B-hydroxybuturate	No Rx effect on cognition, no correlation between glucose or B-hydroxybuturate levels and cognition or behavior (control group higher B-hydroxybuturate $p < .01$; glucose not significant)	Not crossover, small samples

BKF, breakfast; Rx, treatment ; CPT, continuous performance test; MFFT, Matching Familiar Figures Test

design but the findings suggest that the time between eating and being tested was the explanation and that the improvement occurs soon after eating and is transient.

In Peru [29], 10 rural schools were randomized to treatment or no treatment for 15 to 30 days. Overall attendance improved and children who were heavier for their height improved in vocabulary. The investigators suggest that short children with high weight for height may be more undernourished than those with lower weight for height.

A crossover study in Jamaica was run in which classrooms were randomized to breakfast or no breakfast for 1 to 3 weeks and then after a gap of approximately 3 weeks the order was reversed [45]. On both occasions the children were given a battery of four cognitive tests. In this case we had no control over what was eaten at home and due to logistical problems the testing began at any time between 9 and 11 am. Out of four tests given, categorical fluency showed a benefit but only in undernourished children. This finding was similar to the Jamaican laboratory study of missing breakfast [41].

We also observed the behavior of a subsample of children [46]. They were observed for four half-hour periods, two during structured teaching and two while they were working at a set task. We observed whether the children were attending to the task in hand, i.e., “on-task” or not attending. We also looked at whether they were talking when they should not have been, whether they were participating in class activities, or moving around, fidgeting a lot or out of their seats. Of the four schools (A, B, C, D) we found that only one showed the pattern of behavioral change we had hypothesized. In the teaching situation children in school A were more on-task and moved around or fidgeted less when given breakfast. In contrast children in school B indulged in more inappropriate chatting and in the set task children in schools B and C were less on-task. School D was not affected by breakfast. There were marked differences in the school facilities and school A was the only school where each class had a separate room and each child a separate desk. The other schools had several children at the same desk and several classes in the same room. They tended to be overcrowded and noisy.

Comments on studies of short-term effects of giving school breakfast

All four studies found some effect of providing breakfast. These results suggest that the transient improvement in cognitive function following breakfast is a reasonably robust finding but varies by the nutrition status of the child and the timing of the assessment. On the other hand, children’s behavioral changes in response to breakfast varies by the quality of the class-

TABLE 4. Short-term randomized trials of the effects of school breakfast on cognition or behavior in schoolchildren

Study	Sample	Study design	Measurements	Results	Comments
Chandler et al. Jamaica 1995 [45]	Four schools, grades 3 and 4 well-nourished: $n = 100$ undernourished: $n = 100$ aged 8–11 years	Crossover trial Classes randomized to 1–3 weeks of school BKF or no BKF but given 1/4 orange; 3 weeks later treatment reversed (tested in both conditions)	Tested between 9:00 and 12:00 a.m. Fluency Digit span Visual search Speed of information processing	BKF improved fluency $p < .05$ The undernourished group improved in fluency with breakfast; well-nourished did not Interaction between nutritional group and BKF $p < .05$ No other significant effect	All children may have eaten BKF at home Under-nourished WAZ < -1 SD
Chang et al. 1996 Jamaica Same study as above [46]	Four schools, grades 3 and 4 subsample of above undernourished: $n = 60$ well-nourished: $n = 60$	Crossover Same as above Observed in two half hours during teaching and two half hours doing a set writing task	Behavior observations: on task, participation, moving around, unauthorized talking	Initially: height and on task, $r = 0.16$; $p < .05$, height and moving around $r = -0.18$ $p < .05$ Rx effects: Interaction between school and BKF significant In one well-organized school, BKF improved time on task and reduced moving around; in poor schools BKF reduced time on task and increased talk	There was an interaction between BKF and school quality
Jacoby et al. 1996 Peru [29]	Ten rural schools, grades 4–5 age 11 years BKF $n = 201$, control $n = 151$	RCT 10 schools randomized to BKF or not for 15 to 30 days	Attendance, coding, reading, vocabulary, math	Attendance improved 0.59% and control decreased 2.9%; $p < .05$ No main effect of BKF on tests but heavier children (controlling for height) in BKF group improved in vocabulary	Initially heavier children had lower scores on tests (authors suggest high weight for height is malnourished)
Vaisman et al. 1996 Israel [47]	17 classes in grades 5 and 6 in five schools $n = 569$	Pre- and post-testing Randomized: 2/3 given BKF for 15 days, while 1/3 ate usual home BKF or none	Rey auditory-verbal learning test, memory for narrative prose, visual memory Tested 8:55 to 9:35 a.m. Three factors were formed from the learning test: acquisition, delayed recognition, delayed recall	Initially children who ate BKF at home had higher scores on immediate recall only; 430 had both tests; children who had school BKF were significantly better than other children whether they ate at home or not in nearly all tests of memory	Not clear if controlled for initial test scores Some controls ate BKF at home Not crossover

BKF, breakfast; WAZ, weight-for-age

room environment and may not always be beneficial in chaotic classrooms; however, these findings need replication. The only study measuring attendance [29] found improvements.

Studies comparing school breakfast participants with non-participants

Several investigators in the USA have piggy backed the introduction of a school breakfast program and tested children before the introduction of the program and afterward (**table 5** [17, 17, 48]). They have then compared children who participated in breakfast with those who did not [48], or those who increased participation in breakfast with those who did not [17] or those that increased their nutrition intake with those who did not [16]. The studies covered breakfast programs from 3 to 6 months duration. In all three studies, compared with non-participants, the participants improved more in school grades in at least one subject and attendance during the time breakfast was given. Participants were also less tardy in two studies. In two studies where psychosocial function was measured [16, 17] participants improved more than other children.

Comments on studies comparing participants with non-participants

These findings suggest that eating school breakfast improves children's academic performance, psychosocial function, attendance, and tardiness in the first 3 to 6 months. However, the studies suffer from probable bias due to breakfast participation being chosen by the children. Children who choose to eat breakfast are likely to be different from children who do not.

Studies comparing matched schools or classrooms

For this section see **table 6** [49–51]. Two studies introduced breakfast [50] or lunch [51] into one or more schools and compared the children's progress with those in matched schools which did not receive breakfast. One study in India [51] ran for 2 school years and the supplemented children were heavier, had higher IQs, and better scores in arithmetic and one of seven Piagetian tests at the end. The other study in South Africa [50] ran for only 6 weeks. Children in one school received breakfast and were compared with children who did not receive breakfast in a matched school. They were assessed before and after the intervention. The fed children did better in tests of digit span and vigilance but not in coding. The children's classroom behavior was also observed and the breakfast group changed more than the non-breakfast group. They were less off-task and out of their seats and showed more class participation and positive peer interaction. Unlike many other studies there was no effect on attendance. A third study was conducted in Jamaica [49], and children in three classrooms of the same grade level in a large rural school were monitored over one semester, then breakfast was introduced in one classroom for the second semester. The breakfast group improved in arithmetic scores and attendance compared with the other two classes combined. The arithmetic improvement remained after controlling for increased attendance. There was no effect on spelling or weight. The authors suggest that the mechanism of the arithmetic improvement was the relief of short term hunger.

Comments on studies using matched control schools or classes

All three of the above studies found benefits in cognitive or/and arithmetic tests from school meals. Improvement in attendance was found in one [49] but not in another [50] and was not reported in the third [51]. However, in the two studies that used matched schools for comparison [50, 51] the experimental and control schools were poorly matched and varied by age and nutrition status of the children. In addition, in the South African study, one school was urban and the other was rural with poorer children. The failure of the South African study to find benefits to attendance was surprising; however, attendance was compared with the previous term and attendance pattern frequently changes over a school year. Therefore, without a well-matched control school, this finding could be misleading.

The main strength of design in the Jamaican study [49] was that children's academic progress in the first trimester was controlled for in the analyses of effects of treatment in the second semester. However, it is still possible that the classes varied in other characteristics that may have affected the outcome.

Longer term randomized controlled trial of giving breakfast

Although it is essential to have randomized controlled trials to determine with any certainty the benefits from school feeding, I could find only one study [28] (see **table 7**) in which children were randomized to school breakfast or no breakfast for longer than one month. Another study is reported at this meeting that involved giving meat [52]. The Jamaican study [28] ran for one school year except for time for pre- and post-testing. Poorly nourished children (< –1 z-score in weight for age) were identified in grades two to five and then matched with adequately nourished children in the same classroom. Both groups were stratified by

TABLE 5. Trials comparing participants with non-participants of school breakfast

Study	Sample	Study design	Measurements	Results	Comments
Meyers et al. 1989 USA [48]	Six public schools, grades 3–6, children entitled to meal subsidies with intact records Participant = had BKF 60% of time ($n = 335$) Non-participant = does not eat BKF ($n = 688$)	Free BKF introduced for 3 months Measures taken before and after Attendance over same semester previous year Compared participants with non-participants	School test battery of reading, language, math Tardiness, attendance	Participants improved more than non-participants in total score $p < .01$, language $p < .05$, math and reading $p < .1$; decreased in tardiness $p < .01$ and attendance $p < .05$	Not randomized Self-selected BKF participation BKF participation recorded only for 1 week
Murphy et al. 1998 USA [17]	Three inner city schools in Philadelphia and Baltimore: grades 4 and 5 in 1 school ($n = 126$), grades 3–8 in two schools ($n = 493$), 169 (34%) agreed and had pretest measures, 90 completed post-tests	Free BKF offered for 4 months Pre- and post-intervention measures Change in outcome measures compared with change in BKF participation	School grades in math, science, social studies, reading, attendance, tardiness, child depression inventory (CDI), and anxiety scale (RCMAS), parent psychosocial checklist, Conners Teacher Rating Scale	56 increased BKF participation, 49 same, 28 decreased Children who increased had greater increase in math than others $p < .001$, decrease in absences and tardiness both $p < .01$, reduction in CDI $p < .005$, RCMAS $p < .05$ and Conners hyperactivity $p < .01$	Large loss from sample Not randomized BKF participation recorded only for 1 week at beginning and end Daily BKF participation in total school rose significantly from 15% to 27% Self-selected BKF participation
Kleinman et al. 2002 USA [16]	Three inner city Boston schools; grades 4–6 ($n = 99$; 44%) Based on 24-hour recall, children divided into low-intake group (2 or more micronutrients at < 50% RDA and or energy < 50% RDA) ($n = 29$) and adequate-intake group ($n = 70$)	24-hour dietary recall Tests given before and 6 months after free BKF began Compared children who improved their nutrition intake with those who did not	Parent and child report pediatric symptom check list (PSC) School grades ($n = 79$) in math, science, social studies and reading, attendance, tardiness	Initially: nutritionally at-risk had worse attendance, punctuality, grades, and behavior; 19% increased their intake rating and showed significant improvement in PSC child report $p < .01$, and in math $p < .05$, and attendance $p < .01$	BKF participation recorded for only 1 week at beginning and end Not all who improved intake had increase BKF participation

BKF, breakfast; RCMAS, Revised Children's Manifest Anxiety Scale

TABLE 6. Trials comparing children given school meals with matched children not receiving meals

Study	Sample	Study design	Measurements	Results	Comments
Powell et al. 1983 Jamaica [49]	Lowest three streams (classes) from 10 streams in grade 7 in large rural public school BKF class $n = 44$ 2 control classes $n = 71$ (combined)	Observed during first term then one class given BKF for second term (10 weeks); other 2 classes controls Compared classes in change in test scores in second term when BKF given, controlling for change in first term	Tested at beginning and end of first term and end of second term in math, spelling, reading; attendance, weight	Controlling for change in scores in first term, BKF class improved more than other 2 classes in second term in math $p < .05$ and attendance $p < .05$ No benefit to spelling or weight	Reading not tested at end of first term Controlled for change in first term
Richter et al. 1997 South Africa [50]	55 children in grade 1 and 2 in farm school given BKF, mean age = 10.5 years 53 in same grades in inner city control school, mean age 8.3 years	Farm school given 6 weeks BKF and compared with control school Pre and post tests	RPM coding, digit span, vigilance, video observations of class behavior: on-task, peer interaction, class participation, teacher rating for hyperactivity Attendance	Improvement in off-task and out of seat, positive peer interaction and participation behavior BKF group improved more in digit span and vigilance. RPM coding and attendance not significant	Control school very different from experimental in SES, IQ age, and nutrition status Urban versus rural
Agarwal et al. 1989 India [51]	146 6-to 8-year-olds in 5 schools given lunch; 304 from non-supplemented schools matched for social and family variables	Lunch [450–500 kcals] provided for 2 years of 175 days and 181 days Matched schools Pre- and post-testing	Weight WISC 7 Piagetian tasks Bender visual motor Gestalt test Arithmetic	Lunch group was significantly heavier and had higher scores in global IQ, verbal and performance subscales, one Piagetian test and arithmetic at end. Bender Gestalt was not significant	Groups poorly matched in age and nutrition status Significance of change in performance not given

BKF, breakfast; SES, socioeconomic status; RPM, Raven's progressive matrices; WISC, Wechsler Intelligence Scale for Children classroom and then randomized to school breakfast or a small slice of orange. Overall improvements were found in attendance, weight and height and the lowest two grades improved in arithmetic. Reading and spelling did not benefit. Unlike the findings from studies of short term effects of missing breakfast, the response was similar in both nutrition groups.

Comments on the randomized trial

The study was robust as the children were randomized to treatment within schools and classrooms. We gave the children who were not offered breakfast a slice of orange in an attempt to control for the extra attention the breakfast group received, however, it was not a true placebo. Even though the children were not very undernourished, both nutrition groups showed benefits in weight and height. It is likely that in schools elsewhere where children have much worse nutrition status, improvements would be greater. The arithmetic improvements suggest that the younger children were more likely to benefit. The attendance improvement was encouraging but small and was unlikely to solve the whole problem of poor attendance. It is possible that a longer term program would produce greater benefits to academic progress and nutrition status. There is an obvious need for longer term randomized trials to be run in poorer countries where undernutrition and hunger are greater problems.

Summary of findings

Short-term: It is well established that missing breakfast has a transient detrimental effect on cognition in the late morning. Analogously, giving a school breakfast benefits cognition. The effect on behavior is more complex and probably depends on the classroom environment.

Longer term (> 3 months): Longer term studies have had many design problems (see above). However, all studies have found some benefits. The finding of school meals improving attendance was consistent and of the seven studied measuring it (one for < 1 month) six found benefits. Benefits to school grades have also generally been found. Six reported school grades and all found benefits in arithmetic; however, other topics were much less likely to benefit. Benefits to psychosocial function has been assessed twice and showed benefits but these studies had design problems.

There is a suggestion that undernourished children and younger children are more likely to benefit. Conversely it is likely that children in better schools are more likely to benefit.

TABLE 7. Long-term randomized controlled trial of school breakfast

Study	Sample	Study design	Measurements	Results	Comments
Powell et al. 1998 Jamaica [28]	16 schools, grades 2–5 Undernourished group: children with WAZ < -1 SD (n = 407) Well-nourished group: children with WAZ > -1 SD (n = 407) Matched for age, sex, and class	Randomized controlled trial Children randomized within classes to BKF or 1/4 of orange for 8 months Pre- and post-testing	Weight, height, arithmetic, reading, spelling, attendance	BKF improved attendance $p < .05$ BMI, height, age, and arithmetic Arithmetic $p < .05$ Grades 3 and 4 showed greatest benefit Interaction between BKF and grade $p < .052$	Younger children benefited most in arithmetic

BKF, breakfast; WAZ, weight-for-age

Other relevant considerations

There are additional considerations that may be relevant when deciding school feeding policy that I have not discussed above, although they may have benefits or disadvantages for the children and community. I will mention a few of them briefly. For example, eating school meals together may improve children's social behavior and their attitudes to school. If the food provides a well-balanced diet it may not only improve children's nutrition status but also help to develop good dietary habits for the future. On the other hand, if providing school meals is poorly organized it may detract from the time spent in the classroom by both children and teachers. Where teachers actually plan and supervise meal preparation it may distract them from teaching duties.

Providing school meals can be a form of income transfer to the families and may provide employment for local people as cooks and use products from local farmers. It may even be a source of revenue for teachers. On the other hand, it may be used as an outlet for surplus food grown elsewhere and have a harmful effect on local agriculture.

Orphans

Finally, I would like to draw attention to the urgent need for both schooling and food for orphans in sub-Saharan Africa. It is estimated that there are 11 million orphans at present and these numbers are expected to increase to 20 million by 2015 [53]. These children are less likely to enroll and attend school regularly [54]. In a recent study in Tanzania [22], orphans were significantly less likely to be attending school and more likely to go to bed hungry than non-orphans. They also had many more symptoms of depression. We used multivariate analyses to determine which stressors contributed to their depressive symptoms. After controlling for many socioeconomic variables, bedtime hunger and school attendance predicted depression. A similar study in rural Mozambique had stronger findings (Paula Libombo, personal communication). Hunger, not attending school, and depression were even more prevalent in orphans compared with non-orphans. There is thus an urgent need for interventions that provide both food and access to school. Some form of school feeding probably combined with take home food is an obvious choice.

Research needs

There are alarmingly few well-designed studies conducted over at least one school year and few of any kind from the poorest countries. Long-term randomized controlled trials in countries where children's nutrition status is poorest are urgently needed. Some of the important questions which need addressing are listed below.

What is the effect on children's nutrition status, school performance, and psychosocial function? What are the relative benefits of breakfast versus lunch versus take home food? How are the effects modified by the age and nutrition status of the children and the quality of the school? Do educational and nutrition inputs have additive or interactive effects? We also need to look at more outcomes such as the children's hunger, social development, behavior, psychosocial function, and attitude to school. Finally we need to explore what is the best way school feeding can help orphans in sub-Saharan Africa.

Conclusions

Despite the shortage of robust studies, it is clear that school feeding can help children's educational progress, particularly in undernourished children. However, there are limits to the benefits from both nutrition and health programs in poor educational settings. The achievement of children is inextricably linked to both their biologic state and the quality of the school. For example, if school feeding programs are successful in increasing enrollment and attendance but there are insufficient space and teachers to accommodate the children, overall performance levels may not improve. Similarly, we have shown that improvements in behavior with school meals only occurred in better schools. If we are to make significant advances to children's education in developing countries, there is an obvious need for integrated programs combining educational with health and nutritional inputs.

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Linking nutrition and education: A cross-generation model

Theodore D. Wachs

Abstract

Psychosocial influences, such as the family or the school, and biologic influences, such as nutrition or the presence of environmental toxins, can be viewed as elements of a child's overall environment. Family and school influences define dimensions of the child's psychosocial environment whereas nutrition and exposure to toxins define dimensions of the child's bioecologic environment. This paper presents a cross-generation model specifying both the nature and consequences of linkages between the psychosocial and bioecologic environments, with specific reference to schooling, nutrition, and development. Data from two studies done in Egypt and Peru are used to illustrate this model, showing how duration of breastfeeding and quality of the young child's diet are positively associated with higher levels of maternal education and intelligence.

Key words: Maternal education, maternal intelligence, breastfeeding, infant nutrition, environment

Introduction

Research conducted during the past half century has made it increasingly clear that children's development is determined by multiple psychosocial and biologic factors, with both sets of influences linked together in multiple ways [1]. Both psychosocial influences, such as the family or the school, and biologic influences, such as nutrition or the presence of environmental toxins, can be viewed as elements of the child's overall environment, with the former defining dimensions of the child's psychosocial environment, and the latter defining dimensions of the child's bioecologic environment. In the present paper I will first briefly discuss the characteristics of the psychosocial and bioecologic environments. This will be followed by presentation of a cross-generation model specifying both the nature and consequences of linkages between the psychosocial and bioecologic environments, with specific reference to schooling, nutrition and development.

The multiple environments of the child

The psychosocial environment

In terms of influencing development, the most critical aspects of the psychosocial environment are those that involve "proximal processes." Proximal processes refer to ongoing social and object stimulation that is directly and repeatedly encountered by children in their real world contexts, such as family, childcare, school, or peer environments—the microsystem [2]. While much of the available research on proximal environmental influences on children's development has involved the family environment [3], proximal environmental influences are not restricted just to the family. Another critical proximal influence is the amount of schooling the child receives and the quality of the child's school environment. Amount and quality of schooling have been related to individual differences in children's intellectual functioning [4, 5], children's level of achievement motivation [6], children's resilience under stress conditions [7], and individual differences in anti-social behavior patterns [8].

While necessary, proximal processes are not the only aspect of the psychosocial environment that can influence children's development. As described by Bronfenbrenner in his Ecological Model [9] (**fig. 1**), the psychosocial environment of the child is hierarchical in nature, encompassing multiple levels from family to culture. While proximal environmental influences such

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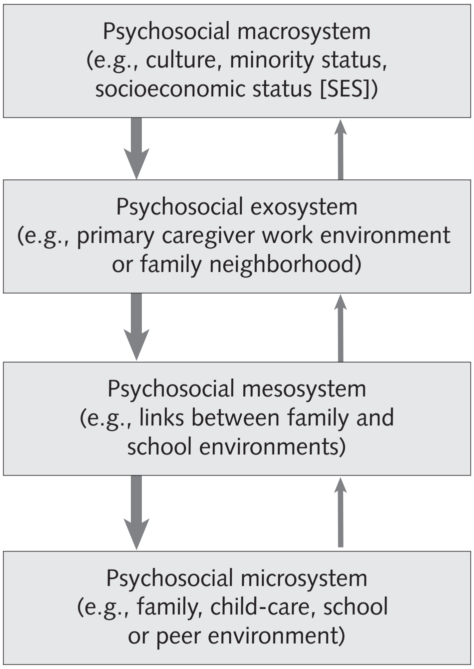

FIG. 1. Bronfenbrenner's ecologic model of the psychosocial environment

as family and school characteristics are critical for children's development, the influence of proximal environmental characteristics can be structured, weakened or strengthened by higher order levels of the environment which the child may not directly encounter. For example, both the nature of rearing strategies used by parents and the effectiveness of parental rearing strategies depend, in part, on the quality of the neighborhood within which the family resides [10–12]. Similarly, the developmental influences of the child's proximal school environment will vary systematically depending on the nature of higher levels of the environmental hierarchy, such as characteristics of communities within which schools function [13].

The bioecologic environment

While the psychosocial environment of the child is a necessary influence on development, we know that the environment consists of more then just persons or objects. Beyond persons and objects children also live in a broader natural context defined by ecologic characteristics, such as climate, natural resources, the quality of air breathed, the availability of different types of food, degree of exposure to infectious agents, and the characteristics of natural terrain [14]. These natural contextual dimensions define the child's bioecologic environment. As shown in **figure 2**, dimensions of the bioecologic environment have a hierarchical structure similar to that found for the psychosocial environment.

A number of dimensions of the bioecologic environment, such as exposure to environmental toxins, exposure to parasites, and climatologic conditions, have been identified as influences upon children's development [1]. A particularly critical bioecologic dimension is the child's nutrition status. A large body of evidence has linked deficits in children's cognitive and social-emotional development to both macronutrient (e.g., protein and calorie intake) and micro-nutrient deficiencies (e.g., iodine deficiency, iron-deficiency anemia) [15, 16].

The nature and consequences of links between the psychosocial and bioecologic environments

Although both psychosocial and bioecologic factors influence children's development, for the most part researchers investigating children's development have treated these two major dimensions of the environment in isolation from each other. Behaviorally oriented researchers and interventions specialists have tended to ignore the contributions of biologic influences upon development, just as biologically oriented researchers and intervention specialists have tended to ignore the contributions of psychosocial influences [1]. Given current knowledge about the nature of children's environment, plus evidence documenting the multi-determined nature of children's development, treating psychosocial and bioecologic influences in isolation from each other is clearly an oversimplification. Rather than functioning in isolation from each other, these two dimensions of the overall environment of the child are clearly linked, as illustrated in **figure 2** [17].

The model shown in **figure 2** is consistent with multiple examples in the research literature showing systematic covariance between psychosocial and bioecologic risk factors [1]. For example, both undernourished children [18, 19] and children with greater exposure to environmental lead [20] are far more likely to be living in homes with low levels of stimulation and reduced parental responsiveness and parental involvement than are more adequately nourished children or children with low exposure to environmental lead. One implication derived from the model shown in **figure 2** is the likelihood of interactions between specific aspects of the psychosocial and bioecologic environments. By interaction I mean that we cannot understand the contributions of bioecologic influences in isolation from psychosocial environmental influences, nor can we consider the impact of psychosocial environmental influences without also considering bioecologic characteristics [1]. Illustrating such interactions, Grantham-McGregor and colleagues [21] have shown how the impact of breakfast feeding upon undernourished children will vary depending upon school characteristics, such that in orderly organized school situations breakfast feeding increased children's on-task attention,

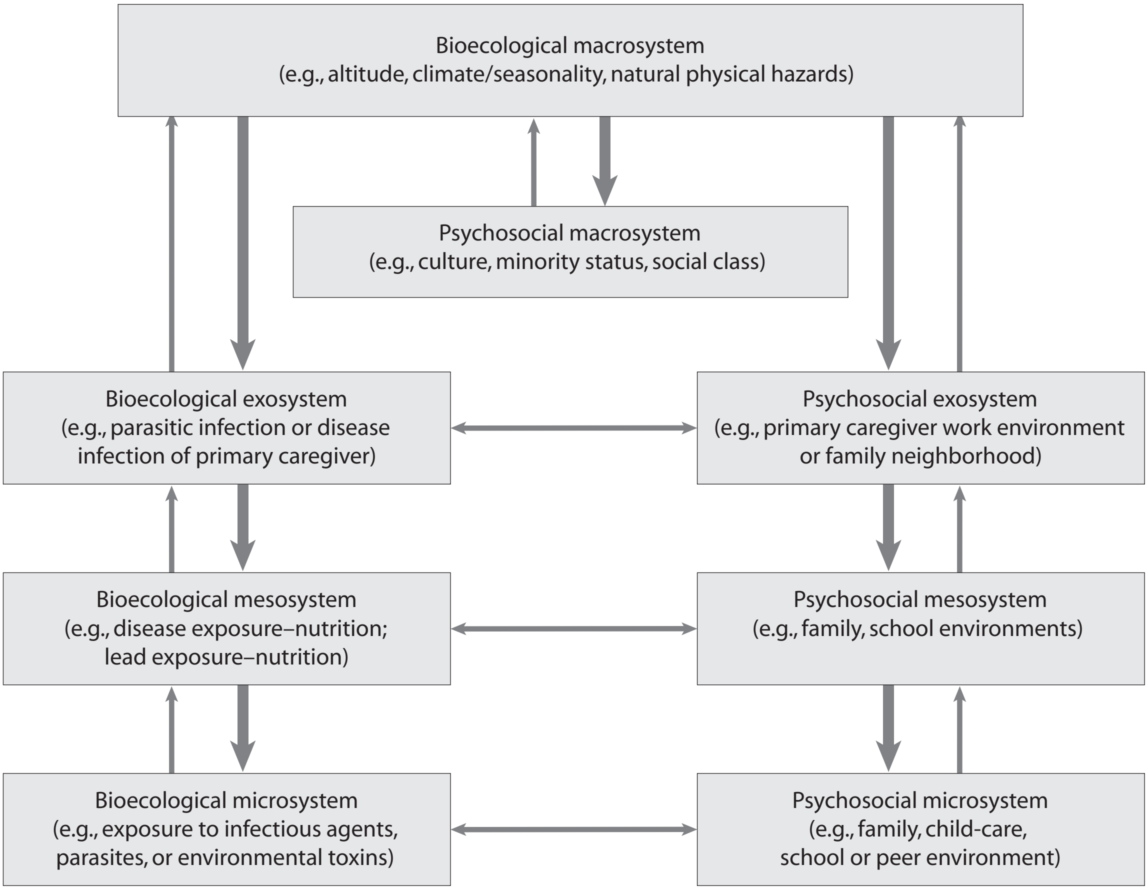

FIG. 2. Integrated model of the bioecological and psychosocial environments
Source: Wachs TD. Expanding our view of context: The bio-ecological environment and development. In: Kail R (ed). Advances in Child Development and Behavior, 2003, volume 31 (p.390). Reprinted with permission from Academic Press.

whereas in chaotic disorganized school environments breakfast feeding reduced children's on-task attention to school tasks. Similarly, Winick and colleagues [22] have shown how the impact of adoption into higher quality home environments will vary depending upon the child's pre-adoption nutrition status, with children having more severe malnutrition prior to adoption showing lower cognitive and educational benefits following adoption than do those children with less severe malnutrition.

Documenting links between the psychosocial and bioecologic environments

To illustrate the importance of integrating across the psychosocial and bioecologic environments, data from two studies will be presented. These data are particularly noteworthy in that they indicate a cross-generation linkage between characteristics of the psychosocial environment (maternal education level) and characteristics of the child's bioecologic environment (nutrition intake).

Etiology of childhood nutrition deficiencies

Conceptual models attempting to explain the etiology of childhood nutrition deficiencies traditionally have focused primarily on the availability of food or on economic factors influencing the family's ability to purchase food [23]. For example, Engle [24] has shown that physical growth in children is related to the percent of family income earned by mothers. However, the assumption that childhood nutrition deficiencies are essentially due either to overall food scarcity or to a lack of family resources to purchase available food has been increasingly questioned [25–27]. Substantial variability in children's nutrition status has been documented even among very low-income families living in the same neighborhood or district [19, 28, 29]. Similarly, even when family income is relatively restricted or food is scarce families can make choices as to what they spend their money on [26], and these choices can affect the adequacy of offspring nutrition [30]. For the most part, researchers investigating non-economic causes of variability in the adequacy of children's diet have focused primarily on cultural characteristics such as culturally driven beliefs about feeding practices [31, 32].

However, cultural beliefs are not the only non-economic factor influencing children's nutrition. Another likely influence is maternal education level. In discussing the impact of maternal education I am not referring to targeted nutrition education programs or targeted psychosocial education programs for women, but rather to the years of schooling achieved by the mother in the public school system.

It has been hypothesized that more educated women may develop a wider range of strategies that can be used to promote offspring health and nutrition, or that more educated women may be less fatalistic in their outlook on life and thus more likely to take an active role in promoting their child's nutrition and health [26]. Alternatively, given that studies from both developed [4] and developing countries [33, 34] indicate that more education is related to higher intelligence, more intelligent women from low-income families may be better able to make decisions about how best to allocate scarce family resources. Supporting a link between maternal education and offspring nutrition, research done in developed countries indicates that more educated women are more likely to breastfeed their offspring than are women with lower education levels [35]. While the relation between maternal education and breastfeeding in developing countries is less clear, several recent studies also have reported longer or more exclusive breastfeeding by more educated women in developing countries [36–39]. Far less evidence is available on the relation between maternal education and offspring diet and what little evidence is available has come primarily from studies carried out in developed countries [40]. However, what little evidence is available from developing countries also suggests a link between maternal education and offspring diet. Specifically, Imong et al. [41] have recorded lower bacterial counts in food given to infants by more highly educated mothers, while Tucker and Young [26] have reported that the combination of maternal education level, other maternal educational experiences, and maternal nutrition knowledge positively predicted offspring intake of both protein and calcium. Far less evidence is available in either developed or developing countries on the relation of maternal intelligence to offspring nutrition. In one of the few available studies Sandiford et al. [42] have reported that the relation of maternal intelligence to offspring physical growth varies depending upon the level of maternal schooling, with higher maternal intelligence being associated with better physical growth of preschoolers primarily when the mother is illiterate or unschooled. Further evidence on the relation between offspring nutrition and maternal education and intelligence comes from our research in both Egypt and Peru.

Maternal education, maternal intelligence, and offspring nutrition: Egypt

The research carried out in Egypt involved a 12-month longitudinal study of 76 toddlers starting at 18 months of age and a 12-month longitudinal study of 57 school-age children who were between 7 and 10 years old when they entered the study [43]. The question raised in this study was whether either maternal education or intelligence level would predict quality of offspring diet after controlling for family demographics. Our measure of offspring diet in both toddlers and school-age children was based on the combination of maternal dietary recall and food weighing taken on two consecutive days each month over the 12-month study period. Food recall and food weighing data were translated into energy and nutrient composition of the child's diet based on use of local food composition tables plus laboratory analyses. Maternal years of education were coded from a detailed social interview while maternal intelligence was based on administration by trained psychologists of the Raven's Progressive Matrices and four subscales from the Egyptian version of the Wechsler Adult Intelligence Scale. The average maternal educational level in our sample was 1.4 years of schooling (SD = 2.75), with less than 2% of our sample having more than 7 years of education. Despite this restricted range of education, as expected, in both our toddler and school-age samples there was a moderate and significant correlation between maternal educational level and maternal intelligence (mean r = .39, $p < .01$). A detailed social interview was used to assess family social class or socioeconomic status (SES), based on family assets and paternal occupation.

Because our emphasis in this project was on offspring dietary quality (e.g., intake of animal source foods and critical micronutrients like iron, zinc, and B vitamins) in addition to statistically controlling for family demographics we also statistically controlled for the child's overall energy (caloric) intake. Our results, presented in **table 1**, show that maternal education level was a unique and significant predictor of quality of dietary intake for school-age children. Maternal intellectual level was a unique and significant predictor of quality of toddler dietary intake with a trend for similar prediction for school-age children. Directly contrasting maternal education level and maternal intelligence our analysis showed that maternal education level was a stronger predictor for school-age children's diet, while maternal intelligence was a stronger predictor for toddler dietary intake. At both ages dietary quality intake was higher for children of more educated or more intelligent mothers.

TABLE 1. Prediction of offspring dietary quality intake from maternal educational and intellectual level

Predictor variables	Control variables	Age group	Partial correlation	
			Model R^2	Predictor R^2
Maternal educational level	KCAL	Toddlers	.74	.31***
		School-age	.59	.41***
	KCAL, OCC	Toddlers	.76	.27**
		School-age	.60	.35**
	KCAL, OCC, SES	Toddlers	.82	.09
		School-age	.65	.30**
Maternal intellectual level	KCAL	Toddlers	.75	.33***
		School-age	.54	.28**
	KCAL, OCC	Toddlers	.76	.32***
		School-age	.58	.29**
	KCAL, OCC, SES	Toddlers	.83	.24**
		School-age	.64	.25*

KCAL, total caloric intake; OCC, paternal occupational level; SES, family socioeconomic status
*.05 < *p* > .10; ***p* < .05; ****p* < .01
Source: Adapted from [43]. Reprinted with permission of the International Society for the Study of Behavioral Development.

Maternal education, maternal intelligence and offspring nutrition: Peru

Our current research in Peru offered us the opportunity to determine if the relations reported above replicate in a very different culture with children who are at a much younger age than those in our Egyptian sample. In our ongoing research in Peru our sample consists of 250 infants followed from birth through 18 months of age [44]. At 3 and 6 months of age, based on maternal report, we utilized a four-point feeding code referring to the amount of breastfeeding versus supplementary feeding the infant received, with higher scores indicating more exclusive breastfeeding. At 12 and 18 months of age, using two 24-hour dietary recalls taken on nonconsecutive days we were able to assess the toddler's intake of 15 specific macronutrients (e.g., calories, protein) and micronutrients (e.g., iron, zinc, B vitamins). Our assessment of maternal education level was again based on maternal report of years of schooling. In contrast to our Egyptian sample, mothers in Peru were far more educated, with the average years of schooling 9.73 years (SD = 2.60); 17.1% of women in our sample had less then 7 years of education and 11.6% had more then 11 years. Maternal intelligence was based on the mother's scores on the Raven's Progressive Matrices plus a Peruvian-based measure of verbal intelligence. As in Egypt we find a significant correlation between maternal years of education and maternal intelligence ($r = .66$, $p < .01$). Using a detailed social interview we derived two measures of family SES based on family income and family possessions.

Given that this project is still ongoing, the data analysis reported here is preliminary, but the results are sufficient to determine if our findings are similar to the pattern found in Egypt. The results from our ongoing Peruvian research are shown in **table 2**. As shown in **table 2** both family SES and maternal intelligence were unrelated to level of breastfeeding at either 3 or 6 months. As also shown in **table 2**, higher levels of maternal education were related to longer duration of breastfeeding at both age levels. Partial correlations were computed to assess the relation of maternal education to offspring breast feeding after controlling for SES. The correlations between maternal education and offspring breast feeding remained significant after partialling.

With regard to infants' nutrient intake at 12 and 18 months, of the 60 possible correlations between our two measures of family SES and offspring diet (15 nutrients at 12 and 18 months), only two were significant. Of the 30 possible correlations between maternal education and offspring diet, only three were significant, although all were in the expected direction. Of the 30 possible correlations between maternal intelligence and offspring diet, 20 were statistically significant and all were in the expected direction, with higher levels of macro and micronutrient intake for offspring of more intelligent women. We computed partial correlations for the 20 significant intelligence diet correlations to assess the relation of maternal intelligence to offspring diet after controlling for SES. With one exception (the correlation between maternal intelligence and intake of niacin at 18 months fell to nonsignificance after statistically controlling for SES) all correlations between maternal intelligence and offspring diet remained statistically significant after statistically controlling for family SES.

Our preliminary results from Peru both replicate and expand our previous findings from Egypt, indicating that both education and intelligence are potential influences on offspring diet. Integrating results across

TABLE 2. Summary of initial findings from Peru relating maternal education and intelligence to offspring nutrition[a]

I. Correlations between breastfeeding at 3 and 6 months and maternal education and intelligence

	Maternal education level	Maternal intelligence
3 month breastfeeding	.17**	.05
6 month breastfeeding	.15*	.07

*$p < .05$; **$p < .01$

a. Neither measure of family socioeconomic status was related to breastfeeding at either 3 (education $r = .06$, intelligence $r = .06$) or 6 months (education $r = .00$, intelligence $r = -.01$)

II. Child nutrient intake at 12 and 18 months (at each age level we assessed intake of 15 specific nutrients)

12 months

Maternal education: There were no significant correlations between nutrient intake and maternal education level.

Maternal intelligence: Of the 15 possible correlations between maternal intelligence and nutrient intake at 12 months, 9 were statistically significant (median significant, $r = 0.17$, range 0.15–0.19).

Family SES: Of 30 possible correlations between intake and our two SES measures, only 1 was statistically significant.

18 months

Maternal education: Of the 15 possible correlations between maternal education and nutrient intake at 18 months 3 were statistically significant (r range 0.19–0.22).

Maternal intelligence: Of the 15 possible correlations between maternal intelligence and nutrient intake 11 were statistically significant (median $r = 0.24$, range 0.20–0.31).

Family SES: Of the 30 possible correlations between intake and our two SES measures only 2 were statistically significant.

both studies, maternal education appears to relate to both duration of breastfeeding and the quality of the diet of older children, whereas maternal intelligence appears to relate to the quality of diet given to toddlers and preschool children. In all cases, relations between offspring nutrition and maternal education and intelligence appear to be relatively independent of family social class factors. Why maternal education and intelligence appear to have different predictive value in Egypt and Peru, depending on offspring age, remains an open question. However, the fact that there is a pattern of differential relations indicates that maternal education is not simply a proxy for maternal intelligence, nor is maternal intelligence simply a proxy for maternal education. How maternal education and intelligence translate into differential variability in offspring nutrition remains a critical question for future research.

Linking development to maternal schooling, intelligence, and offspring nutrition: a conceptual model

In **figure 3** I present a conceptual model that integrates current knowledge on maternal intelligence, maternal education, offspring diet and children's development. As shown in **figure 3**, one dimension of the psychosocial environment (maternal education) both directly and indirectly influences a critical aspect of the child's bioecologic environment (nutrition). Specifically, there appears to be both a direct influence of maternal education upon offspring diet as well as an indirect influence, with more educated women having higher intelligence, which in turn also contributes to the quality of offspring diet. While the processes linking maternal education and intelligence to offspring diet are as yet, unclear, as suggested earlier the link may involve either different adaptive strategies or differing levels of adaptive coping used by more or less educated women.

As also shown in **figure 3**, both our conceptual model and the empiric data presented argue for the importance of integrating both children's nutrition and maternal schooling to better understand variability in children's development. The contributions of nutrition to children's development can be both direct (more optimal brain development for more adequately nourished children) and indirect (more involvement with the environment by more adequately nourished children). Children's development is facilitated both by more optimal brain development and by more involvement with the environment (and more optimal environmental involvement also serves to promote brain development [50]). Increased maternal education can also promote offspring development, not only through increasing the likelihood of better offspring nutrition as shown above, but also through more educated women providing a more optimal rearing environment for their children [51].

Both the conceptual model and the empirical data presented here also have applied implications with regard to emphasizing the importance of schooling for women, not only in terms of the impact on the mother per se but also in terms of influencing the development of the next generation of children in developing countries. Even when food resources are relatively scarce or economic factors make it difficult to purchase food, education for women may be a critical mechanism through which to promote the health and psychologic development of the next generation of children, thus increasing a country's store of human capital.

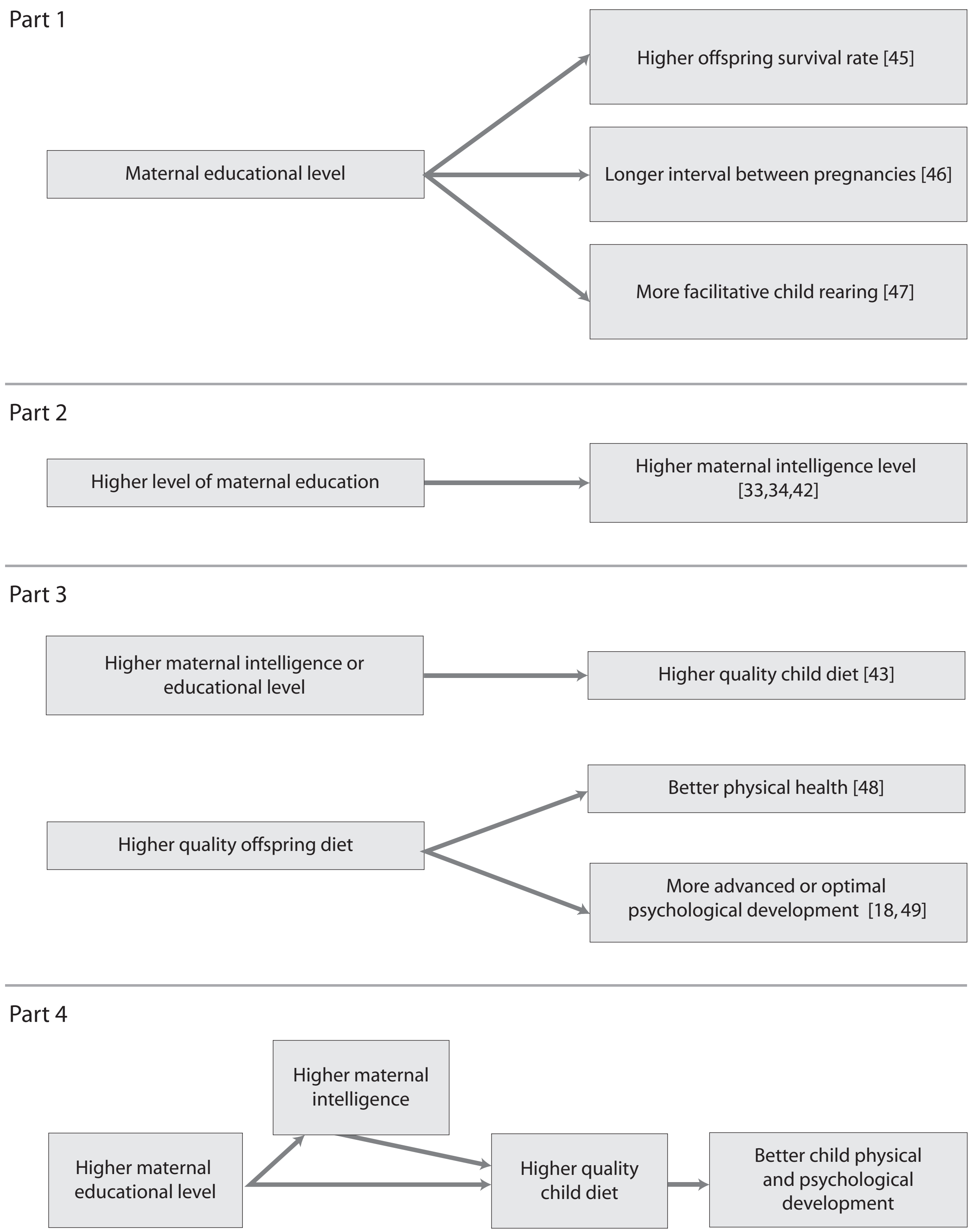

FIG. 3. Proposed model linking nutrition, intelligence and child outcomes

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Crucial role of nutrition in education: The Kenya experience

Kilemi Mwiria

Improved health and nutrition among children contributes to high school enrollment, better school attendance, lower rates of dropout, and improved performance in academic work, as well as to social equity and economic growth. It also enhances children's classroom and school participation, which is important not just for academic but for social development of children. Moreover, child malnutrition can lead to disability or even death. It is the leading cause of death among children under 5 years of age.

The exemplary performance of Makueni children in the Kenya Certificate of Primary Education (KCPE) has partly been credited to a sustainable school-feeding program and other health programs, such as vitamin A supplementation and de-worming, supported by parents and the World Food Programme. If we agree that one must be physically fit to engage in any productive work, then it is easy to appreciate why children need to be well-fed not only to grow but also to concentrate on learning while at school. In any case, health, even more than education, is a basic human need.

Because the poor may not view educating their children as a priority in the context of more pressing problems, many of their children are not only underfed (and consuming an imbalanced diet) before attending school, but they are also made to take part in family labor. As a result, some of them faint in school, especially where they are required to take part in physical education and other practical learning situations. Poor nutrition leads to poor health that leads to poor body stamina and, hence, low interest in performance in extracurricular activities. Because of their backgrounds, some of these children may suffer micronutrient deficiencies, which affect brain development and compromise the immune system, making children more susceptible to illness and thus even increased absenteeism. Therefore, investment in education that is not accompanied by investment in the health and nutrition of school children is a net loss for the country, if those children are unable to learn effectively or drop out of school due to illness.

A number of interventions are likely to promote the health and nutrition status of school children. Most important is a national policy on health and nutrition education. A national school health and nutrition policy is in draft form at the Ministry of Education in Kenya, and is being discussed for finalization. Food and nutrition policy (now under revision) needs to be integrated much more with educational programs. Such a policy should be clear on the objectives of health and nutrition programs and their bearing on education. While integrating health and nutrition as core elements of education programs, the policy should further spell out broad but realistic guidelines on specific targets and benchmarks as well as ways of achieving and evaluating success or failure.

These programs need to be factored in the national budget. In addition, departments that coordinate such programs and fund or vote for nutrition and health initiatives must be strengthened through employment and deployment of more field officers equipped with nutrition knowledge and skills to oversee the correct implementation. If the policy needs the support of the general population, communities should be involved in its preparation, implementation, and evaluation. An enforceable legal framework should back the policy.

Second, a comprehensive program should guide the implementation of the identified policy goals through an inter-ministerial co-coordinating unit comprising representatives of the most concerned ministries, namely the following: Education, Health, Agriculture, Water, Gender and Sports, Home Affairs, Transport and Communications, and Trade and Industry and Planning, among others. There is already an inter-agency Co-coordinating Committee (ICC) on school health that brings together all the most concerned minis-

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tries and other partners, such as non-governmental organizations (NGOs) and donor organizations, to implement programs on school health. This team has to review progress made and plan a future joint agenda and should strengthen collaboration between field officers and institutions of these different ministries. For example, schools could be more closely linked to clinics and public health programs.

Third, health and nutrition curricula need to be expanded following consultations with key stakeholders. Under such curricula, nutrition and health education should be a teaching and examinable subject. In addition, the teaching of related subjects (science, agriculture, life skills, and physical education and sports) should be strengthened. It’s also important to capture the positive aspects of indigenous nutrition and health care practices of traditional and non-traditional foods. To be an effective advocate of these ideals, the school environment has to make adjustments. All schools must have adequate and clean toilets, clean drinking water, and sanitary facilities for girls. This is in line with the global initiative toward “a health promoting school.” This is a school that enhances health, is safe, and protects those in it, but also has health policies and linkages with its wider community on health promotion.

Fourth, facilities for the physical maintenance of school health and nutrition and minimum health (first-aid kits, etc) need to be in place. Where possible, regular medical check-ups could be undertaken. Future school designs should also take account of kitchen and minimum health facilities, while school nutrition and health committees and food production units should be part of a new school environment. This means that schools will need a vote for such facilities and not just for books and teachers, a vote which may be supported through cost-sharing.

Fifth, a revised health and nutrition education curriculum and a changed school environment require training of teachers and education administrators.

Finally, awareness campaigns need to be mounted in some communities to support such school feeding programs and dispel potential rumors (e.g., that donated food is mixed with contraceptives to introduce contraception involuntarily). Such misconceptions surfaced in some parts of the country during the start of the school milk program in Kenya in 1979.

Investment in primary education that is not accompanied by investment in promoting the health and nutrition of schoolchildren is a loss to Kenya. Sick and malnourished children do not learn effectively and drop out of school. A national policy to ensure the health and nutrition of schoolchildren has been drafted for Kenya by the Ministry of Education and is currently being reviewed. Realistic guidelines, specific targets and benchmarks, and ways to evaluate success will be included. The national budget must be allocated as well as an increase in trained field officers to implement the nutrition and health activities. The general population and community must be involved and an enforceable legal framework implemented to support the new policies. An interministerial coordinating body involving education, health, agriculture, water sports, and others must be formed, and it must involve the NGO and donor communities. Existing coordinating committees must be strengthened. School facilities must be improved to ensure a healthy, safe, and sanitary environment. Facilities for food preparation and improved and updated health and nutrition curricula must be introduced, accompanied by appropriate teacher training. Broad community support is needed with parent involvement.

School feeding, school reform, and food security: Connecting the dots

Beryl Levinger

Abstract

Universal access to basic education is a prerequisite for long-term food security, which, in turn, is critical to achieving the Millennium Development goals. This paper examines how Food for Education interventions can contribute to improved food security, improved education outcomes, and a broader set of development goals. Food for Education entails the distribution of food commodities to children who attend school. The commodities may be locally grown and purchased or contributed by aid donors. The food may be consumed by students in school snack, breakfast, or lunch programs. Alternatively, it may be given as a take-home ration for consumption by a family that regularly sends "at-risk" children (usually girls) to school.

Four interrelated ideas are discussed: (1) the universalization of primary school education is a prerequisite for food security (defined here as availability of, access to, and proper biologic utilization of food supplies); (2) Food for Education boosts primary school participation and, therefore, food security; (3) the effects of primary school education on food security are greatest wherever "quality standards" are met, although important effects are present even when education quality is modest; and (4) efforts to improve primary education participation (demand) and efforts to improve primary education quality (supply) are highly interrelated and mutually reinforcing.

Food for Education is a versatile resource that can be used to address a broad range of issues related to both education supply and demand. To be effective, Food for Education interventions must reflect local education supply and demand realities.

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Key words: Food for Education, Millennium Development Goals, food security, school feeding

Introduction

In September 2000, the member states of the United Nations unanimously adopted the Millennium Declaration that presented seven goals intimately linked to human development in low-income countries (and an eighth goal addressed to developed nations). Four of the goals, all to be achieved by 2015, are closely tied to access to basic education, particularly for girls. These education-related goals are the following: a deep reduction in maternal mortality; a similar decrease in mortality rates in children under 5 years of age; the promotion of gender equity and empowerment for women; and the elimination of gender-based disparities in basic and secondary education participation rates. This last goal envisions that "…by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling" [1].

This paper examines one strategy that has been used to bolster basic education participation rates in low-income countries: Food for Education. While there are many variations on this strategy, the basic Food for Education intervention entails the distribution of food commodities to children who attend school. The commodities may be locally grown and purchased or products furnished by the international donor community. In some instances the food is consumed by students as part of a school snack, breakfast, or lunch program. In other settings, the food is offered in the form of a take-home ration that may be consumed by a family that is regularly sending its "at-risk" children (usually girls) to school. Regardless of the specific program modality, the food is intended to serve as a stimulus to enrollment and to help families offset some of the costs (opportunity and cash outlays) that they must bear when educating their children.

This paper puts forth four important and highly interrelated ideas. The first is that the universalization of primary school education is a prerequisite for food security, which is, in turn, critical to achieving the Millennium Development Goals. The second proposition is that Food for Education leads to improved primary school participation rates and, therefore, long-term achievement of food security. The third idea is that the effects of primary school education on food security are greatest wherever quality standards of education are met; however, important effects are present even when education quality is modest. The final idea is that efforts to improve primary education participation (demand) and efforts to improve primary education quality (supply) are highly interrelated and mutually reinforcing.

The dynamic interactions among these variables are depicted in **figure 1**. Each of the four propositions will be discussed to examine their implications for policies that govern Food for Education.

Proposition #1: the universalization of primary school education enhances food security

Food security is a function of availability of, access to, and utilization of food supplies. This definition is illustrated in **figure 2**. Extensive research has demonstrated a strong link between each of these food security dimensions and schooling, as shown in **table 1**.

As **table 1** suggests, educated individuals are more likely to access information and employ agricultural and environmental management techniques that contribute to increased production and greater food availability. Additionally, individuals who receive a quality education are better able to earn a livelihood that provides cash or in-kind resources to obtain nutritious food. Educated individuals are also more likely to practice safe food storage and preparation techniques and to practice basic principles of nutrition, health, and child care. The unifying element among all these food-security-promoting factors is schooling. The linkages depicted in **table 1** are well supported in the literature and have been documented in a wide variety of settings [2] .

Figure 3 and **figure 4** provide simplified depictions of the strong linkages between access to schooling and food security.

Proposition #2: Food for Education boosts primary school participation and, therefore, food security

Where primary school participation is not universal, the reasons why school-age children are not enrolled in school can be classified under two headings: supply and demand. Supply factors describe any characteristic inherent in the education offering itself including curriculum, school plant, fees, and scheduling. By contrast, demand factors reside within the attitudes, perceptions, and preferences of those who decide whether to send a child to school. Generally, these decision-makers are parents, but, as children grow older, they, too, play an important role in decisions about school attendance. Food for Education has the potential to address both sets of factors—supply and demand—as noted in **table 2**.

The research literature on Food for Education is relatively scant if one distinguishes between Food for Education and traditional school feeding programs. School feeding programs—interventions that deliver a meal or snack to children in the school setting with the intent of improving attendance, enrollment, nutrition status, or learning outcomes—have been extensively evaluated. In general, results of these evaluations have indicated that these programs are effective in stimulating demand for schooling, particularly in settings where attendance is

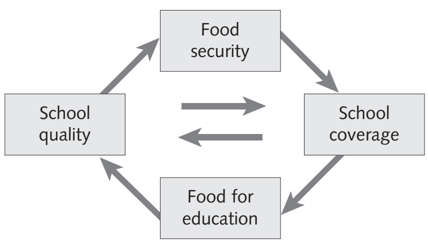

FIG. 1. A web of interactions

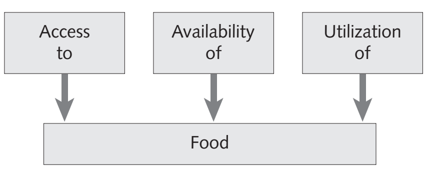

FIG. 2. The three dimensions of food security

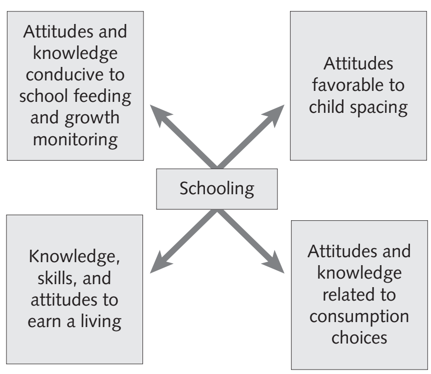

FIG. 3. How access to schooling influences the availability component of food security

not already high and where children come from rural, relatively low socioeconomic backgrounds. School feeding programs appear to contribute to improved attendance and enrollment when there is a good fit between the feeding program design and the environment in which the program operates [3].

Food for Education, in contrast to school feeding, includes a significantly broader array of interventions

TABLE 1. Links between schooling and food security

Availability	Access	Utilization
Definition: There are sufficient stocks of appropriate, necessary types of food. These stocks may come from domestic production, commercial imports, or international donors. Food stocks are in reasonable and consistent proximity to individuals.	Definition: Individuals have adequate means (cash or in-kind resources) to secure for themselves and their families the foods needed to meet dietary and nutrition requirements.	Definition: Individuals can make the proper biologic use of food. Several factors are essential for this to occur: » Access to potable water » Adequate sanitation » Dietary intake of essential nutrients » Appropriate food storage and processing techniques within the household » Maintenance of good health » Proper care for pregnant or lactating women and infants
Factors contributing to availability that are influenced by schooling: » Attitudes and skills related to food production including: » Propensity to adopt technical innovations » Production methods » Partnering or cooperating with others to increase production	Factors contributing to access that are influenced by schooling: » Attitudes and knowledge related to consumption choices including factors related to: » Diet and nutritional value » Calculation of purchase cost per unit » Attitudes favorable to child spacing (so that the decision to have children is linked to a family's ability to provide for them) » Knowledge and attitudes conducive to breastfeeding and growth monitoring » Knowledge, skills, and attitudes favorable to employment in the wage sector and enhanced livelihood through informal channels	Factors contributing to utilization that are influenced by schooling: » Attitudes and skills related to water and sanitation (including partnering/cooperating with others to create communal infrastructure for water and sanitation; proper use of water; proper sanitation practices) » Propensity to use health care facilities » Recognition of factors that interfere with proper absorption of nutrients (e.g., worms) along with the means and disposition to seek treatment when required » Knowledge and attitudes conducive to breastfeeding » Literacy and other skills conducive to following directions and conserving routines related to child care, food preparation and storage, and water quality maintenance

FIG. 4. How access to schooling influences the utilization component of food security

TABLE 2. Relationships among determinants of school participation and Food for Education

Supply factors dampening primary school participation	Demand factors dampening primary school participation
» Rationing of places owing to low school plant absorptive capacity (e.g., limitations of classroom space or number of teachers available) » Irrelevant or inappropriate curriculum » Tuition or fees charged » High teacher absenteeism » Insufficient attention to meeting the special needs of girls or other populations including ethnic or minorities » School distance in relation to households where children reside » School calendar or schedule that is inappropriate in light of local production or cultural practices » Minimal linkages between school and community	Perceptions at the household level concerning any of the following: » Prohibitively prohibitively high tuition, fees or opportunity costs associated with school attendance » Limited value of schooling due to poor quality, teacher absenteeism » Inability of students to meet academic standards » Inappropriateness of schooling (for all or some children within the household) in light of cultural values » Discomfort with teacher's appreciation of family's culture and values » Inadequacy of school plant (especially with regard to separate sex sanitary facilities and distance that girls have to travel)
Illustrative examples of how Food for Education can reduce or overcome these effects: » In-kind payment to community members who contribute labor to expand school absorptive capacity, build new facilities in greater proximity to households, and/or create the infrastructure needed to attract girls » In-kind payment of bonuses to teachers who remain in community and achieve a community-monitored attendance criterion » In-kind payment to teachers who attend training that leads to enhanced classroom instruction » Use of food to offset the opportunity costs of attendance during times when local production practices lead to a spike in opportunity costs » Expanded community involvement in schools as a planned outcome of any Food for Education community-managed intervention	Illustrative examples of how Food for Education can reduce or overcome these effects: » Use of food to partially offset opportunity or out-of-pocket costs associated with school attendance » Use of food to improve "child quality" through supplementary feeding to reduce hunger and malnutrition (which, in turn, will contribute to revised perceptions of a child's ability to perform satisfactorily in school) » Use of food as a stimulus for parents to organize themselves in order to address such concerns as teacher absenteeism, low quality and inappropriate infrastructure, particularly for girls » Greater ties between home and school as an outcome of a Food for Education community-managed intervention (which, in turn, may lead to schools that more closely conform to community values)

designed to improve school enrollment, attendance, community-school linkages, and learning. Among possible Food for Education interventions are take-home rations targeted to girls who attend school with regularity, in-school meals or snacks to reduce short-term hunger and associated cognitive impediments, and food-for-work targeted to teachers or parents engaged in activities to improve schooling outcomes. There is abundant evidence that such interventions can be very effective in, for example, improving a child's active learning capacity, which is, in turn, linked to attendance, enrollment, and completion rates [4]. These relationships are summarized in **figure 5**.

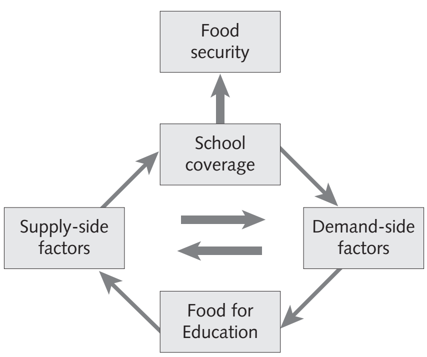

FIG. 5. Food for Education as a determinant of school participation and food security

Anderson has identified 10 building blocks that policy-makers can manipulate in order to achieve universal primary education [5]. These building blocks are depicted in **figure 6**, while **table 3** illustrates how Food for Education can be a critical source of support for change related to each building block.

In summary, there is a strong argument to be made for viewing Food for Education as a program that boosts primary school participation. In so doing,

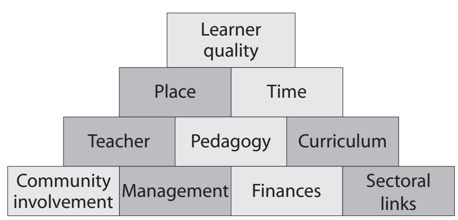

FIG. 6. Education quality building blocks

TABLE 3. Relationships between each building block of school participation and Food for Education

Building blocks	Illustrative related actions	Potential link with Food for Education
Change learner quality	» Change level of hunger or nutrition status » Provide health-care for children » Recruit girls » Recruit children from linguistic minorities	» Provide school lunches to snacks to alleviate short-term hunger » Target food aid to girls and educationally bypassed minorities
Change the place	» Improve water and sanitation » Build satellite facilities closer to communities	Provide food incentives to community members to undertake needed changes
Change the time	Shorten or lengthen the school day	Offset opportunity costs associated with lengthened school attendance through meals or snacks that are consumed at school or on a take-home basis
Change the teacher	» Provide teaching housing; improve salaries » Create additional incentives to improve teacher motivation » Recruit more qualified personnel » Recruit teacher aids from the community	» Provide food incentives to community members who help with teacher housing » Provide food aid to supplement teacher salaries or as a bonus for perfect attendance » Pay portion of teacher aid salaries in food aid
Change the level of community involvement	Create mechanisms so that the community provides resources and guidance for the school	Involve community members in the organization and management of lunch or snack programs
Change the curriculum	Introduce more useful subjects	Use food preparation as an opportunity to impart skills related to: » Good handling » Storage » Nutrition » Sanitation » Food choices
Change the pedagogy	» Introduce more child-centered, active pedagogy » Introduce textbooks and other instructional materials; » Develop metacognitive skills in learners	Introduce snacks to reduce short-term cognitive deficits associated with prolonged fasting
Change the management system	» Introduce accountability for results » Make teacher supervision meaningful	In creating a Food for Education program: » Use participatory needs assessment and project planning methodologies that lay the groundwork for parent and community participation » Use snack or lunch programs as the departure point for creating active PTAS that have the capacity to insist on accountability for results » Organize parents and community members to prepare meals and snacks in ways that lay the groundwork for more extensive participation in school performance monitoring
Change the financial support system	» Provide an outlay that is adequate to educate a child through reallocation of budgetary resources » Achieve appropriate balance between teacher salaries and other kinds of education investments	Food for Education, particularly if accompanied by partial monetization, may offer temporary relief for some of the financial pressures inherent in universalizing primary education
Create linkages to other sectors	Education problems should be viewed in broader contexts. For example, why don't girls attend school? The lack of potable water in a community and the need for a girl's labor in the household can be addressed effectively by other sectors	Food for Education is an intervention that is easily and meaningfully linked to the health sector through such programs as deworming and vitamin A supplementation

the program contributes to enhanced national food security.

Proposition #3: primary school education contributes to food security even when quality is modest, although greater education quality leads to greater food security gains

The impact of primary schooling on food security is greatest wherever "quality education" is offered. "Quality education" describes a setting in which appropriately trained and certified teachers provide a regularized program of instruction that is linguistically, cognitively, and pedagogically appropriate to learner needs. This instruction enables learners to master stipulated curricular objectives. Through exposure to quality education, learners acquire the skills, knowledge, and attitudes needed to successfully secure a livelihood, participate in civic affairs, contribute to their family's well-being, and engage in lifelong learning.

Researchers working in a broad range of developing countries have attempted to isolate the factors most closely identified with "quality." These include class and school size; the use of teaching tools such as textbooks, readers, exercise books and teacher guides; school libraries; and child nutrition and feeding programs. Expenditure per pupil is also closely linked to positive impact in developing countries [2].

Teacher characteristics most closely associated with quality include pre- and in-service teacher education; teacher subject knowledge or language experience; teacher experience; teacher social class; and class preparation time. Instructional time, frequent monitoring of pupil performance, and the frequency of homework are also powerful determinants of learning outcomes [2]. Contrary to conventional wisdom on the subject, class size does not appear to be a major determinant of student achievement.

Unfortunately, in many countries throughout the developing world, the presence of most of these "quality inputs" is the rare exception rather than the rule. Does this mean, then, that Food for Education programs cannot contribute meaningfully to improved food security? This is not the case for two principal reasons.

First, as one might well expect from a list this broad, some interventions are decidedly more powerful than others. Instructional time, cited in 15 of 17 studies reviewed, appears to be the most significant input for improvements in education quality. It should be noted that the most widely documented benefit of school feeding programs is improved attendance, which, of course, has the effect of increasing instructional time [2].

Second, some highly positive effects of education have been documented even when education quality is suboptimal. Research suggests that important contributions to food security come with the acquisition of basic literacy. If the schooling available can meet this minimal quality standard of imparting literacy, it can also enhance food security.

Once literate, the individual has the ability to "decode, interpret, and act efficiently," thus taking advantage of technical change and new economic information [6]. In the agricultural sector, studies indicate that four years of basic education significantly increase farm output. This is particularly the case in those areas that are influenced by "modern" agricultural procedures [7–9]. Such environments are characterized by the availability of new crop varieties; the use of such inputs as insecticides, fertilizers and machinery; and the presence of market-oriented production procedures—all factors that are intimately and positively linked to food security.

Other food security effects associated with even sub-optimal education relate to a woman's childbearing decisions. Econometric analyses suggest that an extra year of schooling reduces female fertility by approximately 10% [10]. These effects were observed in Pakistan among women with as little as one year of formal schooling.

Proposition #4: efforts to improve demand for schooling and school quality are highly interrelated and mutually reinforcing

Food for Education can generate additional demand for schooling through its transfer payment effects. But the contribution of Food for Education to demand generation is not limited to these effects. Thus, for example, the provision of food to hungry children also has cognitive benefits. The boost that a snack or meal gives to a child's active learning capacity in turn influences parental perceptions of child competence. These perceptions play an important role in parental and child decision-making regarding school attendance and enrollment.

As detailed in **table 2** and **table 3**, Food for Education can also be an important component in any effort designed to improve school quality. What is important to note here, however, is that improvements in supply and demand are intimately linked. For example, note the following relationships:

- When more families send their children to school, the constituency for quality education increases.
- Research consistently confirms that the reason parents most often give to explain their decision not to enroll a child in school is that they view the education available as "worthless."
- When education quality improves, student promotion and retention rates tend to increase leading to greater coverage for the school-aged population.
- Mobilization of parents through the creation of PTAs

and similar groups is a strategy that has been shown to have impact on both school quality and demand for schooling.

Food for Education will achieve optimal impact where quality is relatively high and demand is lagging. However, it can be a powerful intervention in other contexts if, at a minimum, the schooling offered leads students to achieve basic literacy. **Table 4** depicts relationships among Food for Education program features, demand for schooling and education quality.

The key inference to draw from this discussion is that efforts to improve demand for schooling are intimately linked to education quality initiatives in "chicken-and-egg style." Improvements in coverage lead, over time, to gains in quality while gains in quality generate additional demand.

Conclusions: policy implications of this "proposition set"

Participation in primary schooling is an important determinant of food security. Food for Education programs can attract students to school who would otherwise not attend, thereby contributing to enhanced food security. Food for Education can also be used as a tool to promote school quality, thereby further enlarging the stream of benefits associated with food security. However, even where school quality is modest, food security benefits are observable, as long as the available schooling enables children to achieve basic literacy.

The optimal use of Food for Education entails customized responses to both coverage and quality issues. If such responses result in contextually appropriate designs (summarized in **fig. 7**), Food for Education can be a powerful tool in the struggle to ensure that every citizen enjoys the upwardly spiraling, intergenerational benefits of food availability, access and proper utilization.

The full potential, then, of Food for Education is realized only when a careful analysis of the factors

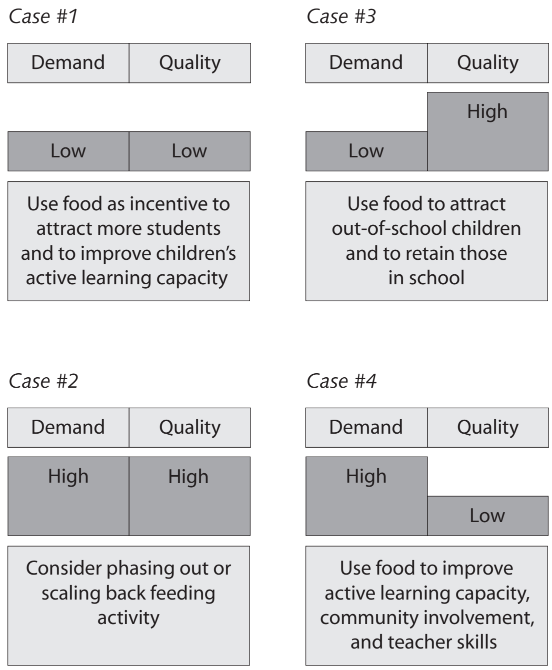

FIG. 7. Contextualizing Food for Education according to education demand and quality levels

TABLE 4. Relationships among schooling demand, schooling quality, and Food for Education program design

Demand/Coverage	Quality	Implications for Food for Education programs
Low	Low	» Program must simultaneously address both supply and demand issues » Food should be used as a transfer payment to attract out-of-school students and members of under-represented groups (e.g., girls, linguistic minorities) » Children whose active learning capacity places them at education risk should be targeted for in-school supplementation » Specific obstacles to quality should be identified and, as appropriate, addressed through the flexible use of food targeted to households, teachers and at-risk children
Low	High	Program should focus on demand generation by targeting bypassed groups through in-school meals or snacks as well as take-home rations
High	Low	Food can be used to: » Bolster children's active learning capacity; » Serve as an entry point for greater community involvement in school affairs (in the hopes that this involvement will lead to effective monitoring of school performance) » Improve teacher characteristics Program should focus on efforts to improve quality
High	High	Program should, in an organized way, be phased out except in those circumstances where food is essential to the maintenance of children's active learning capacity

contributing to supply and demand blockages is undertaken. The four scenarios outlined in **figure 7** illustrate that selection of a particular Food for Education strategy must be context-specific; a setting where education quality is high but demand is low will focus on bringing new children to the school. By contrast, in communities where quality is low but demand is high, Food for Education can best be used to improve what happens within the classroom. Obviously, the creation of strategic linkages between the food resource and whichever building blocks seem most likely to reduce or eliminate identified blockages is a key element of program contextualization.

Figure 8 depicts how Food for Education can be used to modify one or more of the 10 building blocks so that, in turn, education quality and coverage are improved. The figure reflects the view that supply and demand are intimately linked and function as interdependent factors.

Thus, for example, gains in school coverage create more stakeholder-parents who care about the quality of schooling and who have the collective clout to get this issue featured more prominently in local political deliberations. When parents perceive that the quality of the education offering is high, they want their children to participate, thereby generating additional demand for schooling. This additional demand contributes to local food security which, in turn, makes further expansion of school coverage possible.

Improved food security also contributes to enhanced school quality. Consider this example: Children who are unencumbered by hunger and malnutrition are able to reach their full potential as learners. Consequently, teachers do not have to spend a disproportionate level of effort reviewing and reteaching. Instead, more time is available to introduce new concepts to students. An understanding of this complex web of linkages is critical if we wish to ensure that all children—include future generations of learners—enjoy the opportunity to contribute to the development of their families, communities and nations.

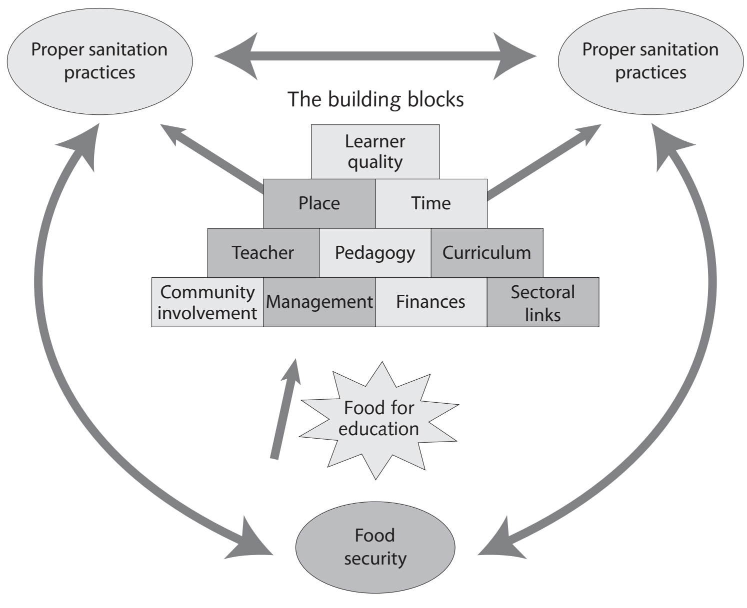

FIG. 8. Achieving the full potential of Food for Education

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Nutrition education in Chilean primary schools

Sonia Olivares, Isabel Zacarías, Margarita Andrade, Juliana Kain, Lydia Lera, Fernando Vio, and Cecilio Morón

Abstract

The purpose of this study was to incorporate nutrition education in Chilean primary schools. The baseline information included nutritional status, food consumption and physical activity of 1,701 children from 3rd to 7th grade in ten urban and rural schools. Main results showed a high prevalence of obesity (15.4%) and overweight (19.6%), low consumption of vegetables, fruits, and dairy products, high intake of snacks and a low level of physical activity, especially in girls. Because the Ministry of Education does not allow the incorporation of new programs into the curriculum, the educational strategy was based on the development of a text book, a teacher's guide, five practical guides for students from third to eighth grade and a CD-Rom. These materials were validated by 36 teachers in six schools through an educational intervention. Teachers and students considered the educational materials useful, motivational and easy to understand. This program is being implemented in 57 schools.

Key words: Nutrition education, school children

Introduction

According to the Population Census carried out in 2002, Chile had 15,116,435 inhabitants, an annual growth rate of 1.2%, 86.5% of the population living in urban areas, and a literacy rate of 95.8% among those 10 years of age and older. The per capita income was US $4,590 and 20.6% of the population was living under the line of poverty.

Approximately 2 million children attend 10,621 primary schools, 92.2% of whom attend public schools. Up until 2003, 8 years of mandatory education were required in Chile, but starting in 2004 this has been increased to 12 years [1].

During the last 25 years, important changes have occurred in the epidemiologic profile of the Chilean population. Life expectancy rose from 60 years in 1970 to 73 years in 2001 for men, and from 65 to 80 for women during the same period. The country simultaneously experienced a demographic and epidemiologic transition, resulting in an aging population and a shift from infectious to chronic diseases. A sedentary lifestyle and consumption of processed foods rich in fats, sugars, salt, and low in dietary fiber, all known risk factors for obesity, have also risen considerably [2].

Between 1987 and 2000, the prevalence of obesity (defined as BMI percentile ≥ 95 of the CDC 2000 reference) among schoolchildren entering first grade at public schools across the country increased from 5.1% to 14.7% for boys and from 4.0% to 15.8% for girls, [3, 4]. On the other hand, the prevalence of stunting (defined as height/age < 2 SD of the National Center for Health Statistics (NCHS/WHO) reference declined from 5.9% in 1993 to 3.1% in 2002, whereas weight deficit (defined as weight/height < 2 SD of the same reference) was very low, 1.6% in 2002 [5].

Considering that obesity is the main nutrition problem among Chilean children and that it has been demonstrated that being obese in childhood almost doubles the risk of having this condition during adulthood [6], various initiatives are being developed to address this problem [7, 8].

In 1997, the Ministry of Health changed the traditional maternal and childhood policies for new health and nutrition intervention priorities, based on cardiovascular disease, obesity, cancer, hypertension, diabetes, osteoporosis, and anemia. In order to confront the risk factors of this diseases, the Ministry of Health published the Chilean Dietary Guidelines (1997) and

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an inter-sector organization, the National Board for Health Promotion, VIDA CHILE, was created in 1998, with the specific goal of reducing the prevalence of obesity in first grade schoolchildren from 16% in 2000 to 12% in 2010 [7].

In addition, a new strategy in the country, known as "Health-Promoting Schools," has been implemented since 1999 with the purpose of creating positive environmental conditions to promote more healthful eating habits and physical activity among schoolchildren. In the country, currently 3,100 schools (29%) are working in health promotion.

Another specific initiative was to improve the diet quality of low-income schoolchildren who are beneficiaries of the School Feeding Program (SFP) [9,10]. This program started in Chile in 1929, is administered by the National Board of Assistance and Scholarships (Junta Nacional de Auxilio Escolar y Becas or JUNAEB) and will benefit 875,531 primary schoolchildren daily in 2004, with a fiscal annual budget of US $89 million.

The main goal of the SFP is to promote school attendance by providing free meals to children who might otherwise drop out of school. The meals have different nutrition contents (250, 700, and 1000 kcal) and are distributed 178 days per year [5, 9, 10].

In 2000, JUNAEB, with the technical support of the Institute of Nutrition and Food Technology (INTA) of the University of Chile and the Ministry of Health, improved substantially the nutrition quality of meals. Breakfasts now include milk 5 days a week (instead of the milk substitute delivered before). During lunch, the frequency of salads has increased from 4 to 8 times per month, and fruits from 6 to 10 times per month. The new program allows a maximum of 10% of calories from saturated fat, which has been accomplished by changing the type of meat. **Table 1** shows the nutrition characteristics of the basic program (700 kcal/day) provided by private food companies that deliver the meals after receiving a licence from JUNAEB.

Although the quality of the meals has improved, they are still deficient in terms of frequency and amount of low-fat milk, vegetables, and fruits offered. Budget constraints and logistic difficulties for handling fresh foods limit the optimization of the program.

Additionally, each year JUNAEB carries out a census on the weight and height of all first grade children in all public schools throughout the country. This information on the national and regional levels is available on the Internet (nutrition map, http://www.junaeb.cl) [5].

TABLE 1. Nutrition content of meals offered by the Chilean School Feeding Program and its coverage of the US RDA [10]

Nutrition content	Elementary schools[a]	% Coverage of RDA[b]
P% (daily, minimum)	11%	60%
F% (daily, minimum and maximum)	20–25%	36%
SFA% (daily, maximum)	10%	35%
Free sugars	25 g	50%

RDA, Recommended Dietary Allowance; P, protein, F, fat; SFA, saturated fat

a. Contents for breakfast and lunch (700 Kcal)

b. Considering a 2000 Kcal daily requirement

Nutrition education in Chilean primary schools

It is clear that appropriate nutrition is essential for children's growth and the changes in eating and physical activity habits must occur at the earliest age possible. Therefore, the school represents the best opportunity to adopt a healthy lifestyle through knowledge, attitudes, and behavior [11–13]. However, the primary school curriculum of the Chilean Ministry of Education does not yet include nutrition education [1].

The main barriers to implement nutrition education programs for primary schoolchildren in Chile are the teachers' lack of nutrition knowledge, insufficient education materials, and the difficulty in obtaining government support to address these issues with an adequate methodology [14]. Taking these barriers into consideration [15], INTA and the Ministry of Education requested the Food and Agriculture Organization of the United Nations (FAO)* to jointly design and implement a technical cooperation project, the specific objectives of which were the following:

» To promote the integration of nutrition education for 3rd to 8th grade curriculum of Chilean primary schools, based on present food habits and nutrition status.

» To design and validate appropriate learning materials for primary schoolteachers and children.

» To develop and validate a training program for teachers, to be replicated in the whole country.

The project was developed in 10 public schools located in low-income neighborhoods from three different regions representing the geographic variability of the country: North (Region I), Center (Metropolitan Region), and South (Region X). In each region, schools with a minimum of 30 students per grade and from both rural and urban settings were selected. **Figure 1** shows the model followed during the development of the project.

Baseline information

Students from one class (grades 3rd to 7th) from each of the 10 schools participated in the study, totaling 1,701 children between the ages of 8 and 13. The proportion of boys and girls was similar, while the average

* TCP/CHI/0065 "Nutrition Education in Primary Schools" project funded by FAO.

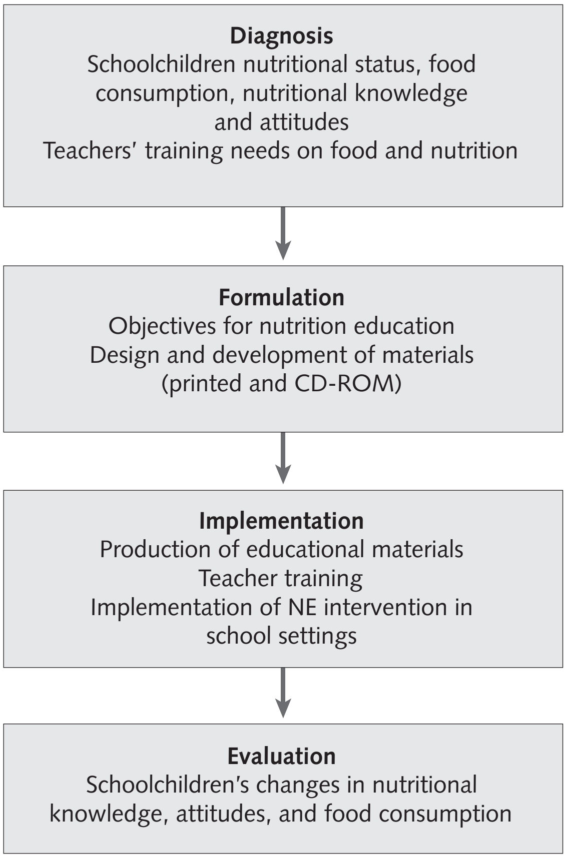

FIG. 1. Nutrition education (NE) strategy

age was exactly the same, (10.6 ± 1.4 years) for both genders. Data were analysed according to gender and by three age groups (8–9, 10–11, and 12–13 years) [16].

In each city, three trained interviewers (nutritionists or teachers), evaluated the nutrition status and interviewed the children on their dietary and physical activity habits. Anthropometric measurements and surveys were performed between April and June of 2001.

Nutrition status was determined using body-mass index (BMI, kg/m^2). For each child, BMI was estimated by age and sex and compared with the CDC/NCHS reference 2000 [4]. This has been recently recommended for evaluating Chilean children from 6 to 18 years of age. The cut-off percentiles used to classify the nutrition status of the children were those recommended by the North American Committee of Experts in Childhood Obesity [17]; underweight: BMI percentile < 10; normal weight: BMI percentile ≥ 10 to < 85; overweight: BMI percentile ≥ 85 to < 95; obese: BMI percentile ≥ 95.

The data analyses showed no significant differences when comparing nutrition status among the three geographic regions, or between urban versus rural settings. Thus, results represented the sample as a whole.

Figure 2 shows the nutrition status in both boys and girls by age group (8–9, 10–11, and 12–13 years). Overall, boys showed a higher rate of obesity than girls. Significant differences in nutrition status were found according to age, with the highest prevalence of obesity among the younger boys ($p < .05$). In girls, no differences were observed according to age.

To evaluate daily food consumption, a quantified food frequency questionnaire (FFQ) [18] was applied by trained interviewers on all children. We obtained information on those foods recommended by the Chilean Dietary Guidelines [8], that is, dairy products, fruits, vegetables, and also bread because its consumption is extremely high in the country. In addition, we collected data on energy-dense foods such as snacks and beverages.

The average daily food intake of the total sample was expressed in grams/day (mean ± SD), by age and gender (**table 2**). Intake of dairy products was low. Boys

TABLE 2. Selected food intake by Chilean schoolchildren, by group and gender (mean ± SD in grams/day)

	8–9 y, *n* = 611		10–11 y, *n* = 654		12–13 y, *n* = 436		
Food groups	Boys *n* = 324	Girls *n* = 287	Boys *n* = 365	Girls *n* = 289	Boys *n* = 238	Girls *n* = 436	Recommended[a]
Milk and yogurt	308.3 ± 192.2	299.3 ± 182.3	281.7 ± 180.6[b]	242.5 ± 167.5	267.1 ± 171.1[b]	240.9 ± 155.9	750 mL
Fruits and vegetables	197.4 ± 135.9	220.4 ± 149.9[c]	237.2 ± 153.7[c]	210.7±129.7	271.3 ± 183.6[c]	238.1 ± 145.7	400 g
Bread	269.6 ± 97.6[b]	232.1 ± 94.1	295.8 ± 112.7[b]	255.4±112.2	324.6 ± 133.2[b]	270.1 ± 117.8	200 g
Snacks (sweet and salty)	113.0 ± 79.7	111.3 ± 81.3	118.6 ± 85.4[c]	106.7±70.1	135.4 ± 99.7[c]	124.2 ± 94.0	—
Beverages	218.3 ± 167.1	219.3 ± 176.2	279.0 ± 184.8[c]	250.9 ± 173.0	301.1 ± 199.9[c]	295.8 ± 229.4	—

Source: Adapted from [16]

a. Dietary Guidelines, Chilean Ministry of Health

b. $p < .001$ for higher statistical differences between boys and girls.

c. Student's *t*-test $p < .05$

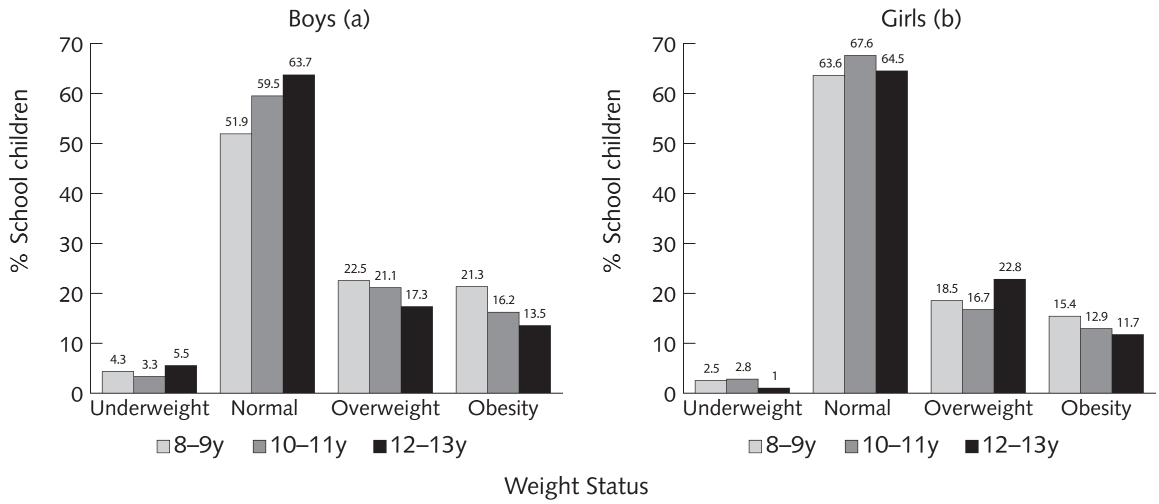

FIG. 2. Nutrition status of Chilean schoolchildren, by age group

consumed significantly more of these products in both 10–11 years and 12–13 years age groups. Intake of fruits and vegetables was also low in all age groups. Other studies have found similar results [19, 20]. Ironically, Chile is not only a fruit exporting country, but fruits are relatively inexpensive. This shows the urgent need to implement nutrition education programs which address the importance of consuming these foods.

Intake of bread was significantly higher in boys across age groups. This has been found consistently in other studies performed in the country [19, 20]. Based on the Chilean Food Pyramid, the Ministry of Health recommends a total daily intake of cereals (apart from bread, this group includes pastas, rice, potatoes, corn) of 350 g and 300 g for 6- to 9-year-old boys and girls, respectively, whereas for children 10–13 years old this recommendation is 375 g and 325 g, respectively. In this study, bread alone accounted for around 80% of the total recommendation; adding other foods from this group, which constitute the staple of our diet, obviously increases the calorie intake.

Intake of snacks rich in fat and sugar was very high and similar for boys and girls in the younger groups. In the older groups, boys consumed significantly more than girls. The intake of snacks represents 450 to 600 kcal extra daily. This is similar to the figures found in schoolchildren by Yáñez et al. [19], whereas Kain et al. [21] reported approximately the same among preschoolchildren (350–500 kcal). In addition, a study about food advertisement and preferences in this age group showed that the products most often remembered and purchased by the children were French fries, sweet and salty snacks, soft drinks and fast foods [22].

When we compare intake of each food group and nutrition status, only the consumption of dairy products was significantly greater among non-obese children for both genders across age groups ($p < .005$). This result is similar to several epidemiologic studies where an inverse association has been found between dairy consumption and risk of being overweight [23].

To estimate the physical activity habits (PA), students were asked about the number of hours spent watching television (TV) during a school day and a typical weekend day, and about the frequency of after-school PA, such as running, jumping, jogging, bicycle riding, or playing soccer. TV viewing was calculated adding the total number of shows watched on a daily basis, as has been done in previous studies [22].

Figure 3 compares total TV viewing during a school day and a typical weekend day. During a school day, 10% of the children reported never watching TV, and 22.3% watched more than 3 hours. During the weekend, the proportion of children who watched more than 3 hours per day increased considerably, to 47%. The difference in TV viewing between a weekend day and a week day was highly significant ($p < .0001$. No differences were found by gender.

The time children spent in after-school PA varied according to age and gender. Although boys were significantly more active than girls, only half of the boys were physically active four or more times a week. Between 7% and 9.5% of boys and between 14% and 21% of girls never engaged in PA. In boys, no differences were noted across age groups. Younger girls were significantly more active than older girls ($p < .03$) (not shown).

When examining the distribution of TV viewing in relation with after-school PA (**fig. 4**), the analysis showed an association between these two variables, that is, the more time children spent in PA, the less time they devoted to TV watching ($p < .03$).

When analyzed for an association between after -school PA and nutrition status according to age and gender, an association was found only among the

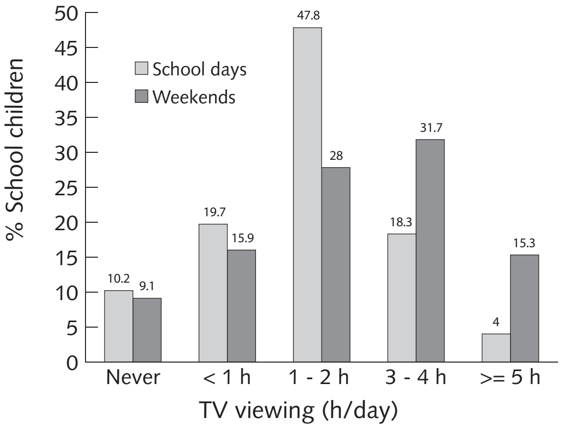

FIG. 3. Comparison of TV viewing during school days and weekends by Chilean schoolchildren (n = 1,701)

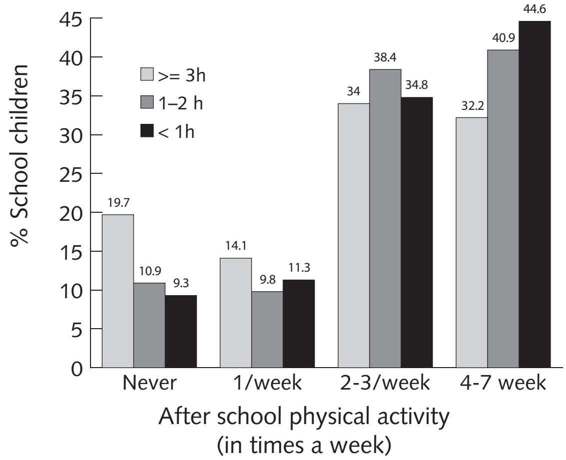

FIG. 4. Frequency of after school physical activity and TV viewing by Chilean schoolchildren

younger boys ($p < .02$), where non-obese boys were more active than obese boys (not shown).

Nutrition education strategy

This background information, plus other complementary studies on teachers' needs and training interests, constituted the core to defining the education strategy on nutrition education for primary schoolchildren, oriented toward modifying their behavior and eventually also that of their families.

Because the Ministry of Education doesn't allow the incorporation of new programs to the curriculum, the education strategy of the project was based on design and validation of a set of learning materials (**fig. 5**), which include a text book, a teacher's guide, five practical guides for students from third to eighth grade and a CD-ROM. All these materials are also available on the Internet [24].

The contents are presented in five modules: Healthy Eating; Nutrition Requirements; Nutrition and Health, with a description of the reason of the main health problems and their prevention; Safe and Healthy Foods; and Household Food Security, focused on the availability, access, and utilization of food by the low-income population.

Before the first version was published, the materials were submitted for revision by nutritionists and 16 primary schoolteachers. The revised materials were published to be used during the teachers' training process and also for the implementation of the nutrition education intervention with students from six schools. The training process was carried out at the beginning of 2002, lasted 3 days, and included 45 primary schools teachers from the three regions of the project. This training program was highly motivational and it allowed those involved to appreciate the usefulness of the education materials. Some of the participants spontaneously trained other colleagues interested in participating in the project, reflecting the importance of the education material in carrying out this task, and meaning that the teachers viewed the nutrition education as an activity for the whole school.

Each text and activity was validated by the teachers when they implemented the education intervention during 5 months. The most successful activities were those that included preparations of healthy foods, where parents also participated.

Among the most important results of this phase, were the teachers' indications that the program and education materials were useful, motivational, and easy to understand. After the education experience, the teachers suggested that they needed at least 2–3 hours weekly during the school year to implement this intervention.

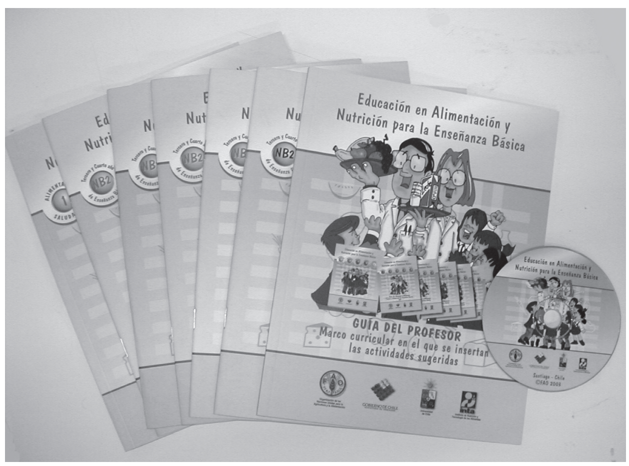

FIG. 5. Nutrition education (NE) strategy

Evaluation results of school experiences

The objectives of this project, which are to promote the incorporation of nutrition education into the school curriculum through the design and validation of a model and education materials for teachers and schoolchildren, were fully achieved.

Although the education intervention only lasted 5 months and we did not expect significant changes in nutrition status and food intake, we nevertheless compared knowledge in food and nutrition and food intake of the intervention group (812 children) versus the control group (540 children). With regard to knowledge, a significant increase was observed among the initial and final scores in children from intervention schools, with the exception of 5th grade. No differences were observed among the control group. The comparison of food consumption before and after the intervention showed a significant increase in the consumption of dairy products among the younger groups of the intervention schools. No increase was noted in the control group. Intake of fruits and vegetables only increased significantly in 10- to 11-year-old girls of the intervention group. The consumption of bread declined significantly among girls of the intervention group. Intake of snacks increased in both groups, but it was significantly higher in the control group. Soft drinks increased significantly in 8- to 9-year-old children from both intervention and control groups.

Because snack foods are very inexpensive and sold at kiosks within and right outside of schools, the increase in the consumption of snacks in both groups makes us conclude that nutrition education will only produce significant changes in food habits if certain initiatives are carried out. Specifically, health and education authorities should regulate what is sold inside the schools and establish some regulations for the food industry. In addition, advertisement for children should not only be regulated, but required to promote healthful foods. It is important to point out that approximately 73% of low-income children take money to school, which is largely spent on snacks. The children should be given the opportunity to spend their money on healthful foods. These initiatives would surely contribute to halting the rapid increase in childhood obesity.

Implementation and follow-up activities

Given the successful experience of this project, the Chilean Ministry of Education assigned the responsibility of incorporating nutrition education in the curriculum of public schools to the JUNAEB. JUNAEB began a new pilot project with 47 schools from 10 regions in 2003, which in its first phase included collecting baseline information on nutrition status, attitudes, and feeding practices of the schoolchildren, as well as teachers' training, which was carried out by INTA. Further education interventions with the schoolchildren will be implemented in 2004 and evaluated at the end of the year.

During the year 2003, INTA carried out four training courses for 122 teachers from 10 regions of the country. Additionally, 31 supervisors of JUNAEB, who will carry out the follow-up of the nutrition education activities at regional level, were trained by INTA.

Presently, every public school in the country has received a CD-ROM, which includes all the teaching materials (which are also available on the Internet). It is estimated that starting in 2005, the Ministry of Education will incorporate these contents into the official text books used by schoolchildren attending public schools.

In addition, FAO has distributed this program to every Latin American country, some of which have already submitted similar projects to be implemented in their respective school systems. This education material with only small modifications can be easily adapted to local realities.

Conclusions

In August 2003, a workshop was organized by FAO and INTA, with the goal of evaluating the entire experience from the participating teacher's perspective. The following conclusions were reached:

The designed and validated nutrition education materials for teachers and primary schoolchildren, developed by this project, proved to be effective and highly motivational, and can be used as part of the general primary curriculum or in independent nutrition education programs.

The nutrition education training program for teachers was successful and motivational, and can be replicated throughout the entire country. The teachers highlighted the usefulness of the education material for their own training, especially their capacity to motivate the participation of the children, which is an outstanding aspect of the learning process.

In summary, this project has provided the basis to carry out systematic nutrition education interventions in primary education, validating a methodology, instruments, and education materials as well as a teachers' training program that is applicable at the national level. This nutrition education strategy represents a significant contribution for developing healthy eating habits and also a means to diminish the prevalence of overweight and obesity among Chilean schoolchildren.

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School health and nutrition: Policy and programs

Donald Bundy

Abstract

This paper argues that there is now reliable evidence that ill health and malnutrition affect education access, participation, completion, and achievement, and that school-based health and nutrition programs can provide a cost-effective and low-cost solution. International coordination around this issue has been helped by a consensus framework to "Focus Resources on Effective School Health (FRESH)," developed jointly by UNESCO, WHO, UNICEF, Education International, and the World Bank, and launched at the World Education Forum in Dakar in April 2000 as part of the global effort to achieve the goal of Education for All (EFA). The need for school health and nutrition programs as part of EFA actions is now recognized by both countries and development partners, and examples of successful practical sector programs that have gone to scale are presented for both low- and middle-income countries. This paper argues that, despite this progress, there are two key unresolved issues related to the targeting of nutrition interventions toward school-age children. The first concerns the role of food as an incentive for participation in education, and the second concerns the appropriate target age group for nutrition interventions. It is suggested that finding clear answers to these key policy questions in nutrition could profoundly influence the impact of future school health and nutrition programs.

Key words: Schoolchildren, nutrition, education, policy, school-based

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Introduction

Improving the health and learning of schoolchildren through school-based nutrition and health programs is not a new concept. However, many early programs have been characterized as being heavily focused on disease prevention, being uncoordinated, lacking integration and poorly evaluated and disseminated. Most importantly, the traditional school nutrition and health programs have been based in the better off schools and in urban centers. This situation is changing as new policies and partnerships are being formulated that help ensure that programs are socially progressive and specifically targeted toward the poor, girls, and the most disadvantaged children. [1, 2]

This change in perspective is timely as countries and agencies seek to achieve Education for All (EFA) by 2015, and address the Millennium Development Goals (MDGs) of Universal Basic Education and Gender Equality in Education Access. If every girl and boy is to be able to complete a basic education of good quality, then school nutrition and health programs are essential to ensure that the poorest children, who suffer the most malnutrition and ill health, are able to both attend school and learn while there.

School health and nutrition policy issues

School health programs appear to be a good economic investment in the future income earning capacity of children. These benefits accrue from both improved education outcomes and the long-term impacts of good health in childhood. The return on investment is greatest if programs are designed to be equitable and pro-poor.

Economic benefit of school health and nutrition programs

Improving the health outcomes for children may have education impacts on enrollment, attendance, grade repetition, and grade attainment, all of which have implications for the assessment of the economic benefits of intervention. Numerous studies have shown a high return on education, associated with, among other things, higher worker productivity, and generally higher productivity in non-market production activities, including greater farmer efficiency and productivity [3, 4]. Psacharopoulos and Patrinos summarize a wide range of studies that focus on individual wage earnings (i.e., excluding returns to education in self-employment activities or returns associated with labor contributions to family business and farms) [5]. Overall they find that the returns to education in wages are higher in developing countries than in developed countries: a 12% rate of return to 1 additional year in school in sub-Saharan Africa, compared with 10% for Asian countries, 7.5% for Organisation for Economic Co-operation and Development (OECD) countries, and 12% for Latin America and the Caribbean. These returns are very high, even allowing for a portion of this return to be capturing ability and other factors rather than schooling itself. [6]

The study by Miguel and Kremer [7] in Kenya showed that a school health program including deworming reduced total primary school absenteeism by at least seven percentage points (one-quarter) in the first 2 years of the project. These gains were largest for the youngest children who suffered most ill health. There were also clear externalities, with significant reductions in worm burdens and increases in school participation among untreated students in treatment schools and among children in neighboring, untreated primary schools. In terms of cost-effectiveness as an education intervention, deworming proved to be far more cost-effective at improving school attendance among a series of education interventions implemented in the larger study in Kenya. [7]

Under a set of assumptions for Kenya, Miguel and Kremer [7] found that this intervention offers a very high rate of return, increasing the net present value of discounted wages by more than $30 per treated child compared with per treatment costs of under $1. They concluded that these benefits still outweigh the costs even if increased school participation leads to greater costs in teacher compensation through the need for additional teachers, and noted that the benefit-cost ratio remains more than 10 if the rate of return to an additional year of schooling is as low as 1.5%. [7]

A non-experimental evaluation by Bleakley [8] of the short-term and long-term impacts of a school-based hookworm control program in the American South (c. 1910) compared treated and untreated areas. Hookworm infection was estimated to cause a 23% drop in the probability of school attendance, a finding that is strikingly similar to the 25% fall seen in the Kenya study. Children with greater access to the intervention program were more likely to be literate, and long-term follow-up of affected cohorts showed that ill health in childhood led to significantly lower wages in adulthood. [8]

Improvements in early health may also have long-term implications for economic outcomes in adulthood through the well documented effects on physical growth [9, 10]. Height has been shown to affect wage-earning capacity as well participation in the labor force for men and women (for example, see [11] and [12]), a relationship that may be strongest in low-income settings where physical endurance yields high returns in the labor market. For a 1% increase in height, Thomas and Strauss [12] find a 7% increase in wages in Brazil compared with a 1% increase in the U.S. [12]

Policy and economic issues in designing interventions

The negative correlation between ill health and malnutrition and income level is clearly demonstrated both in cross-country comparisons and within countries [13], partly because lower incomes and higher poverty themselves promote disease and inadequate diet. Similarly, children who are not enrolled in school come from households with lower income levels [14]. This suggests that there will be a greater return to school health services that are pro-poor and specifically linked to efforts to achieve EFA, and as discussed further below, there are also compelling reasons why such programs should avoid reliance on health service facilities, and should be implemented by the public sector.

Many school health programs, particularly in Africa, have descended from colonial antecedents that were intended to serve the minority of children that had access to school in urban centers or elite boarding facilities. They rely on specific infrastructures and services—such as health team school visits, school nurses and in-school clinics—that are additional to the normal range of health service provision, and are beyond the means of most low-income countries to make available universally. An analysis of a school nurse program in Kwa-Zulu Natal, for example, showed that despite a relatively high investment (the cost per student targeted was $11.50), the coverage was inadequate (18%) and almost no cases of ill health detected resulted in effective referral and treatment [15].

While traditional medical practice emphasizes treatment after individual diagnosis, analysis of the types of health interventions that are part of more inclusive school health programs, such as deworming and micronutrient supplements, suggests that mass approaches are preferable on technical, economic and equity grounds to approaches that require diagnostic screening [16, 17]. Furthermore, there are arguments on the grounds of equity for avoiding the need for access to health service facilities. Given that access to health services is positively and significantly associated with income, poorer populations (which experience more ill health) would be systemically overlooked by intervention programs that operate through diagnosis at health facilities. Similar considerations suggest that health education programs will only be equitable if they are universal since they offer the largest benefit to those populations with the higher incidence of ill health, which are also poorer, have less education and less access to health services.

Overall, the characteristics of school health and nutrition programs make a compelling case for public sector intervention. First, there may be treatment externalities where there are external benefits gained to others in addition to the benefit for the treated individual. This is clearly the case for communicable disease interventions, especially against worm infection. Secondly, some forms of intervention (such as vector control, health education campaigns, epidemiological surveillance, and interventions that have strong externalities) are almost pure public goods; that is, no one can be excluded from using the goods or service they deliver, and thus the private sector is unlikely to compete to deliver these goods. Finally, there is typically little private demand for general preventative measures, such as information on the value of washing hands. None of this is an argument against a private sector role in service delivery, but it does suggest that private sector demand is likely to be greater in middle income populations and where demand has been created by public sector actions. As we shall see in the next section, this appears to be the case in practice.

School health and nutrition program issues

There has been a significant shift in focus of school health and nutrition programs in low-income countries over the last two decades. The programs have moved away from a medical approach that favored elite schools in urban centers, and toward a focus on improving health and nutrition for all children, particularly the poor and disadvantaged. This change began in the 1980s when research began to confirm that good health and nutrition were strongly related to education achievement [18–20]. This led to the recognition that school health and nutrition programs were not only important contributors to health outcomes, but were also essential elements of efforts to improve education access and completion, particularly for the poor. In the 1990s, when the concept of EFA was first launched, school health and nutrition programs were adopted by the education sector, and began to be incorporated within EFA programs. The success of these initial efforts led to demand from countries and agencies for a more coordinated and systematic approach to programming.

A coordinated approach to school health and nutrition programs

A major step forward in international coordination was achieved when a framework to "Focus Resources on Effective School Health (FRESH)" was developed jointly by UNESCO, WHO, UNICEF, Education International, and the World Bank. This partnership effort was launched at the World Education Forum in Dakar in April 2000, and carried the clear message that good school health and nutrition is a key component of efforts to achieve EFA. Since then, UNESCO has adopted FRESH as one of its Flagship Programs contributing to EFA, and other agencies, including the World Food Program, the Partnership for Child Development, and Save the Children (US), have joined the partnership [21].

The FRESH framework is based on good practice recognized by all the partners, and provides a consensus approach for the effective implementation of health and nutrition services within school health programs. The framework calls for four core components to be made available, together, in all schools:

» *Policy*: health- and nutrition-related school policies that provide a non-discriminatory, safe and secure environment
» *School environment*: access to safe water, and provision of separate sanitation facilities for girls and boys
» *Education*: skills based education that addresses health, nutrition, and hygiene issues, and promotes positive behaviors
» *Services*: simple, safe and familiar health and nutrition services that can be delivered cost-effectively in schools (such as deworming, micronutrient supplements, and snacks that avoid hunger), and increased access to youth-friendly clinics

Adoption of this framework does not imply that these core components and strategies are the only important elements, but that implementing all of these in all schools would provide a sound initial basis for any pro-poor school health program. Furthermore, these components can be implemented effectively only if supported by strategic partnerships between the following: (1) health and education sectors, especially teachers and health workers; (2) schools and the community; and (3) pupils and others responsible for implementation.

The common focus has encouraged concerted action by the participating agencies. It has also provided a common platform upon which to build agency-specific programs, such as the "health promoting schools" initiative of WHO and the "child friendly" schools of UNICEF. But perhaps the most important consequence of FRESH has been to offer a common "point of entry" for new efforts to improve health in schools. The following three examples of new international initiatives show how specific school health interventions can be inserted into one or all of the four core components (policy, environment, education, and services) of the FRESH framework:

» The multi-agency effort to accelerate the education sector response to HIV/AIDS in Africa promotes the FRESH framework specifically, and encourages education systems to do the following: (1) adopt *policies* that avoid HIV/AIDS discrimination and stigmatization; (2) provide life skills *education* programs in schools to promote positive sexual and social behaviors; and (3) improve access to youth-friendly health *services*. More than 20 countries, and a similar number of agencies and NGOs, have collaborated in this effort since November 2002.
» The Food for Education initiative of the World Food Program has gone beyond the provision of food aid to develop a programmatic link between nutrition and education by promoting the following: (1) *policies* that make food aid conditional upon girls' participation in education; (2) nutrition *education* that improves the quality of students' diets; and (3) nutrition *services* that include deworming and the alleviation of short term hunger. More than 30 countries have begun to implement these reforms since 2002.
» The Partnership for Parasite Control (PPC), led by WHO, promotes public and private efforts to include de-worming in school health *services,* following a resolution of the 54th World Health Assembly to provide, by 2010, regular deworming treatment to 75% of school-age children at risk (an estimated target population of 398 million). Nineteen of 41 target countries in Africa have begun school-based deworming programs since 2001.

This consensus approach has increased significantly the number of countries implementing school health reforms, and the simplicity of the approach has helped ensure that these programs go to scale. As a result of concerted action by governments and participating agencies, national programs based on the FRESH framework have been adopted by over 30 countries in sub-Saharan Africa, targeting a population of some 100 million school-age children.

Programmatic approaches in practice

The FRESH framework provides strategic guidance for the design of programs to improve the education, health, and nutrition of school-age children, but there is considerable variation in the practical design of actual programs, reflecting differences in local needs and capacity. In a majority of cases, school health and nutrition programs are delivered and funded by the formal public education sector, with a formal role for the health sector in design and supervision. In some countries, it was considered too difficult to immediately incorporate school health within the existing education system, and a more or less separate and time-bound school health and nutrition program was established to initiate a process of progressively handing over responsibility to the education sector. While this public sector "mainstream" model has proven the most popular, it is not the only successful approach. In some cases, the public sector has identified appropriate options and developed operational manuals, but then used a social fund to provide direct support to communities and schools to select and implement the most relevant actions locally, often with the assistance of NGOs. In some middle-income countries the move toward a demand-led approach has gone even further, with NGOs providing a private sector service dependent upon the contributions of parents or guardians.

The following examples from seven low- and middle-income countries have been selected to illustrate this diversity, and to show how the four core components of FRESH are being supported by a mix of public and private actions:

A public sector approach: public sector supported and implemented (Guinea Conakry, Ghana, and Tanzania)

» Policy: In all three countries, the Ministry of Education (or in Ghana, its executive body, the Ghana Education Service) implements the program under the guidance of the Ministry of Health, based on a formal policy agreement. In Tanzania, the Ministries of Community Development and of Local Government are also parties to the agreement. The existing in-service teacher training and supply line infrastructures are used to prepare teachers and supply the necessary materials.
» School environment: Separate sanitation facilities for girls and boys in all new schools; access to potable water in all schools.
» Education: Health, hygiene, and nutrition education as part of the formal curriculum.
» Services: Deworming (for both schistosomiasis and intestinal worms) provided by teachers twice a year; in Guinea this is followed by iron-folate supplementation.

Over 3 years, the Guinea program has reached 600 schools and 350,000 students, the Ghana program 577 schools and 83,000 students (at a cost of US $0.54 per child treated), and the Tanzania program 353 schools and 113,000 students (at a cost of US $0.89 per child treated).

A program approach: parastatal support for public sector intervention (Madagascar)

- Policy: The Community Nutrition Program (SEECALINE II) provides training and support to the Ministry of Education, based on a formally agreed upon health policy for the education sector. In all schools in the 43 poorest districts (44% of all districts) the program prepares teachers and provides materials. In addition, the program also provides parent-teacher associations (PTAs) with access to a social fund to support construction of facilities. Each PTA can request up to US$500, with a 20% community contribution based on a parental contribution of US$0.16 per annum.
- School environment: Access to potable water, handwashing facilities, in all schools; where requested by PTAs, construction of latrines, wells, fences, and sports facilities.
- Education: A formal health education curriculum, supported by community IEC.
- Services: Twice yearly deworming and iron-folate (for 3 months) delivered by teachers; tests kits to confirm iodization of local sources of salt: where requested by PTAs, provision of food preparation facilities.

In 3 years, the program has trained 14,000 teachers in 4,585 schools, and reached 430,000 students at an estimated cost of US$0.78-US$1.08 per capita per annum.

A social fund approach: public sector support for community intervention (Tajikistan)

- Policy: The Ministry of Labour and Social Protection, with the Ministries of Education and of Health, have developed a Memorandum of Understanding that sets out health policies for the education sector. The program channels resources through PTAs, which identify and assist needy children. A training program, delivered by NGOs, prepares PTA members to develop proposals of up to $5000 for their school, to support activities selected from a menu of items.
- School environment: Provision of sanitation facilities, potable water, sports facilities.
- Education: Training of teachers in health promotion,
- Services: Training of teachers to provide first aid, micronutrients and deworming; provision of food preparation facilities.

The program targets the 100,000 neediest children in all 200 schools in the six poorest districts of Tajikistan, at an approximate per capita cost of US$1.00 per annum.

A private sector approach: community support for NGO implemented intervention (Indonesia)

- Policy: The NGO *Yasan Kusuma Buana* has a formal agreement with the education department in Jakarta and three other major cities to train teachers, perform diagnostic tests, and provide medicines and materials. The NGO offers Pap smear tests and referral services to teachers. Unit costs are low because parasite diagnosis involves mass screening in a central laboratory (approximately 2,500 diagnoses per day), and medicines are obtained at preferential rates from two commercial partners.
- School environment: Not included in program.
- Education: Nutrition and hygiene education as part of the curriculum.
- Services: Stool examination by the laboratory, and deworming by teachers as necessary twice a year; iron-folate provided by teachers twice a year (for 3 months).

The program has been in existence for 17 years and currently reaches 627 schools and 161,000 students, at a cost to parents of US$0.10 per annum. The approach is modeled on a program initiated in Japan in 1948, which relied on private sector technicians, working independently at first but later formalized within the Japan Association of Parasite Control, who conducted stool examinations and then treated infected individuals for a per capita fee equivalent to approximately $0.74 in 2004 dollars. With growing prosperity, Japan later implemented a sophisticated, comprehensive school health program based on the 1958 School Health Act, but retained the parasite control element of the program because of its remarkable cost-effectiveness. The prevalence of roundworm infection fell from a high of 73% in 1949 to less than 0.01% by 1985. At its peak, the private sector program conducted some 12 million examinations annually, implying a turnover of nearly $9 million at today's prices.

Analysis of reports of school health and nutrition programs from 40 low- and middle-income countries indicates that some 85% have adopted the mainstream public sector model, with the rest choosing program-based, social fund, or private sector options. Annual external support for these actions is currently approaching $90 million, targeting some 100 million schoolchildren.

Unresolved program and policy issues for school nutrition

As discussed above, there is now reliable evidence that ill health and malnutrition affect education access, participation, completion, and achievement, and that school-based health and nutrition programs can provide a cost-effective and low-cost solution. Furthermore, the need for school health and nutrition programs is now recognized by both countries and development partners, and there are successful examples of practical sector programs that have gone to scale in both low- and middle-income countries.

This does not imply, however, that there are no uncertainties. In terms of health interventions, for example, it is unclear how schools can address the need for prompt treatment of malaria, or how to ensure that first aid kits are both readily accessible and replenished regularly without becoming a source of free medical supplies to the community. But two of the most difficult and potentially important unresolved issues relate to the targeting of nutrition interventions at school age children.

Food or cash? There is a convincing literature that school participation of girls can be increased by providing food to the girls and their families as a condition of school attendance. This is often done in the form of "take-home rations" that the girl student is given on a monthly or more frequent basis provided that school attendance by the student remains above some threshold. There is at least equally compelling evidence that a monetary incentive—so-called conditional cash transfers—can achieve the same objective.

Providing food has the apparent advantage that it will directly improve the nutrition of the girl student, but this depends crucially on whether the family uses the food rather than selling it, and on whether the girl is indeed the recipient of the benefit. Providing cash has the advantage of simplifying logistics.

A key issue here, and one that has tended to blur critical debate, is that if the food ration is in the form of external food aid it is often seen as being essentially without cost—a clear advantage over cash. But this raises questions about the predictability and sustainability of food aid, as well as its impact on local markets and the income of the intended beneficiaries who may well be small farmers.

Should schoolchildren be the first target for food aid? The high prevalence of malnutrition in children, including children of school-age, continues to be a major challenge for low-income countries. Providing food to children at school is often seen as an important part of the solution, and is a major focus for food aid. But the nutrition literature suggests that ensuring good nutrition earlier in life—certainly before 3 years of age, but perhaps earlier—is essential to ensure an appropriate development trajectory throughout life. If food security can be assured for the whole community then there is clearly no issue. But where food aid is finite and limiting, this raises the question whether the first target should be pre-school rather than schoolchildren.

This debate has been blurred by admixing the nutrition outcomes with broader social and education issues. It is clear that providing a meal at school is socially desirable and can offer education benefits for children who would otherwise have to walk often long distances home to eat, or remain hungry. But from a nutrition perspective it remains unclear whether ensuring good nutrition early in life has more impact on subsequent development—including education achievement—than does providing food at school age.

Finding clear answers to these key policy questions in nutrition could profoundly influence the impact of future school health and nutrition programs.

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The long-term impact of preschool health and nutrition on education

Matthew Jukes

Abstract

Malnutrition and infectious diseases in infancy and early childhood have an impact on the cognitive development of children in developing countries. The long-term effects of these diseases are less well understood. A number of studies relate early malnutrition, iron deficiency, and malaria infection to poor cognitive abilities in the school-age years. The long-term effect of randomized interventions in early childhood has been evaluated for nutrition supplementation and psychosocial stimulation of malnourished children and for malaria prevention in a community cohort. The evidence suggests that improving the health and nutrition of young children can improve their subsequent chances of attending school, the gender equity of education access, and performance of children once at school.

Key words: Iron-deficiency anemia, malnutrition, infancy, early childhood, nutrition supplementation, malaria, chemoprohylaxis, cognitive abilities, education

Introduction

There is widespread recognition that ill health and poor nutrition in developing countries can affect mental development in infancy and early childhood and children may thus enter school at a disadvantage. What implications does this have for children's education? A few studies have assessed the long-term education effects associated with common threats to the health of young children in developing countries, such as undernutrition, iron-deficiency anemia, and malaria. This paper reviews the effect of such diseases on mental development and considers the potential for health and nutrition interventions in the preschool years to lay the foundation for universal access and completion of primary schooling.

Pathways for the long-term effects of health and nutrition on cognitive abilities

Health and nutrition can have long-term effects on cognitive abilities through multiple pathways. First, disease can have direct effects on the brain because of a reduction in the supply of nutrients or because infectious agents release neurotoxins or precipitate an immune response that affects the brain. Such incidents may damage the structure of the brain, for example by starving cell-growth processes of essential nutrients. Where such damage is irreversible, long-term effects on cognitive function may ensue.

In addition to direct effects of illness, secondary behavioral consequences may emerge with time. In particular, in early childhood there is a high interdependency between physical and mental development. For example, iron-deficient children are often more fearful and more likely to cling to their mothers [1]. A secondary consequence of this is that children do not explore and interact with their environment to the same extent. This, in turn, will reduce the level of stimulation the brain receives and stunt social and cognitive development. Indirect effects can also be mediated through caregivers. For example, parents have been observed to interact less frequently with children who are severely malnourished [2]. This lack of stimulation may in turn affect children's development further, compounding the symptoms of undernutrition.

It is therefore plausible that cognitive insults in early childhood are exacerbated with time. It is equally plausible that once children are free from infection

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or their nutrition status has improved their cognitive functions too may recover. Thus, evidence is needed to differentiate amongst these possibilities. This evidence is considered in the following sections, after a brief note on the interpretation of cognitive test scores.

Interpretation of cognitive test scores

Throughout the following sections, children's performance on tests of cognitive function and education achievement are frequently reported as the outcome of the impact of health and nutrition. The relevance for one's life of a small increase in, say, short term memory, may not be immediately apparent. This issue is addressed in part by studies relating cognitive abilities to practical life outcomes, such as earning potential. For example, in the United States, Zax and Rees [3] estimate that an increase in IQ of one standard deviation is associated with an increase in wages of over 11%, falling to 6% when controlling for other covariates. Similar estimates for the relationship between IQ and earnings have been made for Pakistan [4], Indonesia [5], and in a review of developing countries [6]. In a study of wages in South Africa, Moll [7] finds that an increase of 1 SD in literacy and numeracy scores was associated with a 35% increase in wages. Extrapolating this result, a 0.25 SD increase in IQ, which is a conservative estimate of the benefit resulting from many school health interventions, would lead to a 5%–10% increase in wages.

Tests of cognitive function, and especially those of education achievement, are also good predictors of long-term academic potential. For example, Liddell and Rae [8] assessed the direct impact of test scores on grade progression in Africa. Children were assessed in Grade 1 and their progress through primary school monitored. Each additional SD scored in Grade 1 exams resulted in children being 4.8 times as likely to reach Grade 7 without repeating a year of schooling. This study suggests that a small improvement in academic performance in the early years of schooling can have substantial long-term benefits for education achievement and thus for success in life. However, despite this evidence, there is much we have to learn about how improvements in specific cognitive function in the early years relate to long-term outcomes relevant to daily life.

Infectious disease

Malaria

A number of diseases directly affect the central nervous system. Of these, by far the most common in low income countries is cerebral malaria. Around 25% of deaths before 4 years of age are attributable to cerebral malaria and of those who survive around 10% suffer neurologic problems that effectively prevent them from attending school in many areas of the world. Many other children suffer more subtle cognitive deficits which may affect their ability to learn later on in life. In Kenya, children aged 6–7 years were studied 3–4 years after hospitalization due to cerebral malaria with impaired consciousness [9]. They were 4.5 times more likely* than other children from similar backgrounds to suffer cognitive impairment ranging from severe learning difficulties requiring care to mild cognitive impairments. Almost half of such children had had no neurologic problems at the time of hospitalization. Similarly, in Senegal, children aged 5–12 were found to have impaired cognitive abilities caused by a bout of cerebral malaria with coma before the age of 5, possibly owing to a primary deficit in attention [10].

A third study in the Gambia looked at children who suffered from cerebral malaria that was not accompanied by neurological symptoms at the time [11]. These children had poorer balance 3.4 years after recovery implying some impaired motor development. However, no other cognitive deficit was found.

In such studies, the likelihood is that cognitive impairments are a direct result of the episode of cerebral malaria. In addition to the immediate effects, a bout of cerebral malaria can leave an individual with an increased chance of epileptic episodes which in turn can lead to cognitive impairment [12].

Other behavioral problems have been associated with cerebral malaria. Psychotic episodes have been reported following bouts of cerebral malaria in Nigeria [13, 14]. Thus, there are multiple ways in which cerebral malaria can affect behavior.

The incidence of cerebral malaria can be reduced with a number of preventative measures. One study has investigated the long-term impact of such preventative measures on cognitive development. This study in the Gambia** found that children who were protected from malaria for three consecutive transmission seasons before the age of 5 had improved cognitive performance at age 17. Scores in the Digit Span Test (a test of short term recall) were 0.26 SD higher and scores in categorical fluency (testing access to long-term memory) were 0.36 SD higher among those children offered prophylaxis during the trial, compared with those given placebo. As **figure 1** shows , scores were also improved among children offered prophylaxis at the end of the trial, especially in the placebo group.

* All study results reported are significant at 5% level unless otherwise stated.

** Jukes MCH, Pinder M, Grigorenko EL, Banos Smith H, Bariau-Meier E, Walraven G, Sternberg RJ, Drake L, Greenwood BM, Bundy DAP. Malaria chemoprophylaxis in early childhood improves cognitive abilities and education outcomes 14 years later: follow-up of a randomised controlled trial in The Gambia. (submitted).

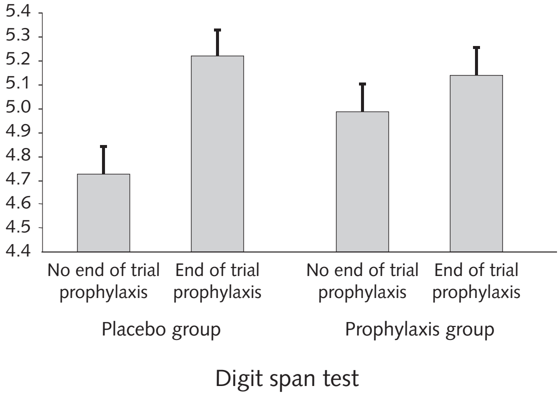

FIG. 1. Digit span of adolescents (mean age 17 years) according to malaria prophylaxis regimen offered to them as young children (aged 6 months – 5 years).

Malaria prophylaxis also improved children's access to schooling and years spent at school. Girls given prophylaxis were around 2.5 times as likely as girls given placebo to attend primary school. (In the absence of prophylaxis, girls in the study were 6 times less likely to attend primary school than boys). Prophylaxis was also responsible for adding an extra year to the time girls and boys alike spent at school. The implications for malaria control are clear. Simple preventative measures in early childhood can increase gender equity in access to primary schooling, increase the length of time spent and school and have a long-term impact on cognitive abilities.

Giardia

There is little evidence on the cognitive impact of other infectious diseases in the preschool years. However, one study in Peru [15] followed a cohort of children, some of whom had had diarrheal diseases, parasitic infection, and severe malnutrition in the first 2 years of life. Severe malnutrition at this age was associated with an IQ 10 points (0.67 SD) lower at age 9. Those who had suffered two or more episodes of *Giardia lamblia* per year scored 4.1 points (0.27 SD) lower than did children with one episode or fewer per year. The authors conclude that *Giardia* infection is likely to be an index of malnutrition which in turn affects mental development.

Nutrition deficiencies in preschool and infancy

Protein energy malnutrition

Effects on early childhood development

Protein energy malnutrition (often used interchangeably with "undernutrition") is a general term applied to children with heights and weights below age-referenced criteria. It typically results from a severe or chronic lack of a range of essential nutrients rather than from a just a lack of protein. Chronic undernutrition is associated with impairment in developmental levels of young children [16, 17] and undernourished infants are found to be less sociable than adequately nourished infants [18].

In addition to the effect of chronic malnutrition, acute episodes of severe malnutrition (typically < 60% reference weight-for-age) bring about characteristic changes in behavior [19]. Affected children show increased apathy, decreased activity and explore their environment less frequently and less thoroughly. After the acute episode, all behavior returns to normal except for the thoroughness of exploration of the environment.

Preventative programs of nutrition supplementation have been successful in improving the development of cognitive and motor skills, adaptive behavior, and personal and social behavior development of infants and young children [20–24]. When preventative nutrition supplementation is combined with maternal education programs, the two interventions work synergistically: supplementation improves the effectiveness of stimulation (or vice versa) such that the benefit of receiving both interventions was greater than the sum of the independent benefits of the two interventions [23]. Remedial measures can also improve cognitive abilities in affected children. Nutrition supplementation combined with education stimulation helps malnourished children close the gap in cognitive abilities between them and their adequately nourished peers [25, 26].

Not only is a child's behavior affected by undernutrition, a mother's behavior is also related to the nutrition status of her child. In Egypt and in Kenya, maternal behavior toward toddlers was found to be influenced by the nutrition intake of the child more than that of the mother [27], with poorly nourished children more likely to be carried by their mother and in general stay closer to their mother than adequately nourished children [2].

Long-term impact

It is clear that undernutrition affects the mental development of young children and that both nutrition supplements and psychosocial stimulation can improve the development of undernourished children. What implications does this have for children's schooling and their ability to learn in the school-age years? A study in Kenya [18] found some continuity in the cognitive development of undernourished children, which would suggest that deficits in infancy are carried through at least to preschool age. Children who were undernourished at 6 months were also less sociable than well nourished peers; those who were less sociable at

6 months had lower development scores at 30 months and poorer verbal comprehension scores at 5 years.

But there is more direct evidence that undernutrition has a long-term impact on cognitive development. Beginning with the most profound nutrition insults, severe malnutrition in early childhood has a long-term effect on development. Children in Jamaica who had suffered from severe malnutrition between the ages of 6 and 24 months were found to lag behind adequately nourished children who had been hospitalized for other reasons at ages 7, 8, 9, and 14 on range of IQ tests. At 14 years they were substantially delayed in overall IQ (1.50 SD below the control group), vocabulary (1.33 SD below control) and tests of education achievement, even after accounting for differences in the background of the two groups of children [28]. Similar results to these have been found in a number of other studies [19]. However, malnourished children come from poor families with less well educated parents, factors which are also associated with poor cognitive development. Thus we cannot be sure when interpreting these studies whether the malnutrition is a genuine cause of poor cognitive development. Evidence from randomized interventions strengthen the case for this causal link.

There is potential for interventions to reduce the gap between severely undernourished children and their peers. The study in Jamaica found that a 3-year program to teach mothers how to improve the development of their child (aged 6–24 months at the beginning of the program) conferred significant long-term benefits to undernourished children. At age 14 the undernourished children whose mothers had taken part in the education program were only 0.28 SD behind adequately nourished children on overall IQ scores and 0.68 SD ahead of undernourished children who had not taken part in the intervention.

Severe malnutrition clearly has a substantial long-term effect on child development. Of potentially greater concern is the effect that mild and moderate malnutrition has on child development, given the high prevalence of this condition among children in developing countries. This issue has again been addressed by research in Jamaica that followed 127 undernourished children for 8 years. Poor, urban and undernourished children aged 9–24 months took part in a 2-year program of either nutrition supplements, psychosocial stimulation, both interventions, or neither intervention. The initial gains in overall development quotient (DQ; an IQ equivalent for infants and young children) were impressive. Nutrition supplementation accounted for an increase of 6.1 DQ points (0.66 SD) over 2 years, while stimulation improved DQ by 7.3 points (0.79 SD). Larger gains were found for the locomotor sub-scale: 12.4 points (1.04 SD) due to supplementation and 10.3 points (0.87 SD) due to stimulation. Similar effects were seen with other sub-scales of the Griffiths Scale. The effects of the two interventions were additive (receiving both interventions was better than receiving only one of them) but there was no interaction between them (nutrition supplementation did not improve the effectiveness of the stimulation program, for example).

The improvements in cognitive abilities persisted over time. Four years after the end of interventions, perceptual/motor skills were superior in those children who had received stimulation [29]. The same skills were also superior for children who had originally received a nutrition supplement and whose mothers had the highest verbal intelligence. One explanation for this interaction was that the most intelligent mothers were also the ones giving children the most stimulation, the effectiveness of which was improved by nutrition supplementation. There were no effects of the intervention on a general cognitive ability score or on memory, although each intervention group had higher scores than the control subjects on more of these cognitive tests than would be expected by chance. Thus, stimulation—and to a lesser extent supplementation—had modest effects on children's cognitive abilities over 4 years.

The study also compared the stunted children taking part in the original intervention with other children from similar backgrounds, but who were known not to be stunted at the time of the interventions. These non-stunted children had higher scores on the general cognitive factor than previously stunted children, although were no better in perceptual-motor skills or memory.

There were similar findings eight years after the end of the intervention. Children who received stimulation as infants had higher IQs at ages 11–12 years by 5.7 points (0.38 SD) while supplementation had no effect on cognitive abilities of children at this age. Again, children who were stunted before two years of age performed more poorly on cognitive tests at age 11–12 than did children who were not stunted before two years of age [30]. These children were also more likely to have conduct disorders, and to perform poorly in arithmetic, spelling, and reading tests [31].

In Guatemala, children given nutrition supplements prenatally and in the immediate postnatal period (up to 2 years) were found to perform better as adolescents (aged 13–19 years) on tests of vocabulary, numeracy, knowledge, and reading achievement [32]. Nutrition supplementation was also associated with faster reaction times in an information processing task. Greater benefits were found only for those children of low socioeconomic status. In tests of reading and vocabulary, the effect of supplements was greater for children with the highest levels of education.

The studies in Jamaica and Guatemala show that a fairly sustained program of nutrition supplementation and/or psychosocial stimulation, lasting for 2 years, can have long-term benefits for children's development. A study in Indonesia shows that even a 3-month program of supplementation can have long-term effects [33]. Children supplemented before 18 months were found to have improved performance on a test of working memory at age 8, although no effect was observed on other measures of information processing, vocabulary, verbal fluency, arithmetic, or tests of emotional response to a stressor.

Timing

It might be expected that nutrition deficits in the first year of life have the greatest impact on development. However, evidence does not bear this out. A study in Colombia found that giving nutrition supplements to children between 6 months and 36 months of age had a greater impact on cognitive development at 36 months than supplements given to the mother in the third trimester of pregnancy and then to the child up to 6 months of age and the same impact as a continuous supplementation running from the third trimester of pregnancy to 36 months [23]. A longer-term study in the Philippines found that malnutrition in the second year of life actually had a greater impact on the performance of 8-year-olds on a non-verbal test of intelligence than malnutrition in the first year of life [34]. The assumption that supplementation is more effective earlier in life during periods of rapid brain growth does not receive support from either of these studies.

Other studies support early supplementation. In Indonesia children supplemented before, but not after, 18 months of age were found to have improved performance on a test of working memory at age 8 years [33]. Another study in the Philippines found that children stunted in the first six months were more likely than those stunted later on to have impaired cognitive performance at 8 years of age [35]. This, however, was explained by the fact the children suffering the earliest bouts of malnutrition also suffered the most severe and persistent malnutrition. A confounding factor such as this is a reminder of the difficulty in interpreting findings related to timing effects of nutrition deficiencies on cognitive development. At present, there is no strong evidence that early (first year of life) interventions with children suffering from or at risk of malnutrition are more effective than interventions at a later age.

Low birthweight

Children with a low birthweight (LBW) or more generally, those born small for their gestational age (SGA), have poor developmental outcomes in the long-term. Differences between SGA babies and those of normal birthweight typically do not appear in the first year of life [36], although this can depend on environmental factors. In Brazil, developmental delays were observed only in SGA babies who also received little stimulation in the home. Similarly, LBW affects infant development to a greater extent in the homes of illiterate mothers as compared with literate mothers. Deficits in developmental levels appear with high-risk infants in the second year with clear significant differences apparent by the third year. Some deficits were also found in the development levels of SGA babies between the ages of 4 and 7. A number of longer-term studies have found cognitive deficits and poorer school performance in adolescents who were SGA [37]. Only one such longer term study has been conducted in a developing country. This study found a small long-term effect of SGA on the mental performance of adolescent boys in India, but poor nutrition in early childhood had a greater impact on performance than SGA [38].

Breastfeeding

Breastfeeding is associated with a moderate long-term improvement in cognitive development. A review of 17 studies in developed countries estimated that breastfeeding led to an improvement of 3.2 IQ points (~ 0.21 SD), which was fairly stable across the lifespan from 3 to 50 years of age [39]. LBW babies benefit most from breastfeeding, gaining 5.2 IQ points (0.35 SD) compared with a gain of 2.7 points (0.18 SD) for children of normal birthweight.

The length of breastfeeding is also important. Scandinavian children breastfed for longer than 6 months were found to have improved cognitive test outcomes at 5 years compared with children who were breastfed for less than 3 months [40]. However, it is difficult to be certain about such findings since mothers who choose to breastfeed are often more educated or more wealthy and this difference could explain some of the difference in IQ scores [41], although review studies do attempt to account for such factors in their estimates of IQ differences [39]. In general, the evidence is not conclusive but is strongly suggestive of a link between breastfeeding and cognitive ability in later life.

Iron-deficiency anemia

Iron deficiency and mental development: children younger than 2 years

It is a common finding that infants with iron deficiency have lower developmental levels than iron replete children [1, 42–44]. Iron-deficiency anemia appears to affect other aspects of infant behavior. In the Costa Rica study [1], infants with iron-deficiency anemia were found to maintain closer contact with caregivers; to show less pleasure and delight; to be more wary, hesitant, and easily tired; to make fewer attempts at test items; to be less attentive to instructions and demonstrations; and to be less playful. In addition, adults were found to behave differently toward iron deficient children, showing less affect and being less active in their interactions with these children. Such findings have serious implications for the amount of stimulation children receive, both from their own exploration of their environment and in the stimulation they receive from their caregivers. Such lack of stimulation is likely to affect children's long-term development, an issue to which we return in the following section.

What impact does iron supplementation have on the development of iron deficient children? Only one randomized controlled trial has been conducted with children under two years of age in low-income countries [44]. This study in Indonesia gave iron supplementation (iron sulfate) or placebo to iron deficient children aged 12–18 months. Those receiving iron supplementation showed impressive gains in the Bayley Scales of Infant Development. Their Mental Development Index rose by 19.3 points (1.3 SD) and the Psychomotor Development Index rose by 23.5 points (1.6 SD). The comparable gains for the placebo group were 0.5 points and 5.1 points respectively. These results show substantial improvement by children receiving iron supplementation. At the end of the 4-month trial, these children had similar developmental levels to those who were not iron deficient at the beginning of the trial.

A number of other studies have conducted supplementation trials over a similar time period (≥ 12 weeks), although none had the same rigorous experimental design. One other study in Indonesia succeeded in eliminating differences between iron deficient and iron replete children after supplementation, whilst in two other studies, in Chile [42] and Costa Rica [1], there was no observed effect of supplementation. However, in the Costa Rica study, children whose iron status recovered completely also showed improvement in their mental and psychomotor development indices. A number of shorter term trials (< 15 days) have also been conducted. There is no evidence of cognitive improvement in iron deficient children over such a short time period [45].

Taken together, the evidence from all trials suggests that iron supplementation can improve the development of children under 2 years of age if sustained over a sufficiently long period of time (~ 12 weeks). However, this conclusion is based largely on the results of one trial.

Iron deficiency and mental development: children aged 2–6 yrs

A number of studies have compared iron deficient/anemic children with iron replete children. A study with preschool children in Guatemala [46] found that children with iron-deficiency anemia took longer to learn a discrimination task than did their iron-replete peers. The difference between the two groups was substantial (> 3 SD), although there were no differences in two other tests. Similarly, a study in Indonesia [47] found that children with iron-deficiency anemia were slower than iron replete children in a categorization task, although the two groups performed similarly on tests of learning and vocabulary, although no such differences were found with younger children in one study in India [48].

All five studies in the preschool age group have found improvements in the cognitive function of iron deficient children following iron supplementation, including improvements in a learning task [46, 47] and in an IQ test [48]. One study in Zanzibar [49] gave 12 months of iron supplementation and deworming treatment to children aged 6–59 months from a population in which iron deficiency was common. They found that iron supplementation improved preschoolers' language and motor outcomes by 0.14 and 0.18 SD respectively.

The conclusion from studies of preschool children and infants is that iron deficiency can have a substantial effect on children's cognitive development. The next section considers the implications this has for children's later development in the school-age years and beyond.

Long-term effects

Several effects of iron deficiency in infancy indicate that resulting cognitive impairments may be long-term. It may cause irreversible changes to the developing brain that result in permanent impairment of cognitive function. Also, the finding that the behavior of affected infants and their caregivers changes due to iron deficiency will affect their interaction with the environment and thus the amount of stimulation the children receive which in turn is likely to affect cognitive development.

A number of studies have investigated the long-term effects of iron deficiency [45]. The most comprehensive of these followed a group of Costa Rican infants for more than 10 years [50, 51]. At 12–24 months of age, 30 of the group of 191 infants had moderate anemia and received treatment. At age 5 years, formerly anemic infants performed more poorly on a range of tests of motor function and non-verbal intelligence after accounting for differences between the two groups in a number of variables such as socioeconomic status, birthweight, maternal IQ, height, and education. Verbal skills were more equally matched between groups. At age 11–12 years the formerly anemic group performed more poorly in writing and arithmetic, a motor test, and spatial memory. Older children only were poorer in a selective attention test. Also the formerly anemic group was more likely to have a number of behavioral problems. They were more anxious and depressed, had more attention problems, social problems and total behavioral problems. They were also more likely to repeat grades at school and to be referred for special education services.

Similar findings have emerged from a number of other studies. Anemic infants in Chile [52] were later found to have lower IQs and poorer performance on a range of tests of motor, verbal, and visual abilities at 5 years of age. Studies have attempted to quantify the relationship between infant anemia and later cognitive impairment. A study with infants in Israel [53] found that a reduction in hemoglobin levels of 10 g/L at 9 months was associated with a reduction of 1.75 IQ points at 5 years of age (although no effect on developmental levels was found at 2 and 3 years of age). Children in the anemic group were found to be learning less well and to be less task-oriented than control children in second grade [54].

All of the above studies followed a relatively small group of children from infancy in order to chart their development. One study in America took a different approach [55] by retrospectively linking education assessments of 10 year old children with data on their nutrition status between birth and 5 years. They found that children with low levels of Hb (hemoglobin) in early childhood were more likely to be classified has having mild to moderate mental retardation at age 10. (A decrease of 1 g/L of Hb was associated with being 1.28 more times likely to be classed as having mental retardation.)

It should be noted that none of the studies reported in this section allow causal inferences to be drawn. In each study, the anemic group most likely differed from the control groups on a number of background variables such as socioeconomic status. One study [53] found that in comparison to the control group the homes of anemic infants were less stimulating and their mothers were more depressed and less affectionate. Thus we cannot be sure that differences in performance between groups are not attributable to these other background characteristics, even though comprehensive attempts were made to control for them statistically in most studies.

Nevertheless, the evidence of the effect of anemia and iron deficiency on the behaviors of infants, preschoolers and their caregivers and the suggestion that the effect is a long-term one combine to make a persuasive case for early intervention to prevent iron deficiency.

Conclusion

In all, five studies have looked at the impact of preschool health and nutrition interventions and assessed their consequences for children's education in the long-term (**table 1**). Four of these studies have investigated the effect of nutrition supplementation or psychosocial stimulation on mental development of malnourished children. The fifth looked at the long-term effect of malaria chemoprophylaxis. All five studies found a positive long-term impact of health and nutrition inputs on cognitive function. In three of these cases remedial or preventative treatment of the disease was responsible for the improvement. In the remaining two cases psychosocial stimulation was responsible. The long-term improvement in cognitive scores was as high 0.68 SD in one study of children who were initially severely malnourished. Moderate long-term improvements of around 0.25 SD were seen in one study undertaken at the community level was an improvement seen in education test scores. One study found an increase in education access for girls and an increase in length of time spent at school.

TABLE 1. Long-term cognitive effects of preschool health and nutrition interventions

Study	Country	Intervention	Age	Sample characteristics	Effect size	Outcomes
Grantham-McGregor et al. [28]	Jamaica	Maternal education	14	Severely malnourished	0.68	IQ
Walker et al. [30]	Jamaica	Stimulation	11–12	Stunted	0.38	IQ
Chang et al. [31]					No effect	Education tests
Pollitt et al. [32]	Guatemala	Nutrition supplements	13–19	Community cohort	+*	Education tests, reaction time
Pollitt et al. [33]	Indonesia	Nutrition supplements	8	Initially > 18 months	+*	Working memory
Jukes et al.**	Gambia	Malaria prevention	14–19	Community cohort	0.26–0.36	Digit span, fluency

* Effect is positive, size not reported in paper.

** Jukes MCH, Pinder M, Grigorenko EL, Banos Smith H, Bariau-Meier E, Walraven G, Sternberg RJ, Drake L, Greenwood BM, Bundy DAP. Malaria chemoprophylaxis in early childhood improves cognitive abilities and education outcomes 14 years later: follow-up of a randomised controlled trial in The Gambia. (submitted).

To date, only the handful of studies shown have evaluated the long-term impact of health and nutrition interventions conducted in the preschool years. Studies have focused mainly on undernourished children. Evidence is needed on the long-term effects of other early childhood interventions, such as iron supplementation. Evidence is needed also on the effects of such interventions on education access. However, the evidence amassed so far suggests that improving the health and nutrition of young children could be an effective way to increase access to education, to improve the gender equity of access to education, and to improve the performance of children once they are attending school.

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Diet quality affects the playground activities of Kenyan children

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Abstract

The present study examined the effects of a school breakfast program on the activity level, emotional state, and social interactions of a group of Kenyan schoolchildren on the playground. Five hundred forty children in rural Kenya participated in the study. The first standard (grade) classes were randomly assigned to groups provided for 21 months with school breakfasts of equivalent caloric value while families with children in the control group were given a goat at the end of the study. The study aimed to determine whether enhanced caloric intake or diet quality influenced the children's behavior on the school playground. The results indicate that supplemented children were more active and showed more leadership behavior and initiative than did non-supplemented children. In addition, children given meat showed fewer periods of low activity and more leadership behaviors and initiative than did children provided entirely with vegetable source foods. These results support our previous findings from naturalistic studies in the same community that both diet quality and quantity are important for children's development.

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Key words: Animal source foods, diet quality, Kenya, schoolers, social development

Introduction

The importance of the quantity and quality of schoolchildren's diets for their functioning and development is largely unexplored. In Western countries, poor diets frequently supply an excess of calories, lipids, and, sometimes, protein, while, in developing countries, they supply too few calories and are often missing important minerals and vitamins. Additionally, children in developing countries may have had insufficient caloric intakes and poor quality diets since conception so that they must overcome the effects of their earlier malnutrition. In a booklet recently published under the auspices of the World Bank and United Nations Educational, Scientific, and Cultural Organization (UNESCO), the authors [1] write that while "under-nutrition is widespread among schoolchildren (particularly in South Asia and Africa), there is much debate about whether schoolchildren can catch up in their physical growth or in their mental capacity. These authors go on to state that "school feeding, particularly breakfasts or morning snacks, can help hungry children stay attentive, but the high cost of such programs demands a high degree of targeting and additional research to improve their impact on under-nutrition." The aim of this paper is to examine the effects of a school breakfast program on the activity level, emotional state, and social interactions of a group of Kenyan schoolchildren on the playground. The research described in this paper is part of a long-term program devoted to identifying the influence of improved diet quality and quantity on children's cognitive, social and physical development.

This research program was begun in the 1980s with a set of parallel, longitudinal studies—the Human Nutrition Collaborative Research Support Program (NCRSP)—carried out in Kenya, Egypt, and Mexico to examine the associations between children's food intake and their level of functioning and development. The sites of the studies were chosen to focus on mild to moderate malnutrition because so much of the previous research had been concerned with severe malnutrition, particularly in infancy and early childhood [2–4]. The results of the NCRSP studies showed that there were differential associations between food quantity (energy intakes) and food quality and schoolchildren's development and behavior [5, 6], with the marker for food quality being the extent of animal source food in the children's diets. Because animal source food was so limited in the diets of the children in these countries, children could have adequate intake of energy but very poor intake of minerals such as iron and zinc in bioavailable form.

Among the schoolchildren in Kenya, those who were better fed, in terms of both energy and animal source food, had higher cognitive scores [5] and were more active and happy and showed more leadership behavior on the playground than did less well-fed schoolchildren [7]. The associations between nutrient intake and child skills and behaviors persisted even when family socioeconomic status (SES), parental literacy, and duration of schooling were co-varied. Using hierarchical regressions, there appeared to be differential effects of energy and food quality on cognitive abilities and behaviors (7). The cognitive abilities of the school-age children were more highly associated with the level of intake of animal source food than with overall energy intake. This pattern was opposite to that found for activity level, positive emotion, and leadership on the playground, where food quantity seemed more important than diet quality. These results suggested that children can maintain their social activities if they have an adequate level of energy but that cognitive skill acquisition requires adequate diet quality as well.

The present study improves on our previous research by employing an experimental approach with random assignment of children to differential nutrition interventions. This mitigates the effects of confounding variables and facilitates differentiation of the benefits of food quantity versus food quality. The study was implemented in the community in rural Kenya where the earlier naturalistic study had been conducted. This offered enormous advantages such as the availability of experienced individuals already trained in the cognitive assessments and observations to be utilized, and knowledge that the measures to be used were appropriate for the children in the community and had established reliability and validity.

The topic of this paper is the differential effect of nutrition interventions on children's behaviors and physical activity in the school playground. Playground behavior is important for several reasons. First, observations of playground behavior measure the adequacy of the children's level of arousal and behavioral regulation as these are expressed in social interactions. Such behaviors are sensitive to fluctuations in nutrition and health in ways that are not true for more stable behaviors. For example, activity level declined during a food shortage in this community while there were no changes in cognitive performance [8]. Secondly, the school playground is a milieu in which one can measure the frequency and nature of peer interactions during unstructured play. These interactions reflect and, in turn, may affect children's social capacities.

Based on the previous results of our naturalistic study, we hypothesized that children supplemented with a better quality snack (one including animal source food) would perform better on cognitive measures than children supplemented with an equivalent amount of energy from plant source foods [9]. Additionally, we hypothesized that children supplemented with meat or milk would out-perform a group of children receiving no supplementation. We expected that meat supplementation would be particularly efficacious because the children in this community have very low intakes of iron, zinc, and vitamin B_{12} and high rates of anemia [10]. The evidence that children receiving meat supplementation had significantly higher rate of increase in scores on the Raven's Progressive Matrices than all the other children supported the hypothesis that food quality is important for cognitive development [9]. In addition, children supplemented either with meat or calories outperformed children in both the milk and control groups on tests of arithmetic ability [9]. The poor performance of the group supplemented with *githeri* (a traditional vegetable stew consisting of beans, corn, and greens) plus milk is not surprising given the different micronutrient contents of milk and meat. There were no group differences on measures of verbal comprehension.

In summary, based on our previous findings, we expected that, in contrast to the control group, supplemented children would show more episodes of high activity, fewer episodes of low activity, and more positive affect, leadership, and social initiations. We did not expect the group provided with meat or milk to have any particular advantage over the other supplemented group.

Subjects and methods

Description of the study area

The study area lies 120 miles northeast of Nairobi and approximately 30 km northeast of the town of Embu. The homes, or shambas, have no electricity. Relatively few of these shambas have access to a piped water system. The Embu district consists of mostly subsistence agriculture and some cash crops, primarily coffee, cotton and tobacco. Families own little or no livestock and rely on their own food production to feed themselves. *Githeri*, a vegetable stew made of maize, beans, vegetable oil and some greens, is the staple food of the region. There are about 2,600 households in the study area, with an average of six people per household. Most of the individuals living here are members of the Embu tribe and speak Kiembu.

Children in Kenya commence schooling in Standard 1 (equivalent to US Grade 1) when they are about 7–8 years old. The school year starts in January and is in session for 3-month terms with breaks lasting 1 month between each term. Breaks from school occur in April, August, and December. Children in Standards 1 and 2 are in school from 8:00 a.m. to 1:00 p.m. and are given a 30-minute playground break at roughly 10:30 a.m. Children in Standard 3 are in school from 8:00 a.m. to 4:00 p.m. and are given a 1-hour lunch break. Prior to this study, the children rarely ate at school since there were no feeding programs in place or meals brought to the school by the schoolchildren.

Study design and supplemental diet

The Office of Science and Technology of Kenya approved the overall study. The UCLA Institutional Review Board, the Ethics Committee of the University of Nairobi, and the Ministries of Health and Education in Kenya reviewed and approved all protocol developed and used for this study. Verbal community consent, parental consent, and child assent were obtained prior to the initiation of the study. Based on their size and location, 12 out of 18 schools were included in the study. As a prerequisite for inclusion, schools needed between 15 and 90 children in their Standard 1 classrooms in the first year of the study (1998), and had to be accessible by vehicles traveling on the dirt roads in the rainy season. Of the 12 schools in the study, one had three Standard 1 classrooms, two had two Standard 1 classrooms, and nine had one Standard 1 classroom. Baseline assessments for all of the children in participating schools were performed between May and July, 1998 (see "Measures and procedures" section).

Upon completion of the baseline assessments, schools were randomized into one of four feeding interventions. The Meat condition supplemented children with *githeri* plus meat; the Milk condition supplemented children with *githeri* plus milk; the Energy condition supplemented children only with *githeri*; and the Control condition did not supplement children at all. For the Meat intervention, finely ground beef (10% fat) from a highly reputable commercial supplier was added to the *githeri*. Grinding the meat guaranteed that it was evenly distributed throughout the dish. The Milk intervention group received whole cow's milk ultra heat-treated (UHT) to prevent spoilage in addition to the basic *githeri*. The Energy intervention received the basic *githeri* with retinol-fortified vegetable oil to equalize the number of calories with the other feeding interventions. In the first year of supplementation, all groups except for the control group were given 240 kcal to maintain energy equivalent across groups. In the second year, the amount of the supplement was increased to 313 kcal to match the greater food needs of the growing children. A more detailed description of the supplements is presented in **table 1.**

The 12 schools were randomly assigned so that three schools were in each feeding group. The children in these schools remained in their respective feeding group throughout the study, from December 2000 until the end of the Standard 3 school year. Randomization was somewhat constrained in that the schools with more than one Standard 1 classroom could not be randomized to the same feeding condition. We began providing supplemental food mid-morning to the nine intervention schools in the fall term of 1998. The feeding was scheduled for a time of the day that would not replace breakfast or lunch in order to ensure that the snack would supplement the child's diet.

Designation of a centrally located kitchen was integral to proper food preparation and timely delivery of the meal to each school. A staff of two supervisor cook/nutritionists and 10 assistants prepared the meals in individually sealed bowls from Sunday through Thursday. Each of these bowls had a number corresponding to each child. A feeding assistant was present at every school to observe and supervise the school feeding, take attendance, and weigh and record any food not consumed. This procedure continued for a total of seven school terms, or 21 months, through the Standard 2 and Standard 3 school years for this cohort of children.

TABLE 1. Supplemental intervention diets

Year 1: September–December 1998[a]			
	Githeri + Meat	*Githeri* + Milk	Plain *Githeri*
Energy (kcal)	239	241	240
Protein (g)	19.2	12.7	7.9
Iron[c] (mg)	2.42	1.52	3.16
Zinc (mg)	2.38	1.46	1.35
Vit B_{12} (μg)	0.75	0.96	0.0
Years 2–3: January 1999–December 2000[b]			
	Githeri + Meat	*Githeri* + Milk	Plain *Githeri*
Energy (kcal)	313	313	313
Protein (g)	21.7	15.2	8.4
Iron (mg)	2.94	1.57	3.93
Zinc (mg)	2.89	1.66	1.68
Vit B_{12} (μg)	0.91	1.16	0.0

a. Serving size 185 g (includes 60 g meat); 100 g + 200 mL milk; 185 g
b. Serving size 225 g (includes 85g meat); 100 g + 250 mL milk; 230 g
c. Value reflects total iron. Although iron in plain *githeri* column appears higher, the actual amount absorbed is very low (~ 5%) due to the high phytate and fiber content.

Participants

A total of 540 Standard 1 children were enrolled into the study at baseline (May–July 1998) and had at least one playground observation measurement. After randomization of schools into treatment conditions, 126 children were assigned to the Meat condition, 143 children were assigned to the Milk condition, 130 children were assigned to the Energy condition, and 141 children were assigned to the Control condition. Midway through the study, 18 children transferred to a different school and thus a different treatment group, 14 children (8 from the Milk condition and 6 from the Meat condition) refused the assigned diet, and 3 children died (2 with severe malaria and the other of cirrhosis of the liver). The data for several children who did not stay in the study for the full seven terms of feeding were kept in the analysis up until they stopped receiving supplementation.

Measures and procedures

We took multiple child and family measures of participants in this study. Most were repeated several times over the course of the study but a few were assessed only once. The frequency with which each measure was taken is described below along with a description of each measure.

Child measures

Playground Observations. Playground observations were carried out on all children at baseline and terms 1, 2, 4, and 6 of feeding. Children were observed during the morning recess on their school playgrounds in unstructured, social interactions with peers. The behavioral observations used in this study were adapted from those used in our previous study and focused on activity level, emotional state, and social interactions with peers. In our previous study, rates of high and low activity were associated with nutrition intakes with better fed children showing more high activity and less low activity than less well-fed children. Based on these findings, we hypothesized that, in the current study, supplemented children would show more high activity and less low activity than did non-supplemented children.

In the previous study, we measured the rates of the following different emotional states: positive, anxious, angry, and sad. Positive emotions were observed during the vast majority of playground observations whereas anger, sadness, and anxiety were observed very infrequently. Moreover, positive affect was associated with energy intake. For this reason, we hypothesized that, in the current study, supplemented children would show more positive affect than non-supplemented children.

Finally, four different forms of peer interaction were observed and recorded in the previous naturalistic study: ongoing peer involvement, leadership behavior, solitary play, and aggression. In that study, children were engaged with peers about half the time and solitary play was also very common whereas leadership and aggressive behaviors were infrequently observed. The results showed that only leadership behavior was associated with food intake. Children who had higher energy intakes manifested more leadership behavior on the playground. Based on this finding from the previous study, we hypothesized that supplemented children would demonstrate more leadership behavior than non-supplemented children. Although there were no associations between food intake and other forms of peer interaction in the previous study, the extent to which supplementation affected ongoing peer involvement, solitary play, and aggression, as well as the rate of social initiations, was examined in the current study.

As in the previous study, observations were conducted by using a sampling procedure with 30 seconds of observation time followed by 30 seconds of recording time. Each child was observed for a minimum of 20 minutes, and observation duration ranged from 20–30 minutes at each term.

Predominant activity level for each 30 seconds of observation was recorded as low, medium, or high. The extent to which the children showed high or low activity was of interest in this study. The extent of medium activity was also coded in order to have an activity level coding for each period.

The child's predominant emotional state was recorded as positive, negative, or neutral. We expected from the previous study that children would primarily show positive affect rather than negative or neutral affect, and this expectation was confirmed. Because there was so little negative or neutral affect, these codes were not used in analyses.

The peer interaction coding differs from the activity level and emotion coding in that individual behaviors were observed and recorded rather than predominant states. Moreover, the peer interaction behaviors are not mutually exclusive so several kinds of peer interaction could occur in the same time period. The same behaviors were coded as in the previous study—ongoing peer involvement, leadership, solitary play, and aggression. In addition, one new behavior, initiation of social interactions with peers, was observed and coded. Any or all of these five behaviors could be recorded during each 30-second interval. The rate of each coded behavior was then calculated for each child.

The observations were carried out by a team of 12 individuals specifically trained by two of the authors (M. Sigman and S. Whaley). Observers were assigned to different playgrounds over time. The observers were generally not naïve about the assignment of schools to conditions because it was impossible to conduct these observations with naïve observers. Observers needed to know the children, the school setting, and the language in order to carry out the observations and, even if strangers could have been hired, they would have become aware of the food condition after a few days. Videotaping was impossible in a setting in which there is no electricity so that it is difficult to maintain even battery operated video cameras. Moreover, video cameras and unfamiliar observers are so rare in the study area that the children's typical play patterns would have been disrupted by their use. We attempted to guard against observer bias by using fine-grained observational codes. In addition, the observers were not familiar with the hypotheses of the study.

Throughout the period of observation, reliability sessions were interspersed, such that two observers watched the same child on the playground and independently scored the child's behaviors. Reliability data were available for 384 observations sessions, for 15% of the sample. The mean intra-class correlation was .95 (range = .91 to .99) for the nine variables coded.

Anthropometry. Twelve enumerators trained in anthropometry procedures weighed the children every month and measured their height every 4 months. Working in teams of two, they measured the children at school during school hours, or at home in the case of absenteeism. Intra-team and inter-team measurement error was monitored by independently repeating all measurements during the same session in a random sample of 5% for weight/intra-team ($n = 418$), 5% for weight/inter-team ($n = 373$), 2% for height/intra-team ($n = 165$), and 3% for height/inter-team ($n = 255$). The mean technical error, expressed as a standard deviation (SD = $\sqrt{\Sigma d^2/2n}$, where d = the difference between paired measurements and n = the number of paired measurement) was 127 g for weight/intra-team, 109 g for weight/inter-team, 0.11 cm for height/intra-team, and 0.30 cm for height/inter-team.

Consumption of the supplemental food. We hired classroom aides to help monitor the children as they ate to be sure that no sharing or spilling of food occurred. If children missed a day of school, their food portion for that day was sent back to the kitchen. All food or milk that the children did not consume was sealed in their bowl or cup and weighed in the kitchen. With the exception of the 14 children who refused the diet mid-study, children usually ate the food provided to them. Children in the meat, milk, and energy groups consumed 76%, 80%, and 77% of the supplement served, respectively over the entire course of the study.

Family measures

Maternal literacy. Maternal reading and writing skills were assessed during the first year of the study on 490 (91%) of the mothers of study children. Local Kiembu textbooks were used to select passages for both the reading and writing tests. These passages reflected grade levels of difficulty. Based on the mother's language preference, tests were administered in either Kiembu (92.9%) or English (7.1%) by one of six local testers trained in cognitive assessment. The reading test was administered by having the adult read passages out loud and respond orally to comprehension questions. Writing passages were dictated twice. A grade level score for both the reading and writing test was calculated based on the highest level passed by the mother. Two testers simultaneously scored the responses of 83 mothers (15.1%), and identical scores were obtained in all instances.

SES. SES of all families was assessed at baseline. Enumerators administered a survey to the mother and father of all study participants regarding the number and types of possessions owned by the family, years of education completed by both parents, family income, the extent of involvement in community organizations, leadership positions and the use of banks, the post office and telephones. A summary SES score was then calculated for each family based on all variables.

Results

Baseline characteristics of the sample

Analyses were conducted to determine whether the treatment groups differed at baseline in terms of demographic variables consisting of child age, gender, and height; maternal reading and writing grade equivalent; and family SES. **Table 2** presents means and standard deviations of these baseline demographic factors and shows that there were no significant differences between treatment groups at baseline. For the group as a whole, children's heights and weights reflected significant stunting and underweight. Twenty-three percent of the boys and 15.5% of the girls were stunted (height-for-age z-scores at or below –2 SD). Approximately 30% of the children (30.2% of boys and 30.6% of girls) were moderately to severely underweight (weight-for-age z-scores at or below –1 SD).

Comparisons of playground variables using one-way ANOVA, with school as a random effect, revealed a significant difference at baseline between groups only in the percentage of time that the children were engaged in low activity level play, $p < .004$. There were no significant differences between treatment groups at baseline in any other behavioral measure. Thus, the randomization of schools to treatment conditions was largely successful in obtaining comparability across groups.

Data analysis

This study is a four-condition design with three schools randomized to each condition. Five longitudinal measurements were taken for each child enrolled in these

TABLE 2. Baseline characteristics of the study sample and intervention groups

Variable		Entire sample	Meat group	Milk group	Energy group	Control group	p[a]
Age at time 0	Mean	7.60	7.42	7.52	8.02	7.44	NS
	SD	1.37	1.22	1.34	1.41	1.40	
Sex (% male)		51.85	51.59	53.85	50.77	51.06	NS[b]
Height	Mean	115.72	115.53	115.57	116.91	114.98	NS
	SD	6.25	5.53	5.96	6.28	6.94	
Reading ability	Mean	6.82	6.54	7.44	6.52	6.73	NS
	SD	5.25	5.48	5.18	5.04	5.32	
SES	Mean	82.77	86.62	78.33	84.83	81.93	NS
	SD	25.07	29.99	24.11	22.69	22.70	
Writing ability	Mean	5.12	5.08	5.80	4.53	5.04	NS
	SD	4.95	5.06	4.99	4.83	4.91	

NS, not significant; SES, socioeconomic status
a. One-way analysis of variance with school random effect.
b. Chi-square test.

schools. Hierarchical linear random effects models and associated methods [11, 12] were used to examine the effects of treatment group on changes in playground activity and behavior over time. A random intercept and slope (RIAS) model, which naturally accommodates between-children variation in initial status and in slope, was used to analyze the longitudinal measurements. Restricted maximum likelihood methods as implemented in SAS PROC MIXED (SAS Institute, Inc. (1999) SAS 8.0 SAS Institute, Inc., Cary, NC) were used to obtain estimates, standard errors and contrasts and to test their statistical significance. SAS PROC MIXED was used to analyze the following eight outcomes: high activity, low activity, positive emotion, leadership, initiates, ongoing peer interaction, solitary play, and aggression. Log2 transformations on each of these outcomes were used in the analysis. The fractions of medium activity, positive emotion and ongoing behavior were close to 1 so Log2 transformations on (1-fraction) for these 3 variables were used. However, the slopes are presented so that positive scores represent increases in behaviors and negative scores represent decreases in behavior.

The models included time and treatment by time, as well as sex and baseline age, as predictors. Child height, maternal reading and writing literacy, and family SES were also examined separately as covariates. For each of the outcomes combined with each covariate, the mixed model includes the following fixed effects: year, year-by-treatment interaction, sex, age at baseline, covariates, and year-by-covariate interaction. The random effects are intercept and slope for all children nested within school effects.

Frequency of playground behaviors

The distribution of activity levels, emotional states, and rates of peer interaction are quite similar to those observed 12 years ago, although the rates cannot be compared directly across the two studies because of differences in data collection methods. As found previously in the naturalistic study, children's activity levels were predominantly in the medium range (**fig. 1**). The predominant emotion displayed on the playground was positive affect (**fig. 2**) and the children's rates of ongoing peer involvement were quite high (**fig. 3**). The rates of leadership behavior and aggression continued to be low.

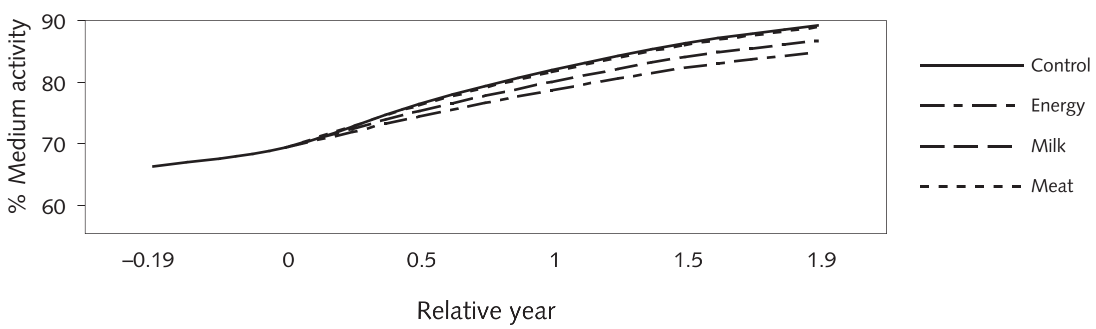

FIG. 1. Change in medium activity over time by feeding group

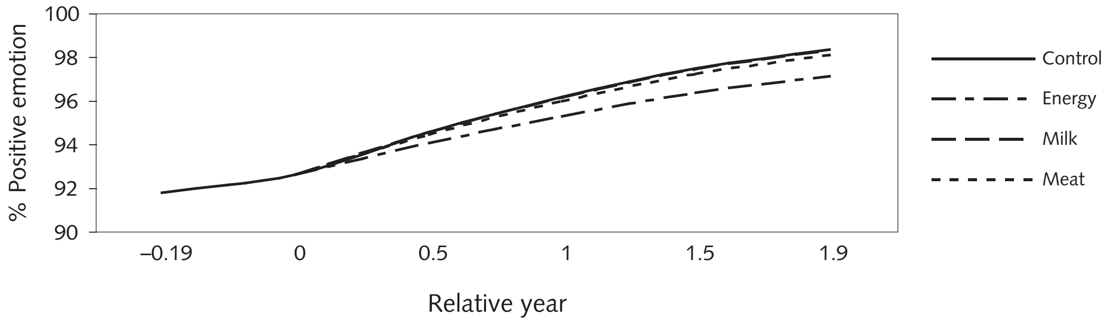

FIG. 2. Change in positive emotion over time by feeding group

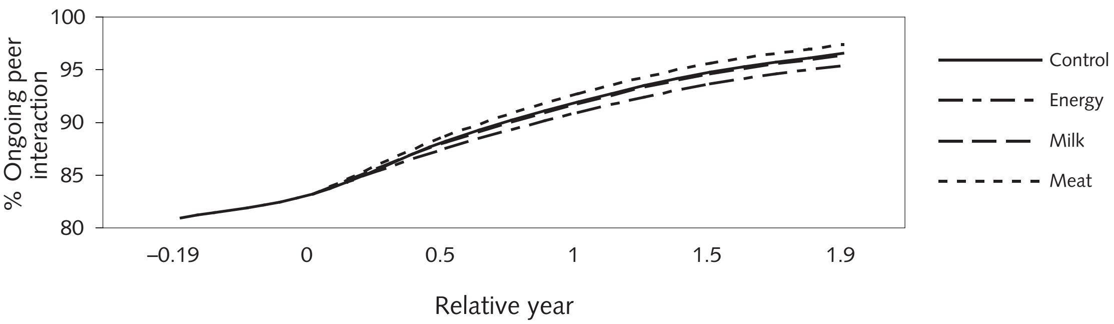

FIG. 3. Change in ongoing peer interaction over time by feeding group

Change in playground behaviors and activity level over time

Initial analyses investigated the presence of trends over time. Hypotheses about trends over time were difficult to generate based on previous information, as we did not examine changes over time in our last study. In that study, children who had attended school for longer durations were less solitary and showed less low activity behavior on the school playground. For this reason, we hypothesized that there would be a decline in rates of low activity and solitary behavior over time. We had no hypotheses regarding trends over time for the remaining variables.

The analyses showed significant declines in the percentages of high and low activity and a significant increase in the percentage of medium activity over time (**table 3**). There were also significant increases in positive emotion and ongoing peer involvement over time and significant decreases in leadership, initiative, aggression, and solitary behavior over time.

TABLE 3. Average slopes*

Variable	Estimated Slope (SEE)
High activity	–0.176 (0.032)
Low activity	–0.656 (0.033)
Medium activity	0.576 (0.031)
Positive emotion	0.525 (0.031)
Leadership	–0.194 (0.018)
Initiates	–0.370 (0.022)
Ongoing behavior peer interaction	0.860 (0.034)
Aggression	–0.179 (0.013)
Solitary play	–0.714 (0.034)

*All slopes are significantly different from zero ($p < .05$).

The impact of intervention on child behavioral outcomes

Using the analyses described previously, longitudinal growth curves were calculated for all children on each of the eight playground behaviors across the five time points at which playground behaviors were observed. The overall results are tabulated in **table 4**. As this table shows, when the significant covariates were considered, there were reliable treatment effects for high activity, low activity, leadership, initiative, and solitary play but not for positive emotion, ongoing peer involvement, or aggression. Thus, the current results mirror those from the previous naturalistic study and support our hypotheses. The only predicted effect that did not occur was that supplemented children did not show more positive emotion than non-supplemented groups.

In contrast, the data did not support our hypothesis that food quantity rather than food quality would have the major impact on playground behaviors. To confirm our hypothesis about food quantity rather than food quality, the pattern of results should show the slope of the children in the Control condition as differing from the three other groups with no significant differences between the slopes of the three supplemented groups.

TABLE 4. Treatment effects

Outcome	Covariate effect		Time x covariate effect	Treatment effect
High activity	SES	**	NS	**
	Reading ability	NS	NS	*
	Writing ability	NS	NS	**
	Height	*	NS	**
	None			**
Low activity	SES	**	NS	**
	Reading ability	NS	NS	*
	Writing ability	NS	NS	*
	Height	**	*	**
	None			**
Positive emotion	SES	NS	NS	*
	Reading ability	NS	*	NS
	Writing ability	NS	NS	NS
	Height	*	*	NS
	None			*
Leadership	SES	**	*	**
	Reading ability	*	NS	**
	Writing ability	NS	NS	**
	Height	**	**	**
	None			**
Initiates	SES	NS	NS	**
	Reading ability	NS	*	**
	Writing ability	NS	*	**
	Height	NS	NS	**
	None			**
Ongoing behavior	SES	NS	NS	NS
	Reading ability	NS	*	NS
	Writing ability	NS	*	NS
	Height	**	NS	NS
	None			NS
Aggression	SES	NS	NS	NS
	Reading ability	NS	*	NS
	Writing ability	NS	NS	NS
	Height	*	*	NS
	None			NS
Solitary play	SES	*	NS	NS
	Reading ability	NS	NS	NS
	Writing ability	NS	NS	NS
	Height	**	NS	NS
	None			*

SES, socioeconomic status; NS, not significant
*$p < .05$; **$p < .001$

Alternatively, if food quality were more important, then the slope of the Meat group should differ from the slopes of both the Energy and Control groups with no differences between the slopes of the Energy and Control group. If the slopes of the Meat group differed from the other slopes and the slopes of the Energy and Control groups differed, this pattern of results would suggest that both food quantity and quality were important. (For simplicity sake, we will leave out the data from the milk group for the time being.)

The comparison of slopes for the four groups (**table 5**) is shown without adjustments for significant covariates because the group differences are identical with or without adjustments. For both *leadership and initiating behaviors*, the pattern of results supports the importance of both food quantity and quality (**figs. 4 and 5**). There is less of a decline in leadership and initiative in the Meat condition than in any other condition and less of a decline in the Energy condition than in the Control condition. Thus, all the supplemented children show more leadership and initiate more interactions but this is particularly true for the children in the Meat condition. The only significant difference in *low activity* (**fig. 6**) is between the meat-fed groups and the other groups, again pointing out the importance of food quality.

Only the results for the rates of *high activity* (**fig. 7**) support the hypothesized importance of food quantity in that the Control group showed more of a decline in high activity than was true for the supplemented groups, and the slopes of the Meat and the Energy groups did not differ significantly. However, even here, the meat-fed group shows the smallest decline in high activity compared with the other three groups.

Discussion

The results of this study show that both the quality of children's diets and the energy that their diets provide influence the activities of children on the school playground. Children who were fed mid-morning were more active and showed more leadership and social initiation behaviors than did children who were not provided with this mid-morning nutrition snack. However, the quality of the extra nutrition was also important in regulating the children's activities. Children who were provided with meat as part of their morning nutrition remained more active and maintained greater social initiative over time than children provided with snacks that provided equal levels of energy but less protein, iron, and zinc.

The snack including milk did not have the same advantages as the snack including meat. Children who were fed *githeri* and milk were no more active or involved than children who were fed *githeri* alone, although both supplemented groups were more active

TABLE 5. Comparisons of treatment slopes

% High activity (overall p-value < .001)	Est. Slope (SEE)	Control	Energy	Milk	Meat
Control	–0.339 (0.051)		*	*	**
Energy	–0.165 (0.055)	*			
Milk	–0.177 (0.054)	*			*
Meat	–0.025 (0.059)	**		*	
% Low activity (overall p-value < .001)	**Est. Slope (SEE)**	**Control**	**Energy**	**Milk**	**Meat**
Control	–0.587 (0.049)				**
Energy	–0.558 (0.053)				**
Milk	–0.656 (0.052)				*
Meat	–0.821 (0.057)	**	**	*	
% Leadership (overall p-value < .001)	**Est. Slope (SEE)**	**Control**	**Energy**	**Milk**	**Meat**
Control	–0.271 (0.025)		*		**
Energy	–0.193 (0.027)	*			**
Milk	–0.236 (0.026)				**
Meat	–0.077 (0.029)	**	**	**	
% Initates (overall p-value < .001)	**Est. Slope (SEE)**	**Control**	**Energy**	**Milk**	**Meat**
Control	–0.502 (0.032)		**	**	**
Energy	–0.375 (0.034)	**			**
Milk	–0.376 (0.034)	**			**
Meat	–0.227 (0.036)	**	**	**	
% Solitary play (overall p-value = .03)	**Est. Slope (SEE)**	**Control**	**Energy**	**Milk**	**Meat**
Control	–0.714 (0.058)				
Energy	–0.593 (0.061)				*
Milk	–0.701 (0.061)				
Meat	–0.848 (0.066)				

*$p < .05$; **$p < .001$

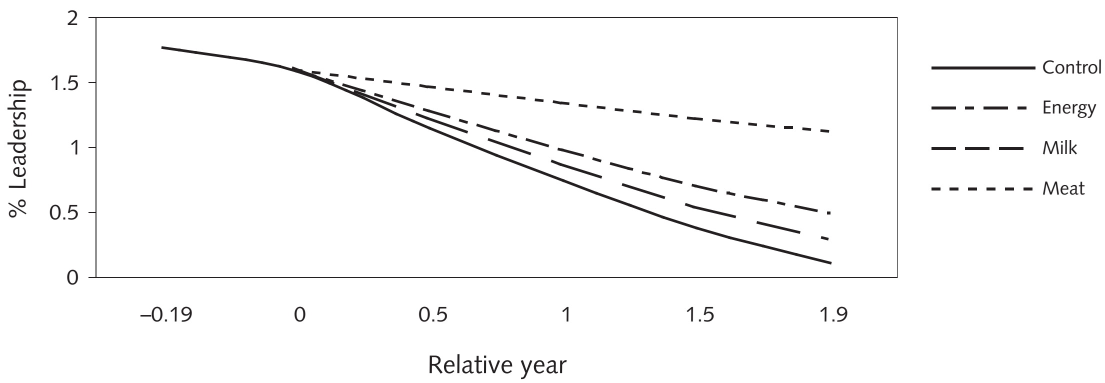

FIG. 4. Change in leadership over time by feeding group

and initiating than the non-supplemented group. The children fed *githeri* and milk did not differ from the non-supplemented group in terms of leadership behavior. As can be seen from **table 1**, the snack composed of *githeri* and milk provided less protein, iron, and zinc than did the snack composed of *githeri* and meat. Thus, the pattern of behaviors shown by the milk-fed group suggests that the addition of protein, iron, and zinc to the diet has the highest impact on the children's behaviors.

It is clear that children's behaviors on the school playground were influenced by other factors than just their current nutrition. The examination of covariates demonstrated that previous nutrition as reflected in the children's height was associated with many of the children's behaviors. However, even when height was covaried, current nutrition supplementation had an effect on playground behavior. These findings and the demonstrated effects of food quality on some of the cognitive tests [9] address the issues raised in the

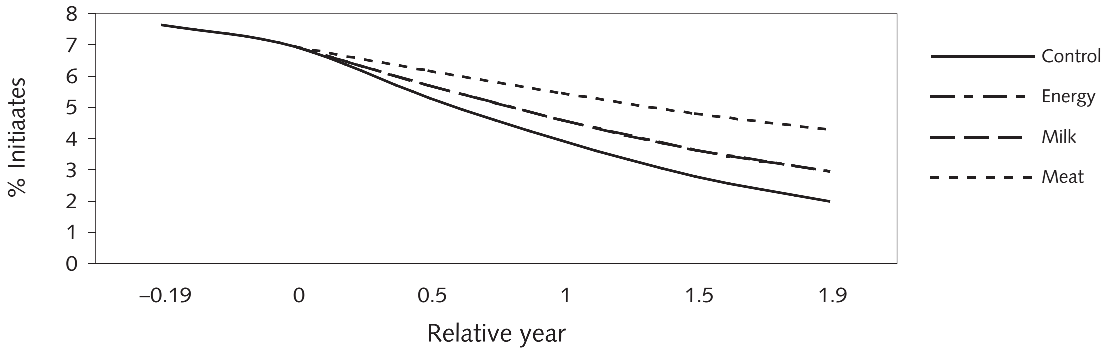

FIG. 5. Change in initiating behavior over time

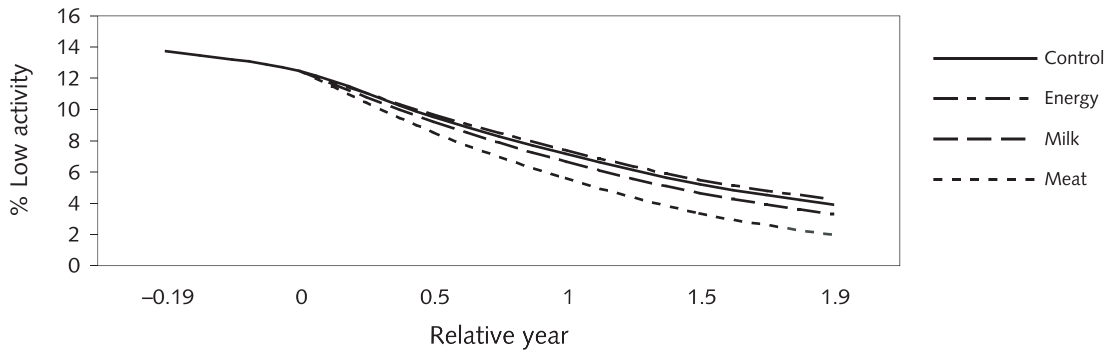

FIG. 6. Change in low activity over time by feeding group

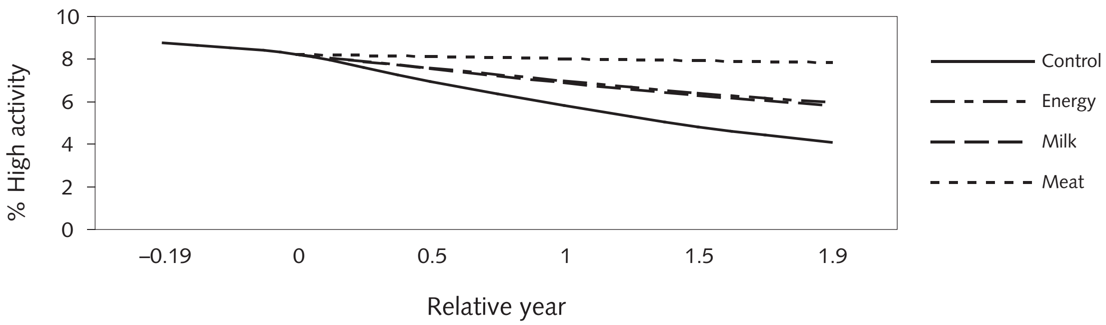

FIG. 7. Change in high activity over time by feeding group

World Bank/UNESCO booklet discussed at the start of this paper. In this project, children provided with high quality diets were more cognitively able, physically active, and social initiating than children provided with lower quality diets regardless of their earlier levels of undernutrition.

The behavioral variables that seem most susceptible to the influence of nutrition intervention are physical activity, leadership, and initiative. In this study, "leadership" was defined as behavior that involved beginning or maintaining an organized group activity. "Initiates" was defined as behavior beginning any kind of social involvement, whether between a pair of children or a larger group. The evidence is that leadership and initiating were increased in groups that were provided with good quality diets while ongoing social involvement was not. This evidence suggests that active initiation and organization of social activities depend on good nutrition while passive social involvement may not require such high levels of nutrition quality.

In this study, the effects on behavior are demonstrated on playgrounds in which all the children have been equivalently supplemented. This raises the issue whether supplementing just some of the children in a classroom would have the overall impact of supplementing all of them. Although this question cannot be addressed in the current study, our previous findings of associations between nutrition intakes and the same behaviors suggests that even supplementing some of the children in a particular classroom would influence their activities.

This study has a number of weaknesses. First, as discussed earlier, it was impossible to do blind observations in this community. However, the results of the current study are strengthened in that they replicate our previous findings in the same community that nutrition intakes were related to activity level and leadership behavior observed by individuals who were naïve as to the children's usual diets. Secondly, we cannot assume that maintaining high activity, leadership, and social initiative is necessarily a positive step in this culture without follow-up information as to how these behaviors predict future development. We do know that malnourished children are often apathetic and underactive and that high activity and leadership behavior characterizes children from more advantaged families in this community. The effects of improving the quantity and quality of children's diets need to be examined much more broadly around the world.

Acknowledgments

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Using the school feeding system as a vehicle for micronutrient fortification: Experience from South Africa

Martha E. van Stuijvenberg

Abstract

School-age children are often a neglected group in terms of micronutrient interventions because they are not reached by the intervention strategies aimed at preschool children or pregnant women. School feeding, however, offers an excellent opportunity for targeted intervention in this age group, especially with regard to fortification. This paper first gives a brief overview of the school-feeding program in South Africa, and second reports on a number of trials conducted in South African schools by the South Africa Medical Research Council that examined the feasibility of using school feeding as a vehicle for micronutrient fortification. Various food items, such as biscuits, bread spread, and soup, are evaluated as potential carriers for micronutrients with positive effects on outcomes such as micronutrient status, growth, morbidity and cognitive function. For schoolchildren to realize their full mental and physical potential and to perform optimally at school, both short-term hunger and hidden hunger (micronutrient deficiencies) need to be addressed. School feeding has the potential to contribute toward alleviating both of these conditions and should therefore be fully utilized.

Key words: School feeding, micronutrient deficiencies, fortification, cognitive function, morbidity

Introduction

School-age children are a neglected group in terms of micronutrient interventions, because they are not reached by the intervention strategies aimed at preschool children or pregnant women. School-feeding programs often focus on relieving short-term hunger, and do not always concentrate on alleviating or preventing micronutrient deficiencies. School feeding, however, offers an excellent opportunity for targeted fortification in this age group. The aim of this paper is to (1) give a brief overview of the school-feeding program in South Africa and (2) report on a number of trials conducted in South African schools by the South Africa Medical Research Council (MRC) that examined the feasibility of using school feeding as a vehicle for micronutrient fortification, and which showed positive effects on outcomes such as micronutrient status, growth, morbidity, and cognitive function.

South Africa's primary school nutrition program

School feeding was introduced on a national scale in South Africa in 1994, following President Nelson Mandela's "State of the Nation Address" in which he declared that a nutrition feeding scheme would be implemented in every primary school where such a need existed.

This plan formed part of the Integrated Nutrition Programme of South Africa. It was implemented by National Department of Health, and managed at the provincial level by the nine provincial Departments of Health. Approximately 5 million children in 15,000 primary schools are annually fed by this program. Geographic areas where poverty levels are highest are targeted, and priority is given to rural and farm schools and schools serving informal settlements [1].

The main purpose of the Primary School Nutrition Programme is to contribute to the improvement of education quality and general health by enhancing active learning capacity, alleviating short-term hunger, improving school attendance and punctuality, and addressing micronutrient deficiencies [1].

The program is being evaluated and monitored on an ongoing basis [2, 3].

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Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

The evaluation conducted in 2000 identified various areas where school feeding could be implemented in a more effective and efficient manner [3]. As a result of this evaluation, the South African government approved various steps that are to be employed to improve the functioning of the school feeding system (Cabinet resolution: 23 January 2002).

At the time, all provinces had the prerogative to decide on the types of menus that they would like to serve as long as they were within the framework of national nutrition, logistical, social, and cost criteria, and they provided 25% of the recommended dietary allowance (RDA) for energy for the 7- to 10-year-old age group per day, and 20% of the RDA for the 11- to 14-year-old age group. Findings of the 2000 evaluation, however, revealed that menu options were not adhered to, neither at the provincial level nor at school level. Energy provided by menus ranged between 12% and 22% of the RDA, with the menus from eight of the nine provinces providing less than 20% of the RDA.

Although addressing micronutrient deficiencies was included in the aims of the Primary School Nutrition Programme, there were no national guidelines with regard to the amount of micronutrients to be provided by school feeding. The evaluation also showed that in only 9% of schools were children fed before 10:00 in the morning, and that in 48% of schools, feeding was provided only after 11:00. This defeats the main purpose of the school-feeding program, which is to alleviate short-term hunger and thereby enhance active learning capacity. There was also inconsistency in the number of feeding days, and a low coverage in terms of the number of days children were fed compared with the number of school days (52%–92%) and the planned number of feeding days (64%–97%) [3].

Steps approved by the government to improve the situation with regard to menu options and feeding times include the standardization of menu options. It was decided that menus should comprise five basic options and include both cooked and uncooked food choices. Provision should also be made for local food choices. It was further decided that menus should provide at least 20% of the RDA for energy, protein, calcium, iron, zinc, and vitamin A, and that the use of food vehicles that are subject to mandatory fortification (e.g., bread and maize meal) is encouraged. In order to optimize the benefits of school feeding, feeding should take place before 10:00 a.m. every day. The number of feeding days was also standardized at 156 school days per year so that children receive school feeding on at least 80% of annual school days. A monitoring system to ensure regular school feeding is to be put in place [1].

The 2000 evaluation also pointed out that recommended targeting directives were not adhered to, neither at provincial level nor at school level, and that targeting was often driven from a political and financial perspective, rather than from a needs perspective, (e.g., compromising the number of feeding days, quantity, and quality of food, and menu options in an effort to feed more children) [3]. It was decided that existing targeting guidelines are to be refined in conjunction with the Department of Education. It was also decided that Grade R learners (preschool class) in targeted primary schools are to be included in the school-feeding system so as to enable children in their most vulnerable years to realize their full mental and physical potential.

Other limitations that were highlighted by the 2000 evaluation were that food quality was often inferior and control of food safety poor. Storage facilities were inadequate and unhygienic, and basic hygiene was often compromised due to lack of water and inadequate infrastructure in terms of utensils and equipment. Thirty percent of schools sampled did not have water on site, despite the fact that most menus require water for preparation [3]. As a result, the government approved steps for the implementation of a standardized monitoring system to ensure food safety and quality, and for the provision of the necessary utensils and equipment for the preparation and serving of meals [1].

The Primary School Nutrition Programme was transferred to the Department of Education in April 2004. The main reasons for the transfer were that school feeding has educational outcomes and that the Department of Education is functionally responsible for schools. This step will to a great extent enhance the effective and efficient implementation of the school-feeding program. The two departments are currently working together to facilitate a smooth transitional phase [1].

Micronutrient deficiencies despite school feeding

Despite the existence of a national school-feeding program, studies undertaken by the MRC have shown that micronutrient deficiencies still persist in some South African schools.

A survey in primary schoolchildren from a rural area in KwaZulu-Natal, e.g., where school feeding had been in operation at the school for approximately 2 years, showed micronutrient deficiencies to be present in a great number of the children attending the school [4]. The meals provided at this school mainly comprised soy beans, rice, cabbage, and potatoes, and 40% of the children had inadequate vitamin A status, 28% were anemic, 97% were iodine deficient based on low urinary iodine excretion, and 21% presented with visible or palpable goiter. Surprisingly, even though there was a high prevalence of micronutrient deficiencies, relatively few children were stunted (12%) or underweight (1.8%). This emphasises the fact that micronutrient malnutrition, often referred to as the "hidden hunger," can be hidden indeed, and highlights the danger of relying on anthropometric status as the only indicator of nutrition status. An investigation of mid-year examination scores of these children showed that children with goiter scored consistently and on average 5.2% lower in their Zulu (the local language) examination papers than did those without goiter ($p = .01$). Children with goiter also scored on average 2.7% lower in their mathematics examination papers than did those with no goiter ($p = .27$) [5].

Trials conducted in South Africa using the school feeding system as a vehicle for micronutrient fortification

A micronutrient-fortified biscuit

In a follow-up to the study in rural KwaZulu-Natal, showing a high prevalence of micronutrient deficiencies, the MRC conducted a randomized controlled trial with a fortified biscuit in an attempt to address the micronutrient deficiencies present in these children [4]. The biscuit was fortified with iron (ferrous fumarate), iodine, and -carotene at 50% of the RDA [6], and given together with a cold drink fortified with 100 mg ascorbic acid to enhance iron absorption. The children received the biscuit daily during the school week; no intervention took place on weekend days, public holidays, or during school holidays.

The intervention was evaluated over a period of 12 months, and resulted in a significant improvement in vitamin A, iron, and iodine status. Vitamin A deficiency (serum retinol < 20 µg/dL) dropped from 40% to 12%; anemia from 28% to 15%; and iodine deficiency from 97% to 30%. In addition, respiratory- and gastrointestinal-related morbidity also appeared to have been favorably affected: 30% fewer school days ($p = .097$) in the experimental group were lost during the intervention period as a result of respiratory-related illnesses, and 35% fewer school days were lost ($p = .013$) as a result of gastrointestinal-related illnesses. Although the effect of vitamin A supplementation on infectious morbidity and mortality in the preschool child is well documented [7], it is less defined in the school child, in whom vitamin A deficiency is seldom life threatening, and who is to a lesser extent susceptible to infections. The ~ 30% reduction in morbidity-related absenteeism observed in this study population is, however, promising and may have significant long-term implications for learning and school performance in children that are vitamin A deficient.

The biscuit intervention also had a positive effect on the cognitive function of these children. Children were given a series of tests designed to measure a range of mental processes and fine motor skills (e.g., verbal learning, visual memory, arousal, attention, retrieval, eye-hand perception, and coordination) that are thought to be affected by nutrition deficits. For each task, either time taken to complete a task, or how much of a task was completed in a given time, was measured. Significant between-group treatment effects were found for the digit span forward task, the verbal fluency task, and the reading numbers task, especially in those children with low iron stores, and in those with goiter at baseline [4, 8]. Although no effect was seen in the study population as a whole, the biscuit intervention had a positive effect on the changes in height and height-for-age Z-scores in the children with low iron stores at baseline, which suggests that iron may have been a limiting factor in the growth of these children.

The use of a fortified biscuit in school feeding has a major advantage over conventional school feeding options in that a biscuit is regarded as a *snack* rather than a meal, and is therefore unlikely to replace meals given to the child at home. Furthermore, the biscuit is a compact source of nutrients that is easy to store, easy to distribute, and needs no preparation. It is therefore ideally suited for schools where there is no water on site, or in schools where there is a lack of adequate storage facilities or the necessary utensils and equipment for meal preparation. The biscuit has a long shelf life and therefore does not require regular delivery. The quantity of biscuits delivered and distributed can also be easily monitored, which makes the system less vulnerable to abuse or corruption. Although this particular biscuit was fortified with iron, iodine, and -carotene, it also has the potential to serve as a carrier for other micronutrients.

Long-term evaluation of the biscuit intervention

The long-term effectiveness of the biscuit program in terms of elimination of micronutrient deficiencies was evaluated over a period of 45 months (3.75 years) using both longitudinal and cross-sectional data [9]. Improved vitamin A status was not maintained during the long summer school holiday breaks when no intervention took place; after each summer break serum retinol levels were back to pre-intervention levels. The biscuit supplied 50% of the RDA per day in the form of -carotene; this was probably enough to maintain serum levels from day to day, but not sufficient to replenish stores or to maintain existing stores during periods when the biscuit was not consumed. A survey of the dietary intake of the children in this school showed that meals given to the child at home contributed only 10% of the RDA for vitamin A [10]. It was therefore not surprising that serum retinol returned to pre-intervention levels during the time that the biscuit was not supplied, and it was recommended that the biscuit program be supplemented with other long-term intervention strategies, such as nutrition education and/or home gardening projects that encourage the production and consumption of -carotene-rich foods.

Iron status also returned to pre-intervention levels after the school holiday break, but showed no recovery during subsequent intervention periods. Ferrous fumarate was used as iron fortificant during the original trial, and when given together with the vitamin C fortified cold drink it was effective in improving iron status. However, when the vitamin C fortified cold drink was provided on a less frequent basis, due to logistical problems during the longitudinal follow-up phase, iron status did not improve. To eliminate the need for ascorbic acid, a presumably more bioavailable form of iron, an amino acid chelate (ferrous bisglycinate), was then introduced. This resulted in some improvement in serum ferritin, but hemoglobin deteriorated further. It is speculated that degradation of the amino acid chelate might have taken place as a result of a too high core temperature in the biscuit during the baking process, and further investigation into optimum baking conditions for the biscuit is therefore needed.

Only iodine status did not return to pre-intervention levels after the school holiday break. This was probably due to the iodization of salt which became mandatory in South Africa in December 1995, 6 months after the start of the biscuit intervention. There is therefore no further need to add iodine to a fortified biscuit distributed in South African schools. The effectiveness of the mandatory salt iodization program is currently being monitored. Jooste et al. [11] reported significantly improved urinary iodine levels in a group of schoolchildren from a previously endemically goitrous area in the Eastern Cape, but no reduction in the prevalence of goiter after one year of mandatory salt iodization. The situation continues to be monitored, and a follow-up 9 years after the introduction of mandatory salt iodization is planned in the school where the original biscuit intervention took place.

Red palm oil as an alternative vitamin A fortificant in the biscuit

A hydrogenated oil, widely used in the baking industry, was used as baking fat in the original biscuit. Hydrogenated oils contain *trans* fatty acids, and because of the negative effects of the latter on plasma lipids and lipoproteins [12, 13], its use in school feeding in the long term may not be desirable.

Red palm oil has a moderate level of saturation and therefore does not require hydrogenation for use as a fat component in foods [14]; as such it is free of *trans* fatty acids. It is also a rich natural source of carotenoids (500–700 ppm), of which approximately 50% comprises -carotene. In addition, red palm oil contains large amounts of tocopherols and tocotrienols (~ 1000 ppm), which have powerful antioxidant properties [15]. By substituting the hydrogenated shortening in the biscuit with a baking fat derived from red palm oil, the biscuit would not only be free of trans fatty acids, but, because of its natural carotenoid and antioxidant content, there would also be no need to add synthetic -carotene and a synthetic antioxidant to the biscuit; concomitantly, quality control with regard to the fortification process would be simplified.

During a subsequent trial, red palm oil in the form of a baking fat was evaluated as an alternative vitamin A fortificant in the biscuit [16]. The trial was conducted in a primary school where there was a ~ 60% prevalence of vitamin A deficiency (serum retinol < 20 µg/dL). The results showed that red palm oil was as effective as -carotene from a synthetic source in improving the vitamin A status of these children. This, together with the various additional qualities of red palm oil, makes it an attractive alternative for use as a vitamin A fortificant, not only in the biscuit, but also in other food products that require fat as an ingredient.

A micronutrient-fortified bread spread

Bread and peanut butter are common food items on school feeding menus in South Africa. Peanut butter, although a good source of energy and protein, is not a good source of micronutrients, and therefore does not contribute toward fighting micronutrient malnutrition in primary schoolchildren. In addition, it carries the risk of being contaminated with aflatoxin. During 2001 there were several reports in the South African press regarding the high levels of aflatoxin (30 times higher than the legal limits) found in the peanut butter given to children in certain areas of the country as part of the Primary School Nutrition Programme [17]. It emerged that limited budgets and personnel did not allow for sufficient screening to control the level of aflatoxin contamination in the peanut butter used for school feeding. Long-term exposure to low levels of this toxin may cause liver cancer, especially in those with chronic hepatitis B infection [18], and giving contaminated peanut butter to schoolchildren on a regular basis may have serious long-term implications for their health [17].

An urgent need therefore arose to find a bread spread that can be used as an alternative for peanut butter in school feeding, and a micronutrient-fortified spread was thus developed by the MRC. Red palm oil fat, a rich natural source of -carotene, was used as a base, and iron, vitamin C, and zinc included as fortificants. This spread was evaluated against peanut butter in a randomized controlled trial, and the results showed the spread to be effective in improving vitamin A status in children with inadequate vitamin A status, and hemoglobin status in children who were anemic (unpublished data). The spread can also be used as a carrier for other micronutrients.

Ferrous bisglycinate vs electrolytic iron as fortificant in bread

A national food fortification program, requiring the mandatory fortification of wheat flour and maize meal with iron, vitamin A, zinc and B-complex vitamins, was launched in South Africa in April 2003. Because bread is widely used in school feeding, this will also contribute towards the micronutrient intake of the schoolchild. Four slices of bread will provide 25% of the iron requirement of the schoolchild per day. There is, however, controversy regarding the form of iron (electrolytic iron) that was selected as fortificant. The MRC conducted a randomized controlled trial in iron deficient primary schoolchildren, comparing electrolytic iron with ferrous bisglycinate as fortificant in bread over a period of 7.5 months [19]. While no significant intervention effect was observed for electrolytic iron, the treatment effect in the ferrous bisglycinate group in terms of hemoglobin, serum iron, and transferrin saturation was significant ($p < .05$), and approximately three times the effect observed in the electrolytic iron group. Ferrous bisglycinate as iron fortificant in bread thus performed better than electrolytic iron in this group of iron-deficient schoolchildren. Whether electrolytic iron will show a significant treatment effect over a longer intervention period and in children who are both iron deficient and anemic is not known. This should be investigated, because the bioavailability of the iron compound used in the national food fortification program will impact on the iron status of the schoolchild as well.

Soup as a vehicle for iron fortification

A soup powder, fortified with 20 mg elemental iron in the form of ferrous fumarate and 100 mg ascorbic acid per serving, was evaluated in 6- to 8-year-old primary schoolchildren over a period of 6 months. The iron intervention was associated with positive changes in hemoglobin, mean corpuscular volume, and serum ferritin, and the effects were greater in the children with low iron status at baseline. The effects were also greater when the iron fortification was combined with anthelmintic therapy. In addition, an improvement in growth was observed in those children with low iron status at baseline when the iron and anthelmintic treatments were combined [20]. This study demonstrated soup to be a feasible vehicle for iron fortification, especially during the cold winter months.

Response to iron fortification in relation to vitamin A status

The response to the above iron intervention was also measured in relation to the vitamin A status of the study population [21]. In the children with inadequate vitamin A status (serum retinol < 20 µg/dL) there was no improvement in terms of serum iron, transferrin saturation, and hemoglobin, while the greatest response was observed in the children with serum retinol > 40 µg/dL. On the contrary, serum ferritin, an indicator of iron stores, improved most in the vitamin A deficient children, suggesting that the absorption of iron was not impaired by the inadequate vitamin A status, but that it was rather the mobilization of the iron from body stores that was affected. Supplementation with vitamin A has been shown to increase serum iron and hemoglobin concentrations, with no or little effect on serum ferritin [22–24]. Although vitamin A status may thus not directly affect the mental ability of the child, it may do so indirectly via its effect on iron metabolism. The presence of even marginal vitamin A deficiency in schoolchildren may therefore limit the effectiveness of an iron intervention and should also be addressed when treatment with iron is considered.

Improved vitamin A status with orange-fleshed sweet potato

The efficacy of the orange-fleshed sweet potato (OFSP) in improving vitamin A status was evaluated in a randomized controlled trial in 5- to 10-year-old primary schoolchildren [25]. Seventy percent of these children were vitamin A deficient at baseline, based on serum retinol concentrations. Consumption of the OFSP, which supplied ~ 150% of the RDA [6], for 53 days resulted in a significant improvement in vitamin A status as measured by the modified relative dose response test. In addition, significantly fewer children, compared with the control group, were absent from school as a result of upper respiratory tract ($p = .006$) and skin infections ($p = .049$). Similar morbidity trends were observed in the schoolchildren participating in the fortified biscuit trial, which supplied 50% of the RDA for vitamin A and stretched over a period of 12 months [4].

Inclusion of omega-3 fatty acids in the diets of schoolchildren

Omega-3 fatty acids play an important role in the development of the brain during pregnancy and early infancy [26, 27]. Evidence from experiments in rats suggests that supplementation with omega-3 fatty acids selectively affects learning [28]. Although learning problems have been found in 6–12-year-old children with low omega-3 plasma phospholipid fatty acid status [29], the effect of supplementation in this age group is not known.

The MRC conducted a randomized placebo-controlled trial with an omega 3-fatty acid oil supplement in 6- to 11-year-old primary schoolchildren over a period of 9 months [30]. The intervention resulted in a significant improvement in omega-3 fatty acid status. In addition, there was a significant improvement ($p = .023$), compared with the control group, in the total recall score of the Hopkins Verbal Learning Test, which suggests that omega-3 fatty acid supplementation may improve verbal learning and memory in schoolchildren.

In a subsequent study a bread spread was developed from fish waste products (fish heads), a rich source of long chain omega-3 polyunsaturated fatty acids (CM Smuts, personal communication). The idea was to give fatty acids to the schoolchildren in a form that would be more acceptable. The effect of this spread is currently being evaluated in a randomized controlled trial in primary schoolchildren, and cognitive function, which includes verbal learning and memory, is also being measured. This bread spread has the potential to be included as an option on school feeding menus and can significantly contribute towards a more balanced fatty acid intake in schoolchildren, with possible positive effects on learning.

Discussion and conclusions

There are indications from several studies that micronutrient deficiencies are present in South African schools despite the existence of a national school-feeding program. The feasibility of using school feeding as a vehicle for micronutrient fortification was examined in various trials, and the feasibility of various food items as potential carriers for micronutrients evaluated. While results from these studies confirm school feeding to be a suitable vehicle for targeted fortification in this age group, finding the ideal iron fortification compound remains a challenge.

Iron is the micronutrient that is most often linked to cognition and performance [31], but due to the low bioavailability and high reactivity of iron fortification compounds [32] this is also the most difficult deficiency to address. From our studies it appears that when ferrous fumarate was used as fortificant, and given together with a vitamin C fortified cold drink, it was effective in improving iron status. However, when given without regular intake of vitamin C it appears to be less effective. The addition of ascorbic acid as fortificant to a food is, however, not always feasible. Not only is vitamin C destroyed during cooking, it is also easily oxidized during storage and a special air-tight packaging material is required to prevent it from degrading. This has both logistical and cost implications. To eliminate the need for vitamin C, the feasibility of a more bioavailable form of iron such as ferrous bisglycinate was examined. Although effective as fortificant in bread, ferrous bisglycinate appears to be destroyed in the biscuit by the higher core temperatures reached during the baking process. It is also a more expensive option.

Another way to improve iron bioavailability would be to include a natural source of vitamin C that would not require special packaging in school feeding menus. A study on Egyptian schoolchildren demonstrated that addition of an orange per day to the school meal resulted in a significant improvement in iron status [33]. This approach may not only enhance iron status, but will also contribute to establishing more healthy eating habits among schoolchildren.

From our studies it is clear that vitamin A deficiency can also be a problem among school-age children, and that the prevalence can be as high as 70% in some areas [25]. Although vitamin A deficiency does not directly affect school performance, it may do so indirectly via its effect on infectious related morbidity, which in turn will affect school attendance [4, 25]. Vitamin A deficiency also affects iron metabolism and suboptimal vitamin A status may therefore limit the effectiveness of iron interventions [21].

Due to the mandatory iodization of table salt there is no further need to include iodine as fortificant in school feeding in South Africa. The iodine status of South African schoolchildren, however, continues to be monitored [11].

Whether supplementation with omega-3 fatty acids holds benefits for cognition in school-age children is still uncertain, although there are indications that this may be so [29, 30]. The role of omega-3 fatty acid supplementation in school-age children is, however, a relatively novel field and merits further investigation.

In conclusion, for schoolchildren to realize their full mental and physical potential and to perform optimally at school, both short-term and hidden hunger need to be addressed. School feeding offers the opportunity to alleviate both these hungers, and should therefore be fully utilized.

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Improved effect of school meals with micronutrient supplementation and deworming

Tara Gopaldas

Abstract

A mid-day meal or school lunch program commenced in Gujarat, India from the sixties. In 1994, it was serving approximately 3 million schoolchildren. In 1994, the program was improved with the addition of a "package" of health inputs, including anthelmintics and micronutrient supplementation of iron and vitamin A, and iodine fortified salt. Tara Consultancy Services (TCS), India, a member of the Partnership of Child Development, Oxford University, evaluated Gujarat's improved mid-day meal program from 1993 to 1996. The program was implemented by the Commissionerate of the mid-day meal program, part of the government of Gujarat. The cost of the 'health package' in 1994, per child per year was 35 US cents (1 US $ = Rs.30). The study to evaluate the improved program included the following components:

Focus group discussions: *Government officials, teachers, students, parents, and community members participated in focus groups to elicit opinions on the proposed program which were predominantly positive.*

Process evaluation: *Logistical delivery defined as the adequacy, timeliness and cost of procurement of the anthelmintic drugs and micronutrients and the cost of this 'health package' per schooler per school year by the pharmaceutical companies was 100%. Efficiency of logistics to the schools, defined as the efficiency and cost of logistical delivery of the 'Health Package', from the State Head Quarters to the District to the Taluka to the School was 100%. Coverage defined as consumption of the 'Health Package' by schooler at least once in the 6–9 months of the school year, as stated by the implementing agency was 94%–100% (urban) and 42%–94% (rural); coverage as stated by the schoolchildren was 71%–79% (urban) and 50%–67% (rural).*

Impact evaluation: *On average, students who received supplements were 1.1 kg heavier and 1.1 cm taller than those who did not; hemoglobin (Hb) levels were > 12 g/dL intestinal parasite prevalence rates dropped from 71% to 39%; prevalence of night blindness and vitamin A deficiency were reduced from 67% to 34%.*

Lesson learned: *Since 2003, 4 states in India, namely, Gujarat, Andhra Pradesh, Karnataka, and Tamil Nadu covering approximately 30 million schoolers have adopted the"Gujarat Model."*

Key words: Schoolchildren, poor health, school meal, improvement, deworming, micronutrients, Gujarat, India

Introduction

A mid-day meal program or school lunch program has been in existence in India and Gujarat, located in North-West India, since the 1960s. In Gujarat, the program functions through an autonomous Commissionerate under the Chairmanship of the Chief Minister. The Commissionerate has strong links with the departments of Education, Revenue, Health, Civil Supplies, Building, and Water Supplies. It also has an efficient and effective "top-down" organizational structure. At the district level the Deputy Collectors are responsible for the procurement, storage, distribution, financial audit, and overall administration of food commodities. Eighty thousand organizers (college or school graduates), along with their cooks and helpers are responsible at the school level to cook and serve hot meals (generally a cereal-lentil preparation) to the schoolchildren. Iodized salt is routinely used. In 1994, the mid-day meal program in Gujarat alone served very nearly 3 million schoolchildren. More than a decade's (1980–92) research at the Maharaja Sayajirao University of Baroda on schoolchildren

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enrolled in Baroda's mid-day meal program in the city's 200 municipal schools clearly established that the nutrition status of children aged 6–15 years was worse than that of preschool children (3–6 years). Further, the older the children (11–15 years), the worse their condition. Overall, the nutrition, health, and intestinal parasite status of these low-income children was grave. Despite the mid-day meal, the greatest nutrient gaps were found with respect to iron and to vitamin A, rather than calories and protein. Intestinal helmintic infection and protozoal infection were seen to seriously interfere with growth, iron utilization, and specific areas of cognition. These functional areas showed improvement after the children received micronutrient supplementation. Vitamin A deficiency was associated with significantly more episodes of upper respiratory tract infections; supplementation helped control these episodes. A package of anthelmintics, iron, and vitamin A supplementation was established and showed clear benefits [1–14]. Similar published reports on the poor health and nutrition status of children aged 6–15 years were available from different parts of India [15–20] and from outside India [21–30].

In essence, a "package" of health inputs consisting of a single dose of albendazole (400 mg), vitamin A tablets (200,000 IU), and iron tablets (20 to 60 mg elemental iron) delivered twice a week at the beginning of each school term succeeded in significantly improving the health and nutrition status of the schoolchildren at a cost of a mere US 35 cents per child per year in 1994.

A defunct school health program did exist on paper. There were approximately 100 functionaries located at the primary health centers of the state who were expected to carry out the school health program. It is indeed ironic that committees set up for school health preceded those for the mid-day meal. Yet the recommendations made by these committees received scant attention in Gujarat until 1992.

The Government of Gujarat in 1994 took immediate and concrete steps to include the anthelmintic plus micronutrient health "package" as an integral part of the mid-day meal program. The Commissionerate of the Mid-Day Meal Program of the Government of Gujarat functioned as the planning and implementing agency of the improved mid-day meal program that included the health package.

Materials and methods

Overall evaluation design

The overall evaluation design consisted of four separate components: focus group interviews, process evaluation, sentinel study, and pre-post impact evaluation.

Sampling design

Two rounds of surveys were conducted:

1. Baseline survey: This survey was conducted before the administration of the health package (consisting of albendazole, vitamin A, and iron in the form of ferrous sulfate) to schoolchildren, in order to record their existing nutrition status in terms of nutrition anthropometry, vitamin A status by ocular signs, iron deficiency by hemoglobin (Hb) levels, and intestinal parasitic status by the children's own observation of their feces.
2. Resurvey: This was carried out 6 to 9 months after the administration of the health package (at least one round of dosing completed) to schoolchildren to record improvements (if any) in the parameters listed above.

Sampling procedure

Selection of districts

Gujarat State has 19 districts with a total population of 35 million. The primary school-age (6–15 years) population (underprivileged) enrolled in the first seven grades is approximately 5 million. For the present evaluation, three districts (Baroda, Ahmedabad, and Rajkot) were selected because they had access roads to the rural and tribal schools and together represented 25% of the state's total population. Further, these three large districts were geographically dispersed and adequately represented Urban, Rural and Tribal Talukas.

Selection of talukas

There were 12, 7, and 13 *talukas* (large rural administrative units comprising 100,000 to 300,000 total population; revenue subdistricts) in Baroda, Ahmedabad, and Rajkot, respectively. District-wise lists were made of the *talukas* and their distance from their respective district headquarters (HQ). The *talukas* (excluding the urban *talukas*) were stratified by distance, namely, those within and greater than 50 km from their district HQ. One taluka from each stratum was randomly selected. This provided two *talukas* per district. All the three urban *talukas* (one for each district) were included in the sample. Hence, the study sample consisted of six rural *talukas* and three urban *talukas*.

Selection of schools

All the primary schools in the sampled rural *talukas* and in the urban *talukas* where the mid-day meal was in operation were listed. For selection of urban schools, a complete list of schools, listed by enrollment, was prepared. From this, the schools having student enrollments of more than 500 were selected. From this list, two schools (one of boys and one of girls where co-education did not exist) per district were randomly selected. From the rural *taluka* schools, the school lists were stratified by school size of less than or more than 250 students. Then two schools from each stratum were randomly sampled. Thus, four schools per rural *taluka* were sampled.

In all, 10 schools (two urban and eight rural schools) per district formed the study universe. Hence, 30 schools in three study districts formed our total sample.

Design of survey

The study design was cross-sectional, with most children serving as their own controls. One school in Baroda served as an independent control. The necessary permission was obtained from the Collector of Baroda district.

Selection of schoolchildren for the baseline survey

To sample children aged 6–15 years, 10 age categories were used (6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 years). For each age category, 25 children from the urban schools and 6–7 children from the rural schools were enrolled for the baseline evaluation based on the children's and their parents' cooperation. Thus, from two urban schools, 500 children (250 per school), and from eight rural schools, 500 children (63 per school), were sampled to arrive at a total sample of 1,000 students per district or 3,000 for the three study districts.

Selection of schoolchildren for the resurvey

As much as possible, schoolchildren covered in the baseline survey were enrolled. The age-wise size of the sample was maintained at 300 schoolchildren per age group (150 boys + 150 girls) by enrolling new children (who were not covered in the baseline survey) from the same schools (schools selected for baseline survey). In total, 3,000 schoolchildren were resurveyed.

Details of the procedures used in the pre-post evaluation

Anthropometric measurements

Children were weighed (wearing minimum clothing) to the nearest 0.5 kg using a Krups weighing scale. The weight was taken twice and average weight was computed and recorded. The scale was adjusted to zero each time the child was weighed. A height meter was used to measure height of the child to the nearest 0.1 cm. The height was measured twice. The average was computed and recorded.

Clinical

All children were examined for preclinical and clinical ocular signs of vitamin A deficiency.

Vitamin A deficiency. Vitamin A deficiency was detected using the *Field Guide to the Detection and Control of Xerophthalmia* (31). The ocular signs of vitamin A deficiency were classified as follows: XN = night-blindness; X1A = conjunctival xerosis; X1B = Bitot's spot; X_2= corneal xerosis; X_3A = corneal ulceration/keratomalacia [31].

Hemoglobin. The cyanometHb procedure was used for Hb measurements [32]. Blood samples were analyzed either in the field by a battery operated colorimeter or brought to a local pathology laboratory for analysis. In the latter case the cyanometHb method as modified by the National Institute of Nutrition [33] using the filter paper technique was employed and Hb estimations were done by a well-recognized pathology laboratory in Baroda.

Data processing and analysis

Data entry, verification, and validation

A special data entry package was developed to enter, verify, and validate the data. This package was designed to check the prespecified minimum and maximum limits of each item of data. It also checked the logical consistency of the responses to a question with responses to other related questions. Data were entered as well as verified under the control of this package. During verification, the data were entered for a second time and were matched with data entered earlier. Any mismatch was rectified. The data set was validated during both entry and verification.

Tabulation and statistical analysis

SPSS (Sony Electronics Inc. 1996. HD-IBM formatted) was used for tabulation and statistical analysis. SPSS commands were written to describe all variables and specify missing values. SPSS commands to produce tables were written and tested. Similarly, SPSS commands were written to do appropriate statistical analyses. Finally, when the complete data set was ready, tables were produced and statistical analyses were carried out, including *t*-test and the chi-square test. All tests were considered significant at $p < .05$.

Results

Results of the focus group interviews, Gujarat (1994)

Focus group interviews or guided group discussions were held with government officials implementing the program, principals, teachers, parents, and the schoolchildren before the program was implemented in the 30 schools. The purpose was to elicit opinions on the intended program. The mid-day meal program officials opined that most of the schoolchildren suffered from worms and nutrition deficiencies. Many schoolchildren stated that they passed worms, felt tired, and could not see properly in failing light. Parents were generally not aware of such problems in their school-going children.

All of the participants (both providers and receivers) were very positive about the intended program. Principals, teachers, and parents said they would help in the dosing rounds and would see to it that the tablets or *golis* were consumed.

Results of the process evaluation, Gujarat

The mid-day meal program Commissionerate worked very hard from early 1994 to make the program a success. It procured the necessary tablets of albendazole (400 mg), ferrous sulphate (60 mg elemental iron), and vitamin A capsules (200,000 IU) to dose nearly 3 million primary schoolchildren in the 19 districts of Gujarat. Iodized salt was used routinely in the cooked meals served in the schools. The pharmaceutical companies transported the supplements to the district or *taluka* HQ where they were stored. Thereafter, the officials and organizers of the program collected their quota and dosed the children as prescribed by the expert technical committee set up by the mid-day meal program. The chief district health officers trained the deputy collectors and rural revenue officials regarding dosing, benefits, side effects, who in turn trained the organizers, who in turn trained the helpers and cooks. This process was found to be highly cost effective and efficient. The procurement, logistical delivery, and receipt by the schoolchildren ranged from 90%–100%. Where necessary, the stocks were stored in the principal's or organizer's lockable office cupboard. The shelf-life of the supplements was well beyond 2 years. Hence, provided they were kept in a dry and dark place, they were absolutely safe for further use. What was very commendable about this program was the enthusiastic acceptance by the providers (mid-day meal Commissionerate assisted by the state health department, state education department, and some voluntary agencies). The children, parents, teachers, and community members were all supportive of the program (**fig. 1**).

Results of the impact evaluation

The impact of the program on various health and nutrition factors can be seen in **tables 1 through 7**.

Impact on intestinal parasites

The sentinel study, or the independent control study, was conducted in urban Baroda only, as reliable diagnostic laboratories were available to do the necessary stool examinations here. The overall prevalence of helmintic and protozoal infections in a representative school child population was as high as 71%. This prevalence level was significantly reduced to 40% 6–9 months later after the mass administration of a single dose of 400 mg albendazole to the schoolchildren. Similarly, helmintic infections were significantly reduced from 24% to 5%, and protozoal infections were significantly reduced from 55% to 35% (**table 1**). We feel that this is the true picture and is more reliable than the responses we obtained by detailed questioning of nearly 3,000 schoolchildren in the baseline survey and the resurvey. Facilities do not exist for mass screening and compliance is very poor.

However, even "questioning" schoolchildren for a positive history of passing any worm visible to the naked eye also showed a significant reduction in the prevalence of helmintic infections from 40% to 32% (**table 2**).

When evaluating intestinal parasites according to age, a larger proportion of younger (6–10 years) children compared with their older (11–15 years) counterparts claimed to be infected with intestinal parasites during

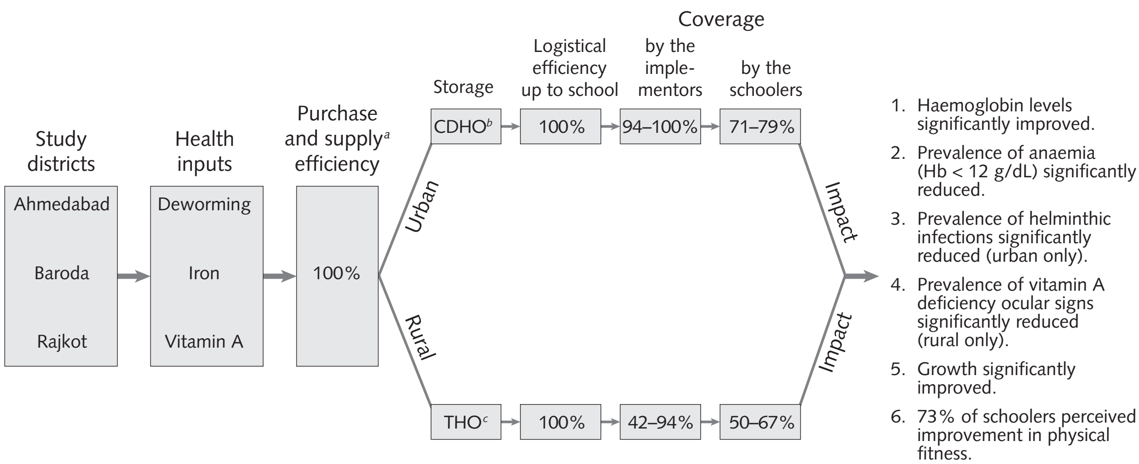

FIG. 1. Overview of delivery logistics and the impact of the health "package" on schoolchildren aged 6–15 years covering the three study districts (*a*: local pharmaceutical company; *b*: chief district health officer; *c*: Tuluka health officer)

TABLE 1. Prevalence of intestinal parasite infections by stool examination in schoolchildren aged 6–15 years before and 6 months after mass deworming with a single dose (400 mg) of albendazole in urban Baroda

Infection	Non-dosed group*		Dosed group	
	n	%	*n*	%
Sample size	181	—	83	—
Infected	128	71[a]	33	40[b]
Helmintic infection	43	24[a]	4	5[b]
Protozoal infection	99	55[a]	29	35[b]

* Figures with different superscripts in the same row are significantly different from each other.

the baseline survey (43% versus 36%). At the resurvey, significant reductions were observed at both the age groups (43% to 36% in the younger group, and 36% to 29% in the older groups). The magnitude of the reduction in the helmintic infections, however, did not vary by age (**table 2**); these findings indicate that in actual numbers, more younger than older schoolchildren were free of worms at the resurvey. This was attributed to the fact that a larger proportion of younger children than older children had received the supplements.

With regard to gender, no appreciable variations were observed in the prevalence of intestinal parasite infections at both the surveys. Again, from the baseline survey to the resurvey significant reductions were recorded in both boys (39% to 32%) as well as girls (40% to 33%) with no gender variations in the magnitude of decrease in the intestinal parasite infection (**table 2**).

With regard to location, the prevalence of intestinal parasite infections did not vary significantly between the urban and rural children at both the surveys. The decreases (**table 2**) from the baseline survey to the resurvey in intestinal parasite infections were significant in the urban (42% to 31%) and nonsignificant in the rural (37% to 34%) children. This could perhaps be attributed to the higher coverage and receipt of the health supplements in the urban schools (**table 2**).

Impact on Hb levels of iron-deficient and non-iron-deficient children

Age and sex. Hb estimations were done to detect the prevalence of iron-deficiency anemia (IDA) before and 6–9 months after the implementation of the health supplements. At the baseline survey the mean Hb level of the younger (6–10 years) and the older (11–15 years) boys and girls ranged between 10.5 ± 0.06 g/dL and 10.9 ± 0.06 g/dL (**table 3**).

At the resurvey there was an average increase of 1.2 g/dL in both age groups of both sexes (11.7 ± 0.059 / dl and 11.6 ± 0.05 / dl respectively). In the younger children, Hb levels increased from 10.5 ± 0.06 g/dL to 11.7 ± 0.05 g/dL in the boys and from 10.5 ± 0.05 g/dL to 11.6 ± 0.05 g/dL in the girls. The corresponding values for older children were 10.9 ± 0.06 g/dL to 12.0 ± 0.06 g/dL and 10.5 ± 0.07 g/dL to 11.9 ± 0.06 g/dL (**table 3**).

This increase was attributed mainly to the iron sup-

TABLE 2. Impact of health inputs on the prevalence of helmintic infections as stated by schoolchildren aged 6–15 years in the resurvey covering the three study districts

Variables	Baseline		Resurvey	
	n	%	*n*	%
All children	1,141 (2,872)*	40[a]	963 (2,964)	32[b]
By age group				
6–10 years old	633 (1,478)	43[a]	560 (1,561)	36[b]
11–15 years old	508 (1,394)	36[a]	403 (1,403)	29[b]
By sex				
Boy	549 (1,395)	39[a]	465 (1,468)	32[b]
Girls	592 (1,477)	40[a]	498 (1,496)	33[b]
By location				
Urban	614 (1,455)	42[a]	477 (1,535)	31[b]
Rural	527 (1,417)	37	486 (1,429)	34

* Figures with different superscripts in the same row are significantly different from each other. Figures in parentheses denote sample size.

TABLE 3. Impact of health inputs on the mean hemoglobin levels (g/dL) of schoolchildren aged 6–15 years in the baseline and resurvey covering the three study districts

Age groups	Baseline	Resurvey
	Mean ± SEM*	
6–10 years		
Boys	10.5 ± 0.06[a] (650)**	11.7 ± 0.05[b] (818)
Girls	10.5 ± 0.05[a] (644)	11.6 ± 0.05[b] (852)
11–15 years		
Boys	10.9 ± 0.06[a] (581)	12.0 ± 0.06[b] (623)
Girls	10.5 ± 0.07[a] (601)	11.9 ± 0.06[b] (626)
6–15 years		
Boys	10.7 ± 0.04[a] (1,231)	11.9 ± 0.04[b] (1,441)
Girls	10.5 ± 0.04[a] (1,245)	11.7 ± 0.04[b] (1,478)

* Figures with different superscripts in the same row, between surveys, are significantly different from each other.
** Figures in parentheses denote sample size.

plementation that the schoolchildren received 6–9 months prior to the resurvey. These findings suggest that the low Hb levels (< 12 g/dL) were mainly due to iron deficiency, because a mean Hb response of > 1.0 g/dL to oral iron therapy has been considered a diagnostic test for IDA**.**

Impact on prevalence of IDA

Location. At the baseline survey, 84% (**table 4**) of schoolchildren were found to be iron deficient (Hb < 12 g/dL). No differences were observed in the prevalence of IDA according to sex, but significantly more rural than urban children had IDA (92% versus 78%). At the resurvey there was a significant reduction in the prevalence of IDA (84% to 53%) among the children. The significant reduction was seen in urban (78% to 57%) as well as in rural children (92% to 49%), using the World Health Organization (WHO) cut-off of < 12 g/dL [34].

Impact on prevalence of ocular signs of vitamin A deficiency

All schoolchildren were clinically examined for ocular signs of vitamin A deficiency (xerophthalmia) at baseline and resurvey.

Sex. More boys than girls tended to be xerophthalmic at both the surveys although the difference was not statistically significant. From baseline to resurvey, the prevalence of xerophthalmia significantly decreased from 10% to 5% in boys and from 9% to 4% in girls.

Location. A significantly larger proportion of the rural than the urban children were xerophthalmic at the baseline survey (13% versus 6%). After the implementation of the program, the percentage of xerophthalmia reduced significantly from 13% to 3% in the rural children, but no reduction was observed in the urban children (**table 5**).

Impact on growth pattern (weight and height)

The weight of the older children increased by 1 to 2 kg and height by 2 to 3 cm, whereas the corresponding values for younger children were 1 kg and 1 to 2 cm (**table 6**). This was surprising because a relatively larger proportion of younger than older children received the supplements (**table 6**), which improved their appetite as stated by the children themselves (to be discussed later).

Schoolchildren's perceived benefits of the program

Physical fitness: an overall impact of the health inputs

The schoolchildren who received the health "package" were asked 6–9 months later about their present physical fitness compared with what it was before receiving the package. Physical fitness was defined as any one or more combinations of being more active and energetic; being able to study well; being able to play well without being tired; falling ill less frequently; eating more food or feeling an improvement in appetite; and attending school more regularly.

It was heartening to note that overall 73% of children felt better than they did before the implementation of the program (**table 7**). The remaining 27%, however, felt no change in their physical fitness. Of those who perceived improvement in their physical fitness, more than 50% said they felt more energetic and active and hence were able to study well and to work. Similarly, more than 40% stated they fell ill less frequently, could play well, and did not feel tired all the time like before.

TABLE 4. Impact of health inputs on the prevalence of iron-deficiency anemia (IDA)* among schoolchildren aged 6–15 years in the baseline and resurvey covering the three study districts**

	Baseline						Resurvey					
	Boys		Girls		Total		Boys		Girls		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Urban												
Iron-deficient	530	77[a]	573	79[a]	1,103	78[a]	408	56[b]	441	57[b]	849	57[b]
Non-iron-deficient	115	23	151	21	306	22	319	44	331	43	650	43
Rural												
Iron-deficient	492	90[ab]	491	94[ab]	983	92[ab]	317	44[bc]	378	54[b]	695	49[bc]
Non-iron-deficient	54	10	30	6	84	8	397	56	328	46	725	51
Total												
Iron-deficient	1,022	83[a]	1,064	86[a]	2,086	84[a]	725	50[b]	819	55[b]	1,544	53[b]
Non-iron-deficient	209	17	181	14	390	16	716	50	659	45	1,375	47

* IDA = Hb < 12 g/dL

** Figures under each matching head with different superscript in the same row between surveys are significantly different from each other. Figures with different superscript in the same column between urban and rural are significantly different from each other.

TABLE 5. Impact of health inputs on the prevalence of xerophthalmia (excluding conjunctival xerosis [X1A]) in relation to age group, sex, and location in the baseline and resurvey covering the three study districts*

Variables	Baseline		Resurvey	
	n	%	*n*	%
Age group				
6–10 years	135 (1,466)**	9^a	69 (1,708)	4^b
11–15 years	144 (1,371)	11^a	62 (1,256)	5^b
Sex				
Boys	144 (1,380)	10^a	70 (1,468)	5^b
Girls	135 (1,457)	9^a	61 (1,496)	4^b
Location				
Urban	90 (1,433)	6^a	86 (1,535)	6^a
Rural	189 (1,404)	13^b	45 (1,429)	3^c

* Figures with different superscripts in the same row between surveys are significantly different from each other. Figures with different superscripts in the same column between "Locations" are significantly different from each other.
** Figures in parentheses denote sample size.

One-fourth of them claimed to be eating more than they ate before taking part in the program. Coming to school more regularly than before, however, was mentioned by only 5%. This was understandable because school attendance in the preceding year was between 71% and 100% at the baseline survey as well at the resurvey. Schoolchildren (approximately 10%–20%) who were infected with roundworm spontaneously mentioned being worm-free at the resurvey.

TABLE 7. Impact of health inputs on the schoolchildren's (age 6–15 years) rating about the improvement in their physical well-being after receiving the health "package" in the three study districts

Benefits	Total children (*n* = 2,218)	%*
Feel better than before	1,622	73^{b**}
Feel active/energetic	1,231	55
Can study well/work well	1,187	53
Can play well, don't feel tired	1,005	45
Fall ill less frequently	906	41
Improvement in appetite, eating more food	513	23
Come to school more regularly	103	5
Feel the same as before	596	27^c

* Column does not add to 100% because each subject could have given any of the responses, in combination or singly.
** Figures with different superscript in the same column are significantly different from each other.

Discussion

Schoolchildren who received the "health package" were in significantly better nutrition status with regard to growth, Hb status, and prevalence of vitamin A deficiency and intestinal parasite infections. The greatest perceived benefit among the children was to be rid of worms. This reinforces our recommendation to integrate the school health package into the ongoing national mid-day meal program for 100 million underprivileged children aged 6–15 years.

WHO recommends mass preventive deworming (*without* screening) with albendazole when prevalence of intestinal parasites is greater than 50%. In the Indian context, mass preventive deworming is certainly indicated for all underprivileged schoolchildren in both urban and rural areas. Bundy and others have consistently been pointing out the high prevalence of intestinal parasite infections in the school-age and young adult population of the developing world [23, 24].

TABLE 6. Impact of health inputs on the mean weight and height of schoolchildren aged 6–15 years by age group in the baseline and resurvey covering the three study districts

Age groups	Weight (kg)		Height (cm)	
	Boys	Girls	Boys	Girls
	Mean ± SEM			
6–10 years				
Baseline (B)	18.5 ± 0.43	18.1 ± 0.20	117.0 ± 0.49	116.0 ± 0.51
Resurvey (R)	19.6 ± 0.21	19.2 ± 0.19	119.1 ± 0.47	117.9 ± 0.43
Change (R–B)	1.1	1.1	2.1	1.9
11–15 years				
Baseline (B)	27.5 ± 0.44	29.0 ± 0.49	138.8 ± 0.76	139.5 ± 0.89
Resurvey (R)	29.1 ± 0.59	30.8 ± 0.68	141.1 ± 0.94	141.7 ± 0.94
Change (R–B)	1.6	1.8	2.3	2.2

Other researchers have amply reinforced the need for mass deworming in the developing world [2, 19, 30].

Many studies in India have reported inadequacy of iron intake in underprivileged children. Not only inadequate iron intake but poor bioavailability of iron is believed to determine iron status of an individual [34, 35, 36]. In the present evaluation, 10% of schoolchildren were seen to be xerophthalmic, exhibiting night-blindness and/or Bitot's spots at baseline. Hence, deficiency of vitamin A could have contributed to the prevalence of iron deficiency. Fortunately, the "health package" included a once in six months dose of 200,000 IU vitamin A.

Vitamin A deficiency among deprived populations in India, including schoolchildren, is seasonal, and is least severe in summer when mangoes are in season. Mangoes are one of the richest sources of β-carotene [37, 38]. A higher prevalence of vitamin A deficiency has been reported in older versus younger children [11, 13]. Boys are more at risk than are girls [11, 39].

One of the major objectives of the mid-day meal program is to improve the nutrition status of schoolchildren. Our evaluation has shown that there was notable and significant increase in growth.

In short, "health packages" should be made an integral part of any school or preschool feeding program. A School Health Commissionerate should also form an integral part of any major feeding program. The teachers should also be included for both "feeding" as well as for the administration of the "package."

Conclusions

Because inexpensive and safe anthelmintics (albendazole and mebendazole) are now available, all school-age children should receive twice yearly dosing at least throughout their primary school years. This will also aid in bringing down the overall prevalence of intestinal parasite infections in whole communities.

The combination anthelmintics and micronutrients cost the Gujarat mid-day meal program only US 35 cents per child per year in 1994. For 5 to 7 years of primary school, the cost would be only US $1.50 to $2.10, making for an extremely sustainable, cost-effective, and impactful program.

Approximately $50 million per year is a small price for India to pay to dramatically reduce the high levels of intestinal parasite infections and the major micronutrient deficiencies that the 100 million Indian school-age children suffer from. Intestinal parasite control would greatly enhance growth and iron and vitamin A status. There is a definite relationship between adequacy in the above micronutrients and improved learning capacity. The nutrition and health impact of the mid-day meal can be enhanced many times over by the addition of the above inputs. In fact, we should ask ourselves the question of whether we can afford to deny our schoolchildren this intervention.

The multiplier effect of a satisfied and healthy school child being the best Information-Education-Communications (IEC) agent for his/her family is immense and should be exploited. The school can become a strong second line of health defense for the whole community and nation. It is of utmost importance to cover *all* schoolchildren for preventing IDA. This is crucial to having actively learning children (cognition and physical work capacity) in our classrooms. India's national IDA control program has bypassed and still bypasses this extremely vulnerable and easily accessible population group.

The improved mid-day meal program of Gujarat has amply shown how feasible and cost-effective it is to integrate the "health package" into an on-going program. Intestinal parasite infections constitute a major public health problem in underprivileged schoolchildren and need to be urgently addressed. Health and nutrition policies should recommend that intestinal parasite control be made a national program for all underprivileged communities, and for schoolchildren in particular.

The country should make provisions to develop its own requirements for the said school health package. Sustainability cannot otherwise be ensured. Unless schoolchildren experience a real and concrete benefit from an intervention, the intervention will not work. While the schoolchildren had a rather vague opinion of the mid-day meal before the addition of the health package, they were able to experience concrete gains in the supplements they received in terms of their physical fitness, increased energy/activity levels, ability to study better, freedom from worms, improved appetites, and fewer feelings of tiredness. Such real or perceived benefits can and should be capitalized upon in IEC programs aimed at schoolchildren, parents, teachers, *panchayats* (rural committees) and communities.

Postscript

The year 2004 brought good news for India's mid-day meal program. In July 2004, the Prime Minister in his Common Minimum Program Speech for 2004–2005 stated that the two thrust areas, among others, will be (1) basic education including a "hot-cooked-lunch," and (2) previously neglected "school health" will also receive attention. Six percent of the country's gross domestic product has been earmarked for education, of which half would go to basic education.

In late 2003, a timely workshop entitled "Mid-Day Meal Programs in Schools in India—The Way Forward," was organized by the Nutrition Foundation of India and held in Delhi [40]. Karnataka, a South Western State of India, has adopted the mantra of "deworming + iron + vitamin A + iodized salt" for 5.5 million schoolchildren in the government or government-aided free schools [41, 42]. Officials from Tamil Nadu (still the best as far as "hot school lunches" are concerned), stated that they had "outdone Gujarat's improved mid-day meal model." They not only gave the "four-in-one package" but also gave all schoolchildren health cards that enabled them to get free and immediate medical services; as part of this program 10 million schoolchildren are fed 365 days a year [43].

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E-learning: A nutritionally ripe environment

Gayle S. Savige

Abstract

Schools provide a social context in which children learn and develop; thus, schools are a desirable environment for nutrition promotion. The kidsfoodclub.org is a web-based technology that has been used in Australian primary schools as a model for nutrition promotion. It provides interactive activities, role models, and opportunities for children to learn from their peers through a bulletin board and story telling. This web-based technology is readily accessible to all schools, thereby overcoming problems associated with geographic location and socioeconomic status. This model can be adapted to meet the needs of different school communities and has the capacity to connect children from different backgrounds and cultures.

Key words: Information technology, communication, school, food, nutrition, kids, children, website

Introduction

Globally the world is changing rapidly. Communication systems have become so effective that the location of community is no longer a barrier against interacting with the outside world. The Internet and email, two relatively new electronic communication tools, enable individuals and communities to access, retrieve, and share information at a local, national, and global level in volumes and speeds unprecedented. This rapidly expanding flow of information around the world is contributing to the creation of knowledge-rich communities.

Dietary habits and other lifestyle patterns are also changing as a result of increasing urbanization and economic development [1]. Food habits are acquired early in life and are shaped by the family and its culture [2]. In many cultures, women have traditionally been the key role models in transferring food knowledge, beliefs, behaviors, and skills to their children. In affluent countries such as Australia, women with dependent children are spending more time in paid employment and less time in the more traditional tasks of preparing and cooking food for their family. This in turn has been responsible, at least in part, for the decline in home-cooked meals and increase in the consumption of convenience and "take-out" or "take-away" foods [3].

The food supply is also changing. Historically, it depended largely on locality and seasonal availability, but with economic development and advances in technology, the food supply has become enormously varied. The food supply is also changing in response to the rising interest in food and its relationship to health. Supermarkets shelves are now stocked with thousands of food items [4] that also include numerous variations of the one food type. For example, in the 1960s the sale of fresh milk in Australia was largely limited to pasteurized whole milk. Today, much of the fresh milk available has been modified so that consumers are now able to choose milks with varying concentrations of fat and/or nutrients.

Decisions about food choice have become more complex. Factors contributing to the complexity of food choice include the increasing range of foods available, advances in the scientific knowledge and understanding about food and health, the introduction of detailed food labeling systems, the competitive marketing strategies of large food companies especially in relation to health messages, and the recent emergence of organic and genetically modified foods. Education can and does play an important role in facilitating the decision making process for consumers [5].

Children's food education (including food habits)

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is shaped largely by the food values and eating habits of their families. Schools can assist families in better managing this process since the school environment (like the home environment) provides an important social context in which children learn and develop. Schools also recognise that children are living in a rapidly changing world and need to be prepared as future learners to deal with these changes successfully. E-learning environments have the capacity to develop the skills that characterise the future learner.

This paper will focus on how one model of e-learning can be used to support the food and nutrition education of future learners. Future learners can be characterized as learners who are profoundly affected by technology. They are independent and self-directed learners who take risks, solve problems, collaborate with others, think critically and reflectively, and are discriminating users of information. Future learners are also aware that they are members of the global community, with skills and knowledge that can be easily applied to their current situation or transferred to new learning experiences [6].

Model of an e-learning environment

A website located at http://kidsfoodclub.org and funded by the Australian Commonwealth government was established to promote food and nutrition among Australian primary schoolchildren. This form of web-based technology was used for a number of reasons. First, the vast majority of children are excited by web-based technologies and these technologies have been shown to improve learner outcomes [7]. Second, a critical analysis of Australian school-based healthful eating programs found that teachers often lacked the appropriate knowledge and skills in food and nutrition to implement these programs effectively [8]. Finally, Australian schools are equipped with computers and have access to the Internet, and technology is a key learning area within the school curriculum.

The website has six major sections that not only use a variety of learning strategies that encourage the qualities of future learners but also cater to a wide range of abilities and interests. The six website sections and learning activities can be summarized as follows:

Treasure chest. In this section, information about food and nutrition is presented in a variety of interactive and challenging activities including quizzes, wordsearches, and "brain teasers." These activities cover many aspects of the key curriculum learning areas and encourage children to solve problems, and to think critically and reflectively.

Monty's bulletin board. The bulletin board enables children to share information and ideas with their peers, especially those from different schools and backgrounds. This not only raises children's awareness that they can connect with the outside world, but also shows them that they're members of a global community. A website character (Professor Monty) is also used to moderate the bulletin board.

Island tales. Children are given the opportunity to have their work (story writing) recognized and published on the website. This builds confidence and self-esteem—factors that help motivate children to become independent and self-directed learners.

Larry's lunchbox. Larry's lunch box challenges children to apply a set of criteria (based on *The Australian Guide to Healthy Eating* and the use of packaging) to rate a variety of lunches. Children receive positive feedback for their ability to rate a lunch. This type of interactivity assists children in developing the skills they need to become discriminating users of information.

Celebrity cove. Positive role models (important in children's learning) are used on the site to expose children to a variety of healthful food habits. There is a growing body of evidence to suggest that healthful food habits need not be restricted to a particular culture. For example, traditional Japanese food habits differ from the food habits of Mediterranean cultures, yet both are considered favorable to health and longevity [9].

Fun park. This section links to a variety of games that have food and nutrition themes. Children not only love playing games, but play-based discovery is also important in children's education development, especially in relation to their critical thinking skills. Play encourages children to take risks, motivating them to solve problems and make decisions.

Online survey

Conducting online surveys is possible in an e-learning environment. Online surveys have several advantages over the more conventional survey methods. For example, as information is collected it is automatically entered into a database that not only minimizes the resources needed but also eliminates potential errors that may occur when transferring information from paper-based forms to a database. The results from an online survey can also be programmed to provide the participant with immediate feedback (i.e., show how their responses compare with other survey participants). The flexibility of e-learning tools also enables programs to be easily modified and adapted based on the feedback provided by the users via survey analysis or through monitoring website statistics to gauge user interest.

The Commonwealth funded project used an online survey to gather information about children's attitudes toward the website as well as their current food habits, opinions, after-school activity patterns, and food knowledge. Ethics approval was obtained from Monash

University, the Department of Education, Employment and Training (DEET) in Victoria, and the Commonwealth Department of Health and Ageing.

Online survey method

The online survey was conducted during the period from March 2003 to December 2003. The study participants (children) were drawn from metropolitan, rural, and remote regions of Victoria and included primary school students from grade four and associated composite grades. The approach taken to gather information on food habits included a 24-hour recall method intended to cover a school day. With the assistance of a checklist, children were asked to select all foods and beverages they had consumed in the previous 24 hours. Participants were also asked a series of questions about the website, home computers, and Internet access, the activities they participated in after school (on the previous day), and how they learned about food.

Results of the online survey

There was a 64% response rate from schools and a total of 1,349 students who participated in the survey. Slightly more girls (51%) than boys (49%) participated in the survey. The girls had a mean age of 9.2 years (± 0.8) and the boys had a mean age of 9.3 years (± 0.8).

The majority of children surveyed (87%) indicated they liked the website, with only 2% responding negatively. When children were asked to nominate their three favorite sections, almost all children (96%) chose the Fun Park (games), with half nominating the Treasure Chest. There was little difference in the percentage of responses for the other four remaining areas: namely, Island Tales (37%), Celebrity Cove (37%), Larry's Lunch Box (33%), and Monty's Mail (31%).

Family, school, and the project website were nominated as the most important sources of food education by children (see **fig. 1**). This was followed by television (60%), books (51%), food packets (45%), the Internet (41%), grandparents (31%), friends (25%), and printed materials such as newspapers and magazines (10%). Children were also asked if they had a computer at home and access to the Internet. Nine out of 10 children indicated they had a home computer and approximately 60% reported having access to the Internet at home (data not shown).

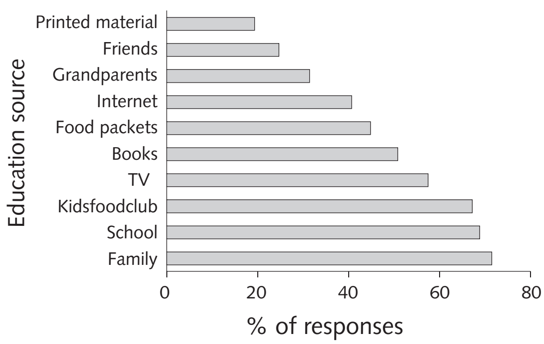

FIG. 1. Food education sources of survey participants

Information that was gathered on food habits was compared with *The Australian Guide to Healthy Eating* [10]. This food guide is portrayed by a pie chart or "plate" and represents the five major food groups:

» Bread, cereals, rice, pasta, and noodles
» Vegetables and legumes
» Fruit
» Milk, yogurt, cheese
» Meat, poultry, fish, eggs, nuts, and legumes

Both children and adults are encouraged to eat a variety of foods from each section of the pie chart everyday. Water is strongly recommended as the best drink. Treats or non-essential foods appear below the chart where it is suggested these foods are eaten occasionally or in small amounts.

The survey results which reflect the self-reported intake of food and drinks of children during the previous 24 hours found vegetables and legumes was the most poorly represented food group, with only 56% of children indicating they had eaten from this food group (**table 1**). Most children (91%) had eaten foods from the bread and cereals food group. This food group was followed by (in descending order) dairy (78%), meat (75%), and fruit (71%). Approximately 80% of children reported drinking plain water (either from the tap or from bottled water). At least one "treat" food was eaten by 19% of children. Although quantities were not measured, the percentage of children who reported eating two, three, four, or more treats was 23%, 14%, and 32% respectively.

Most children (75%) watched television after school, compared with only 55% who reported being physi-

TABLE 1. Comparison of food groups, water, and treats in relation to survey results

Food groups according to the *Australian Guide to Health Eating* (including water and treats)	Children consuming foods from each food group on the day prior to the survey (%)
Bread, cereals, rice, pasta, and noodles	91
Vegetables and legumes	56
Fruit	71
Milk, yogurt, cheese	78
Meat, poultry, fish, eggs, nuts, and legumes	75
Water	80
Treats[a]	88

a. Result based on the consumption of at least one "treat" food cally active. Other after-school activities included reading (40%), playing computer games (37%), and participating in sedentary activities such as playing a musical instrument (35%) (**fig. 2**).

Discussion of survey results

This project used an e-learning environment to promote children's interest and skill in learning about food and to gather information from children about food-related issues. The results suggest that the website was successful in promoting children's interest in food because most children liked the site. Two-thirds of those surveyed considered the kidsfoodclub.org website an important source of their food education, but only 40% viewed the Internet in general as being important. This difference is possibly owing to the level of exposure. Most children completing the survey had been exposed to the kidsfoodclub.org website (at school). During school hours, most children have limited access to the Internet and although 90% of children had a home computer, less than 70% had access to the Internet (at home), and only 37% reported playing computer games after school. In comparison, 75% of children reported watching television after school and this level of exposure probably explains, in part, the 60% response rate of children in listing television as an important source of their food education. It is likely that the internet will become an important source of food education as exposure to this medium increases. The Australian Bureau of Statistics has shown that the proportion of households frequently using a computer increased rapidly from 1994 to 1998 and this trend is not only expected to continue but to accelerate [11].

By comparing the survey results with the *Australian Guide to Healthy Eating* it would appear that the food habits of a relatively high proportion of Victorian primary schoolchildren is less than optimal given that health protective foods such as fruit and vegetables were missing from the diets of 28% and 47% of children, respectively. Furthermore, the percentage of children who selected more than one type of treat from the survey list of foods suggests these foods are not being eaten in small amounts. It is important to note that a lack of fruit and vegetables is among the top ten major risk factors contributing to the burden of disease in Australia (12). Furthermore, the results of this study appear to confirm a National Health and Medical Research Council report that suggested that the gap left by the absence of fruits and vegetables is being filled, at least in part, with energy-dense foods [13].

Regular physical activity is important for a healthy body and protects against weight gain. Results from the online survey suggest a substantial proportion of children are not only physically inactive after school but three out of four children watch television, a sedentary activity linked with an increased body mass [14]. One of the potentially negative effects of using an e-learning environment is that it may encourage greater sedentary behavior and therefore negate some of the potential benefits associated with this form of food education. However, one Australian study found no relationship between children's computer habits and their body-mass index [15].

The cross-sectional nature of the online survey does not provide information about the quantity of food eaten nor the time children spent participating in their after school activities. Data from the survey cannot be compared with the most recent National Nutrition Survey and we are therefore unable to determine any trends. For example, the survey cannot determine whether or not the percentage of children eating vegetables has decreased over time. However, results from the survey suggest a sizeable proportion of children appear to have food habits and physical activity patterns that are associated with the development of chronic disease in adult life.

Conclusion

Technology has not only assisted in creating knowledge-rich communities but it has also contributed to the complexity of food choice available to many com-

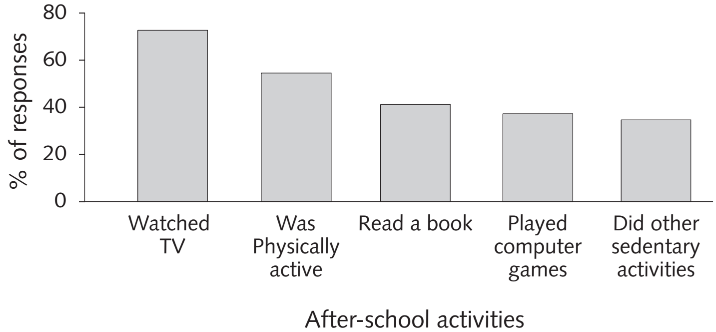

FIG. 2. After-school activity patterns of survey participants

munities. Children need to make sense of the mass of information available and feel comfortable adapting to the changes occurring around them. A web-based e-learning environment is nutritionally ripe because it allows children to interact with the world beyond their classroom and it is flexible enough to accommodate their changing needs.

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The impact of child health and nutrition on education in developing countries: Theory, econometric issues, and recent empirical evidence

Paul Glewwe

Abstract

Analysis of the impact of child health and nutrition on subsequent school performance is hampered by many difficulties. Research using retrospective data is complicated by the possibility that unobserved factors may determine both nutrition and education outcomes, which will generate correlation between these two outcomes that is not necessarily causal. Randomized trials offer a clearer method for identifying causal relationships, but they are relatively rare and encounter several difficulties in practice. This paper examines theory, estimation strategies, and recent empirical evidence to assess the current state of knowledge on the impact of child health and nutrition on education outcomes in developing countries.

Key words: child health, child nutrition, education, developing countries, estimation, econometrics, cross-sectional data, panel data, randomized trials

Introduction

Almost anyone would agree that poor health and nutrition among school-age children has a negative impact on their education. This implies that programs or policies that increase children's health status will also improve children's education outcomes. Given the importance of education for economic development [1], this link could be a key mechanism for improving the quality of life for people in developing countries.

Many researchers have attempted to estimate the impact of child health on education outcomes, but there are formidable obstacles to obtaining credible estimates. Data are often scarce (although they are much less scarce than in previous decades), but even more importantly there are many possible sources of bias when attempting to estimate relationships between child health and education. This paper provides an overview of what has been learned thus far. Although significant progress has been made, much more research is needed.

The remaining sections of this paper do the following: provide a simple analytical framework for investigating the relationship between child health and education; describe estimation problems and potential solutions; summarize recent empirical evidence; and, finally, summarize the findings and make suggestions for future research.

A simple analytical framework

This section provides an analytical framework for thinking about the relationship between child health and nutrition and education outcomes. The first subsection presents a simple but useful model of the determinants of children's academic achievement that highlights the role of child health. This is followed by a short subsection that discusses the relationships in the model that are of the most interest to policymakers. The emphasis throughout this section is on the fundamental relationships that determine children's health and education outcomes, without any regard to the ease or difficulty of estimating these relationships. Estimation issues are addressed in detail in the following section.

A simple model of child health and schooling outcomes

To demonstrate the issues that arise when attempting to assess the impact of child health and nutrition status on

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schooling outcomes, it is useful to begin with a simple model of health and schooling outcomes. Assume that there are three time periods. Time period 1 begins with conception and ends 24 months after the child's birth. Some education psychologists claim that parents cannot discern their children's intelligence until they reach 18–24 months, which (if true) offers a potential method to estimate the impact of child health on schooling outcomes, as will be seen below. Time period 2 is from 24 months to 5–6 years, the time the child is eligible to enroll in school. Finally, time period 3 is the years that the child is of school-age. Most research has focused on the impact of health and nutrition on the school performance of primary school-age children; therefore, time period 3 will be the time that the child is of primary school-age, say from 6 to 11 years old.

A useful starting point is a production function for academic skills, as measured by test scores, when the child is of primary school-age (time period 3). These skills can be denoted by T_3. A simple and very general specification that allows for some key dynamic relationships is the following:

$$T_3 = T(H_1, H_2, H_3, PEI_1, PEI_2, PEI_3, \alpha, SC, YS) \quad (1)$$

where H_i is child health in time period i, PEI_i is parents' provision of education inputs (e.g., school supplies, books, education toys, and—perhaps most importantly—time spent by parents with the child that has pedagogical value) in time period i, α is the child's innate intelligence (ability), SC is school (and teacher) characteristics/quality, and YS is years of schooling. Note that school characteristics are assumed not to change over time. This is done for simplicity; allowing school quality to vary over time would be more realistic but would complicate the exposition without making any fundamental contribution to the model.

The production function in equation (1) emphasizes the role of child health in determining academic skills. It shows how—holding constant parental education inputs, school characteristics, child ability, and years of schooling—changes in child health status in all three time periods affect learning. Technically speaking, this is a *structural* relationship because it shows how all of the variables in the production function *directly* affect academic skills. As will be seen below, *indirect* effects are also possible, but when discussing any effect it is important to distinguish between direct and indirect effects. Equation (1), and only equation (1), shows all the direct effects, and no indirect effects, that determine academic skills.

If one had data on all the variables in equation (1) one could estimate it using relatively simple methods (such as ordinary least squares) and thereby obtain unbiased estimates of the direct impacts of all variables, including child health status in each time period, on academic skills. Unfortunately, one almost never has all the required data, which in one sense is the root cause of almost all estimation problems (which are discussed in detail in the section titled "Estimation: pitfalls and possible solutions"). To see other relationships that may be of equal or greater interest, and to see how these relationships have different data requirements, it is useful to examine the factors that determine many of the variables in equation (1).

Consider first the three parental education input variables (PEI_1, PEI_2, and PEI_3) and the years of schooling variable (YS). Each of these variables is, at least in part, under the control of parents and thus reflects parents' preferences for their children's education. They also reflect parents' preferences for their children's health because parents who choose to allocate more (less) household resources for child health will have less (more) resources available for their children's education. Variables that are partially or fully under the control of the parents (or the child) are called *endogenous* variables. In general, one can express parental education inputs and years of schooling as functions that depend only on exogenous factors, that is variables that are beyond the parents' control. Such equations are called *reduced form* equations. In contrast, recall that equation (1) is a *structural* equation that shows only variables that have direct effects, which can include both exogenous and endogenous variables.

The distinction between these two types of equations raises an immediate complication: it is plausible that a child's health may affect parental decisions about education inputs and years of schooling, but child health is at least partially under the parents' control and therefore is not an exogenous variable. Thus it appears impossible to write a reduced form equation for parental education inputs that includes child health as an explanatory variable. Yet there is a convenient and reasonably plausible way to resolve this, which is to specify parental education inputs (and years of schooling) as functions of child health *in the previous time period*. That is, in each time period parents make decisions based on the (exogenous) variables that they cannot change and the previous time period's values of any endogenous variables. Health outcomes in any time period are partly due to random shocks that occur after parents have made all their decisions for that time period. These shocks require parents to update their decisions in each time period, based on the impacts of shocks that occurred in the previous time period. When making decisions for any time period, parents do not yet know the values of endogenous variables in that time period; instead they use the values in the previous time period, which can no longer be changed and thus are exogenous. Admittedly, this is somewhat unrealistic in the present context because the model here has only three time periods and parents almost certainly update more often than every few years, but for expositional purposes it is very useful to limit the number of time periods to three, and doing so results in a model that can be used to illustrate the most important estimation issues.

Following this approach, the reduced form equations (which include only exogenous explanatory variables) for parental education inputs are:

$$PEI_1 = pe_1(Y, ME, FE, P_S, SC, \sigma, \alpha ; P_{H,1}, HE_1, \tau, \eta) \quad (2)$$

$$PEI_2 = pe_2(H_1, Y, ME, FE, P_S, SC, \sigma, \alpha ; P_{H,2}, HE_2, \tau, \eta) \quad (3)$$

$$PEI_3 = pe_3(H_1, H_2, Y, ME, FE, P_S, SC, \sigma, \alpha ; P_{H,3}, HE_3, \tau, \eta) \quad (4)$$

Years of schooling in time period 3 is essentially the same as equation (4):

$$YS_3 = ys_3(H_1, H_2, Y, ME, FE, P_S, SC, \sigma, \alpha ; P_{H,3}, HE_3, \tau, \eta) \quad (5)$$

where Y is parental income, ME and FE are mother's and father's education, respectively, P_S is a vector of the prices of schooling and education inputs (which are assumed to be constant over time), σ is parent's preferences for their children's schooling (higher values indicate greater desire for educated children), each P_H variable is a vector of prices for health care, which is allowed to vary across the three time periods, HE_i is the health environmental (broadly defined) in time period i, τ is parent's preferences for their children's health (higher values indicate greater desire for healthy children), and η is the innate healthiness of the child. Note that the notations for these functions (pe_1, pe_2, pe_3, and ys_3) are in lower case; this notational convention will be used in this paper to denote all reduced form equations, while upper case will be used to denote structural equations.

Now consider the non-health factors in equations (2) through (4) in more detail. In general, higher income will increase purchases of education inputs, since it allows parents to purchase more of everything that raises their utility. The impact of parental education is more ambiguous; it is often used in empirical work to indicate higher tastes for children's education but in these equations that is already accounted for by σ. Yet the effect of parents' education could still be positive because more educated parents may be able to use education inputs more effectively, conditional on parental tastes for schooling, and thus will purchase more of them.

The remaining variables in equations (2) through (4) highlight the choices that parents must make in allocating their scarce income and their scarce time to maintain their children's health and support their education. The first four variables are directly related to education choices. The prices of schooling and education inputs (tuition, school supplies, cost of educational toys) will almost certainly reduce the amounts purchased. The impact of school quality is more ambiguous; it may serve as a substitute for parental education inputs, and thus it would have a negative effect, or it may be a complement, making parental education inputs more effective and thus increasing their use. Parental tastes for educated children will certainly increase purchases of education inputs. Finally, parents may provide more education inputs to children with higher innate ability, since they are more efficient at using them, but it is also possible that this efficiency allows parents to reduce such inputs since their children need them less.

The last four variables in equations (2) through (4) directly affect health care decisions, but since those decisions are made simultaneously with education decisions they also belong in equations (2) through (4). In contrast with the prices of education inputs, the impact of health care prices is somewhat ambiguous: an increase creates an income effect in that it reduces money available for all other purchases, including education, but it also creates a substitution effect—that is, an incentive to spend less on health care (which frees up resources to spend on education). A better health environment (HE) and an inherently healthier child (η) are both likely to reduce spending on health care, freeing up more resources for education, but they will also increase the probability of better child health in the current period, the impact of which is ambiguous (see below). Less ambiguous is the impact of higher tastes for child health, which will almost certainly increase spending on health inputs and this reduce spending on education inputs.

Turn next to the impact of (lagged) children's health status, which is exogenous, on parental education inputs in equations (3) and (4). In general, it is unclear whether this impact is positive or negative. Some parents may increase their purchases of education inputs for child with poor health (low values of H_t) to compensate them for the negative direct impact of poor health on learning in equation (1). Other parents may decide that the best course of action is to allocate scarce education resources to their healthier children, who may be better situated to benefit from them.

Lastly, briefly consider the variables that determine years of schooling in equation (5). Any variable that makes a year of schooling more effective in imparting academic skills makes each year of schooling more valuable and thus parents will tend to increase years of schooling. Thus increases in child health, school quality and child innate ability (α) will tend to increase years of schooling. The same is likely to be true of mother's and father's education, since educated parents are better able to assist their children with their schoolwork. Household income should have a positive effect, while the price of schooling will have a negative effect. The impact of the prices of health inputs is less clear; an increase lowers overall household resources and thus should have a negative impact (income effect) but it may have a large enough negative impact on purchases of medical goods and services to free up some resources for education (substitution effect). The impacts of a better health environment and of innate child healthiness will be essentially the same as the impacts they have on parental education inputs. Finally, parental tastes for education (σ) will have a positive impact and tastes for health (τ) will have a negative impact.

Substituting equations (2) through (5) into equation (1) yields a different equation for the impact of child health on academic skills:

$$T_3 = t_{CD}(H_1, H_2, H_3, Y, ME, FE, P_S, SC, \sigma, \alpha ; P_{H,1}, P_{H,2}, P_{H,3}, HE_1, HE_2, HE_3, \tau, \eta) \quad (6)$$

Unlike equation (1), equation (6) is not a production function because it includes many variables that have only indirect effects, such as prices and parental tastes. Neither is it a reduced form equation because it contains H_3, which is an endogenous variable (H_1 and H_2 can be considered exogenous because they are determined before parental decisions are made at the beginning of time period 3). Instead, this relationship is called a *conditional demand function* in the economics literature (hence the CD subscript). It shows how academic skills (T_3) and child health in the third time period (H_3) *move together* according to the decisions parents make based on the values of all the exogenous variables. If some process occurred that made H_3 exogenous, then this relationship shows how T_3 changes in response to (conditional on) exogenous changes in H_3.

The impacts of health status in each of the three time periods in equation (6), with one exception, are *not* the same as the impacts of health status in equation (1) because the impacts in equation (6) include indirect as well as direct impacts. For example, in equation (6) part of the impact of poor health in time period 1, H_1, operates indirectly through a change in parental education inputs in time period 2, PEI_2, as seen in equation (3); in equation (1) this impact operates directly through the PEI_2 variable, but this variable has been substituted out in equation (6). Thus, if a decrease in child health in the first time period induces parents to increase education inputs for the child in time period 2, equation (6) will show a smaller negative impact of child health in time period 1 on academic skills than will equation (1). The exact same point holds for H_2 in equation (6), which includes indirect effects that could operate through PEI_3.

For H_3, there are two possibilities regarding the relationship between its impact in equation (6) and its impact in equation (1). In both cases, the order of events in time period 3 is as follows: the government first establishes policies that affect health prices and the health environment, then parents choose education inputs (and make all other choices), and then a health shock occurs, so that H_3 is determined by the interaction among government policies, parental choices and the health shock The first possibility, admittedly unlikely, is that the impact of H_3 in equation (1) is not affected by the values of the other variables (economists call this a strong separability assumption). In this case both equations (1) and (6) can be written as the sum of two distinct functions, one that is a function only of H_3 and another that is a function of all other variables. The first function is identical in both equations, which implies that estimation of equation (6) yields an estimate of the impact of H_3 in equation (1).

The second, more realistic, possibility is that the impact of H_3 in equation (1) depends on the values of some or all of the other variables in that equation, which implies that the impact of H_3 in equation (6) also depends on the values of some or all of the other variables in that equation. In this case, knowledge of equation (6) alone is insufficient to solve for the impacts of H_3 in equation (1), which are conditional on the values of the other variables in that equation, unless additional restrictions are placed on the functional form of equation (1). However, the impacts of H_3 in equation (1) can be derived if one has knowledge of equation (6) *and* of equations (2) through (5).

To complete the model, which in turn leads to a third equation that expresses the determinants of children's academic skills, one can specify the equations that determine child health in each time period:

$$H_1 = H_1(PHI_1, HE_1, HS_1, \eta) \quad (7)$$

$$H_2 = H_2(H_1, PHI_2, HE_2, HS_2, \eta) \quad (8)$$

$$H_3 = H_3(H_2, PHI_3, HE_3, HS_3, \eta) \quad (9)$$

where PHI_i is parental health inputs in time period i and HS_i is the health shock that occurs in time period i after all decisions (by both the government and by parents) for that period have been made. Note that equations (8) and (9) take health in the previous time period as their starting point and thus in effect show how health in the previous time period is altered by parental health inputs and the health environment (and the child's innate healthiness) in the current time period. Since parental health inputs are under parents' control, child health is clearly an endogenous variable (i.e., is partially under parental control).

Just as equation (1) is a production function for education, equations (7) through (9) can be interpreted as production functions for child health: they show the *direct* impact of past health, current parental health inputs, current health environment, and innate healthiness on child health. Parental health inputs are broadly defined to include any actions that parents take (such as giving food, maintaining dwelling sanitation, and providing medicines and health care) that affect their child's health. The local health environment includes prevalence of local diseases, climate, and environmental conditions, all of which have direct impacts on child health. Health shocks occur after all decisions have been made by the government and by parents; both the government and parents can take actions that reduce the negative impact of these shocks or even change the underlying process that produces these shocks (e.g., they take actions to reduce the prevalence of mosquitoes that transmit malaria), but there always remain random components that do not appear until after all decisions have been made.

Only one set of parental choice variables remains, their choice of health inputs. In general, at the beginning of each time period health and education inputs are chosen simultaneously (after the government sets all health and education policies in that time period), so that all variables that influence education inputs also influence parents' health inputs. This implies the following relationships for PHI in the three time periods:

$$PHI_1 = ph_1(Y, ME, FE, P_{H,1}, HE_1, \tau, \eta; P_S, SC, \sigma, \alpha) \quad (10)$$

$$PHI_2 = ph_2(H_1, Y, ME, FE, P_{H,2}, HE_2, \tau, \eta; P_S, SC, \sigma, \alpha) \quad (11)$$

$$PHI_3 = ph_3(H_1, H_2, Y, ME, FE, P_{H,3}, HE_3, \tau, \eta; P_S, SC, \sigma, \alpha) \quad (12)$$

The variables that influence parental health inputs are the same as those that affect parental education inputs, because both sets of input decisions are made at the same time; only the order has been changed to highlight the fact that the last four variables primarily affect education choices. Note that health prices can be interpreted broadly to include also distance to health care facilities and the quality of care at those facilities.

Turn now to each of these variables. In all time periods it is quite intuitive that greater incomes increase parental provision of health inputs, assuming that parents view child health as a normal good. The role of parental education is more ambiguous because it operates in two ways. First, better educated parents may better understand health problems and thus may be more likely to understand the benefits of purchasing health inputs (although in some cases they may also understand that there is no need to purchase certain kinds of health inputs). Second, if better educated parents are more skilled at helping their children with their education development, the greater household efficiency at this task—relative to household efficiency at promoting health—may lead to reductions in the purchase of health inputs.

The role of prices is the same as their role with respect to parental education inputs: higher health prices reduce purchases of health inputs, whereas higher education prices could well increase these purchases (if total spending on health inputs declines). Similarly, higher parental tastes for educated children (σ) will decrease purchases of health inputs (as more income is diverted to education inputs) while higher tastes for healthy children (τ) will lead to increases in the purchase of health inputs. As with parental education inputs, the impact of greater child learning ability (α) is less clear; if an increase in child ability leads to greater (less) expenditure on education inputs it is likely to reduce (increase) expenditure on health inputs. In contrast, greater innate healthiness (η) is almost certain to reduce expenditure on health inputs, and thus raise expenditure on education inputs. The quality of the local health environment is likely to decrease parental health inputs because higher quality raises child health and thus reduces the need for these inputs. The impact of school quality is probably negative; higher school quality makes education more attractive and thus parents are likely to move resources from health to education. Finally, purchases of health inputs in time periods 2 and 3 are likely to be negatively affected by health status in the previous time periods; there is less need for health inputs if the child is relatively healthy.

The fundamental reduced form equation for the determinants of child academic skills is obtained by replacing H_1, H_2, and H_3 in equation (6) with their determinants as given in equations (7) through (9), and then parental health inputs in those three equations should be replaced with their determinants as given in equations (10) through (12):

$$T_3 = t_{RF}(Y, ME, FE, P_S, SC, \sigma, \alpha; P_{H,1}, P_{H,2}, P_{H,3}, HE_1, HE_2, HE_3, \tau, \eta; HS_1, HS_2, HS_3,) \quad (13)$$

Equation (13) is the true reduced form relationship as long as all the variables that enter the $t_{RF}(\ )$ function are exogenous. One could argue that household income (Y) is not exogenous in the sense that family income will increase if a child leaves school and starts working. The appropriate method for handling this will be discussed in the section titled "Estimation: pitfalls and possible solutions."

Relationships of interest

The previous subsection presented three equations that showed the factors that determine children's academic skills, namely equations (1), (6), and (13). Each of the three equations depict different processes, and a key question is: Which of these equations is most useful for making policy decisions? To answer this question, this subsection reviews and compares the deterministic processes underlying each of these equations.

As explained above, equation (1), by definition, measures the direct (structural) impact of all variables that have direct impacts, including health status in each of the three time periods, on children's academic skills in time period 3. At first glance, this would appear to be precisely what policymakers would like to know. (Whether this equation can be estimated is a separate question, discussed below.) Yet it was also explained above that this relationship *does not necessarily imply* that whenever the government implements a policy that improves a child's health status in one or more of those three time periods that the education outcome of that child will increase according to the relationship shown in equation (1). Such discrepancies can arise because changes in child health status may lead households to change parental education inputs and years of schooling. As seen in equations (3), (4), and (5), parental education inputs in time periods 2 and 3 and years of schooling may be altered in response to changes in health status in years 1 and 2. For example, if healthier children are better students, parents may decide to reduce their education inputs in order to reallocate some of the benefit from having healthier children to increased purchases of goods and services that are not directly affected by child health (so that consumption of goods and services other than education can also be raised). Thus while the relationship in equation (1) is very important it does *not* necessarily depict what will happen to children's academic skills if a program or policy increases child health by a certain amount.

The conditional demand relationship in equation (6) may be closer to what policymakers would like to know. Virtually any health policy can be characterized as a change in either health prices ($P_{H,i}$) or the health environment (HE_i). Child health in time period 3 is the only endogenous variable in equation (6), which effectively divides the impact of any health policy on child academic skills into two parts, the health pathway that includes both direct impacts of child health on learning via equation (1) and the indirect impacts of (lagged) child health on parental education inputs via equations (3) through (5), and the reallocation pathway via the substitution and income effects of $P_{H,i}$ and HE_i on parental education inputs via equations (2) through (5). The health pathway is measured by the impacts of the H_i variables in equation (6) and the reallocation pathway operates through the $P_{H,i}$ and HE_i variables in equation (6).

An example using $P_{H,2}$ and HE_2 will make this clearer. Suppose that a health policy is implemented in time period 2 that changes $P_{H,2}$ and/or HE_2 in a way that increases H_2. This will directly increase T_3 in equation (1) via the increase in H_2. This increase in H_2 will also change PEI_3 and YS in equations (4) and (5) (although, as discussed above, the direction of change is less clear), which will in turn affect T_3 via equation (1). All of these effects are the health pathway. Yet $P_{H,2}$ and HE_2 also directly affect PEI_2 in equation (3) by altering the allocation of parental resources across health and education inputs in time period 2; this is the reallocation pathway.

The third and last equation that shows the determinants of children's academic skills is equation (13), a reduced form relationship formed by substituting equations (7) through (9), and then equations (10) through (12), into equation (1). For policymakers working in health, equation (13) may appear much less useful than equation (6) because the health status variables at the three points in time have disappeared (more precisely, have been substituted out). But if the ultimate objective is to assess the impact of health *policies*, as oppose to health *status*, on children's academic skills, then equation (13) is precisely what one needs. In particular, changes in the health environment (HE) and health price ($P_{H,t}$) variables in equation (13) should reflect the effect of any health policy or program. Thus equation (13) can be used to measure the overall effect of any health policy or program on children's education outcomes. If one is also interested in the mechanisms through which these different programs work, via health outcomes, then one must estimate equation (1) or equation (6), but technically speaking one need not estimate equations (1) or (6) to make policy choices if one already has estimates of equation (13).

Yet there may be times when it is more useful to estimate equation (1) or (6) instead of equation (13) to obtain useful estimates of the impact of health policies on health outcomes. For example, suppose one develops a new health policy or program that affects child health only in the first time period. To estimate equation (13), one must wait several years until the children who were exposed to the program in the first 2 years of life are in primary school, which would be about 6–8 years later. If instead one had estimates of equation (1) and of equations (2) through (5) and (7) through (12), where the new health program or policy is one or more of the $P_{H,1}$ or HE_1 variables in equations (2), (7) and (10), the data to (re)estimate equations (2), (7), and (10) would be available in 1–2 years and then one could substitute equations (2) through (5) and (7) through (12) into equation (1) to obtain the impact of that policy or program without waiting for 6–8 years.

In summary, in any analysis of the impact of child health and nutrition on education outcomes, it is important to clarify what relationship one is trying to estimate. Different results in different empirical studies are not necessarily inconsistent; they may be estimates of different relationships. In practice, some of these relationships are more difficult to estimate than others; the final choice of what to estimate is determined both by the relationships of interest and by the feasibility of estimating each of those relationships. This brings us to estimation issues, which are reviewed in the next section.

Estimation: pitfalls and possible solutions

While economists know less about education than do education researchers and certainly know less about health than medical and public health researchers, they have ample experience with, and have rigorously debated, many estimation methods. The methods that can be applied, and indeed the relationships that can be estimated, depend on the data at hand. This section reviews what can be done, and what probably cannot be done, with the three main types of data available: cross-sectional data (data collected from the "real world" at one point in time), panel data (data collected from the real world from households or individuals at several points in time), and data from randomized trials (data collected from an experiment in which one group, or more, is randomly selected to receive a treatment while the non-selected groups serve as a control group).

Retrospective estimates from cross-sectional data

The easiest data to collect, and therefore the most common type of data available, are data collected on a large number of children at a single point in time, which are often referred to as cross-sectional data. Such data usually come from a household survey or a survey of schools. For the purpose of estimating the impact of child health on education outcomes, the minimum requirement for such data is that they contain at least one variable that measures child health and at least one variable that measures a schooling outcome of interest (often, though not always, scores on an academic test). With these two variables alone one can measure correlation at one point in time, but of course correlation does not imply causation.

In fact, to estimate any of the causal relationships that show the impact of child health and nutrition status (or the impact of health policies or programs) on one or more education outcomes, that is to estimate either equations (1), (6), or (13), one needs many more variables. To see why, consider equation (1). To avoid problems of omitted variable bias (this is discussed in more detail below) one needs all of the explanatory variables in that equation: health status in all three time periods, parental education inputs in all three time periods, the child's innate ability, a large number of school and teacher characteristics, and years of schooling. Only the last of these is easy to collect. With cross-sectional data, the only possibility for obtaining child health status and parental education inputs in years past is to ask the children or their parents to recall events from many years ago, which is likely to lead to many recall errors. It is also not trivial to obtain data on a child's innate ability (even defining that concept is difficult), and schools and teachers vary in so many ways that it requires great effort to collect all the relevant data on those variables (some of which are difficult to measure, such as teachers' motivation and principals' managerial ability).

Thus, in most cases cross-sectional data will be incomplete in the sense that not all of the variables that determine equation (1) will be in the data set. This is very likely to lead to omitted variable bias in estimates of the impact of child health on education outcomes. For example, suppose that data are available only on the current health status of the child (H_3), not on past health status (H_1 and H_2). Assume also that the true impact of current health status is small while the impact of past health status is quite large (for example, poor health and nutrition in the first year of life could have a very strong effect on a child's cognitive development). Because current and past health status are likely to be positively correlated, regressing current schooling variables on current health status and the non-health variables in equation (1) is likely to produce a positive and statistically significant coefficient on current health status, overestimating the true impact of current health status. If not interpreted cautiously, this could persuade policymakers to put large resources into programs that attempt to improve the health of school-age children even though programs that focus on infants and very young children may be more effective.

Another example of the possibilities for omitted variable bias concerns estimation of equation (13). Suppose one has little data on aspects of the local health environment (HE) pertaining to the natural prevalence of childhood diseases. Governments may attempt to address this problem by implementing a program (which would also be an HE variable) to reduce the prevalence of one or more of those diseases. Assuming that the program works, the latter HE variable will have a negative causal impact on the former HE variable, and thus a positive impact on education outcomes. But if one observes only the program variable the estimate of the impact of that variable on children's education outcomes will be biased downward. Intuitively, the program is implemented primarily in areas with high disease prevalence, which produces a positive association between the program and the disease and thus a negative association between the program and children's academic performance. In the economics literature this is called bias due to endogenous program placement.

Omitted variable bias can also occur when non-health variables are missing. Suppose that parents of healthy children understand that their children will do relatively well in school, and thus they decide to reduce their efforts, and expenditures, on education inputs. This would lead to underestimation of the impact of child health on education outcomes in equation (1) if the data do not include important components of parents' education inputs. Another plausible example is that parental tastes for child education and child health are positively correlated, for example, some parents are more responsible than others, caring for both the health and the education of their children. These tastes are unlikely to be observed, which will result in positive correlations between child health and child education that are not directly causal. Stated more crudely, irresponsible parents are likely to have children who are less healthy and do less well in school than the children of responsible parents, but much (perhaps even most) of the causality may be from parental tastes to child education outcomes, not only from the direct impact of poor child health on schooling.

In addition to omitted variable bias, another estimation problem can arise: basic econometric theory states that random measurement errors in the explanatory variables typically lead to underestimation of the impact of poorly measured variables on education outcomes. If cross-sectional data include any data on past health status and parental education inputs, these data are likely to be measured with a substantial amount of error and thus estimates based on them are likely to suffer from this attenuation bias. Even current health status and parental education inputs may be measured with error, as could school quality variables.

The discussion thus far has focused primarily on equation (1). Is it any easier to estimate equations (6) and (13) with cross-sectional data? Equation (6) has the advantage that parental education inputs have been replaced by variables that are probably easier to observe (and thus collect data on), such as household income, parental education, and prices of health and education inputs. Yet other hard to observe factors also appear, such as parental tastes for child education and health (σ and τ) and the child's innate healthiness (η), and the child's innate ability (α) is still in this equation, so omitted variable bias remains a very real problem; indeed, it is not clear whether the potential for such bias is lower in equation (6) than in equation (1). Measurement error also remains a worrisome problem, and is likely to be serious for variables in equation (6) that are not in equation (1), such as household income, prices, and the health environment. On the other hand, one could argue that the impacts of the $P_{H,i}$ and HE_i variables and of τ and η in equation (6) are likely to be small and thus these can be dropped from that equation; this may be correct but I know of no study that has attempted to test the plausibility of this conjecture.

Finally, equation (13) may be easier to estimate than equation (6) because the child health variables need not be observed. Yet substituting out the child health variables implies that the impacts of health prices, the health environment, and τ and η will be larger in equation (13) than in equation (6). This suggests that the endogenous program placement bias problem is more likely to occur in estimates of equation (13) than in estimates of equation (6). Moreover, the health environment can vary in dozens if not hundreds of different ways, which could imply major data collection difficulties.

The standard econometric tool for overcoming bias due to omitted variables (other than collecting data on virtually all variables, which may never be possible) and for removing bias due to measurement error in the explanatory variables is instrumental variable (IV) estimation. The basic idea is that all unobserved variables (and errors in measurement) can be considered to be included in the error term (residual) of the regression model, and the bias is due to correlation of the observed variables with that error term. If one can find instrumental variables—that is, variables that are: (1) correlated with the observed variables that have bias problems; (2) uncorrelated with the error term (thus uncorrelated with all unobserved variables and any measurement errors); and (3) not already explanatory variables in the equation of interest—one can then obtain unbiased estimates by first regressing the observed variables that are correlated with the error term on the instruments and then using the predicted values of the observed variables as regressors (instead of their actual values) in the equation of interest.

While IV estimation works in theory, it is very hard to find plausible instrumental variables. Suppose, for example, that one is trying to estimate equation (1) and there are data on child health in time period 3 but not in time periods 1 and 2. As mentioned above, child health in each time period is likely to be positively correlated with child health in the other two time periods, which will lead to overestimation of the impact of child health in time period 3 on students' academic skills if simple ordinary least squares (OLS) estimation is used. The IV method requires an instrument that predicts child health in time period 3 but is not correlated with child health in time periods 1 and 2. At first glance; health prices in time period 3 seem to satisfy these criteria; but health prices may change little over time and thus those prices in period 3 would be correlated with health prices, and thus with child health, in the first two time periods. Other examples of problems finding valid instrumental variables will be discussed in the section titled "Empirical Evidence."

Retrospective estimates from panel data

Panel data are data collected on the same children for two or more time periods. Researchers interested in the impact of child health on education outcomes have an obvious reason for using such data to estimate equations (1), (6), and (13), which is that all three equations include not only variables from the third time period but also variables from the first two time periods. As pointed out above, cross-sectional data can include such variables only if they are obtained from respondents' memories, which could be quite inaccurate; panel data collected over all three time periods need not be based on respondents' memories of past events.

There is another potential benefit of panel data, which is that some unobserved variables that do not change over time can be differenced out of the regression and thus need not be measured. To see how this might work, consider equation (6) for two different years within the third time period. Assume a simple linear functional form for that equation, and denote the two years by 3a and 3b, respectively:

$$T_{3a} = \beta_0 + \beta_1 H_1 + \beta_2 H_2 + \beta_3 H_{3a} + \beta_4 Y + \beta_5 ME + \beta_6 FE + \beta_7 P_S + \beta_8 SC + \beta_9 \sigma + \beta_{10} \alpha + \beta_{11} P_{H,1} + \beta_{12} P_{H,2} + \beta_{13} P_{H,3a} + \beta_{14} HE_1 + \beta_{15} HE_2 + \beta_{16} HE_{3a} + \beta_{17} \tau + \beta_{18} \eta \quad (6a)$$

$$T_{3b} = \beta_0 + \beta_1 H_1 + \beta_2 H_2 + \beta_3 H_{3b} + \beta_4 Y + \beta_5 ME + \beta_6 FE + \beta_7 P_S + \beta_8 SC + \beta_9 \sigma + \beta_{10} \alpha + \beta_{11} P_{H,1} + \beta_{12} P_{H,2} + \beta_{13} P_{H,3b} + \beta_{14} HE_1 + \beta_{15} HE_2 + \beta_{16} HE_{3b} + \beta_{17} \tau + \beta_{18} \eta \quad (6b)$$

Estimates of either of these equations using cross sectional data can lead to biased estimates because many variables that do not change over time, such as child ability and innate healthiness, parental tastes for educated and healthy children, and many aspects of school quality, are not observed and could be correlated with observed child health outcomes (leading to omitted variable bias). Similarly, any such variables that are measured with error are likely to lead to attenuation bias.

In principle, panel data allow one to difference out these unchanging variables and estimate relationships of interest between variables that do change over time. This can be seen by subtracting equation (6a) from equation (6b):

$$\Delta T_3 = \beta_3 \Delta H_{3b} + \beta_{13} \Delta P_{H,3} \quad (14)$$

where it is assumed that the only variables that change over time are academic skills, child health status and health prices (one could also include other variables that may change over time). In many cases, including this example, the variables that change over time may be relatively easy to observe, so the problem of omitted variable bias may disappear, or at least be reduced.

However, this method has its limitations. It assumes that the troublesome variables that are unobserved do not change over time, and that they do not interact with variables that do change over time. If either assumption is untrue, then those variables will remain (and will still be unobserved) in equation (14). Another serious problem is that measurement error in observed explanatory variables could lead to greater bias in estimates based on differenced equations than in estimates based on the original equation. Finally, there is the obvious disadvantage that panel data are more expensive to collect because it involves collecting data at two or more points in time. For a detailed discussion of the benefits and limitations of panel data, as well as practical advice for collecting such data in developing countries, see Glewwe and Jacoby [2]. Further examples of how panel data can be used to estimate the impact of child health on education outcomes are discussed in the section titled "Empirical Evidence."

Randomized trials

In the vast majority of studies, both cross-sectional data and panel data are collected from real world settings in which no attempt is made by the researchers to alter the behavior of the people from whom the data are collected. Yet the problems of bias raised above are very likely, if not almost certain, when using data collected in this manner. A very different approach to estimating the impact of policies and programs is a method that has long been used in medicine and biology: randomized trials. Randomized trials randomly divide a population under study into two groups, one of which participates in the program, called the treatment group, and the other of which does not participate in the program, the control group. In some cases the population is divided into more than two groups, one control group and several treatment groups, each with a different treatment. If the division of the population into these groups is truly random, than the *only* difference between these two groups is that one participated in the program while the other did not. While randomized studies have long been used in health research, until recently they have been rare in education research.

To see how randomized trials can be used to estimate the impact of child health on education outcomes, consider equation (13). A large sample of households or schools can be randomly divided into two groups, a treatment group that receives the health intervention (which can be characterized as a change in one or more of the $P_{H,i}$ and HE_i variables), and a control group that does not receive the intervention. The differences across the two groups in the $P_{H,i}$ and HE_i variables that characterize the intervention are completely uncorrelated with all of the other variables in the $t_{RF}(\,)$ function because these differences are determined solely by random assignment. Thus the difference in the average education outcomes of the two groups, T_3, must be due to the health intervention, since there are no other differences between the two groups. This same logic applies to subgroups of interest within the general population; one can estimate impacts separately by sex, income level, or any other group that can be defined using exogenous variables, or any endogenous variables that are measured before the intervention is implemented.

While this may appear to be the solution to the econometric problems that stymie attempts to estimate such impacts from cross-sectional or panel data, there are some limitations of using randomized trials. First, they can be expensive to implement. Second, they are limited to health interventions that do not violate regulations on human subjects research. In health studies this stricture often is interpreted to mean that anyone who is known to have a treatable health problem cannot be denied access to any treatment that is being made available to others. Third, random assignment to treatment and control groups is often violated in practice, as individuals or households in the control group attempt to switch from being in the control group to being in the treatment group. Even if researchers exclude from the analysis children who were randomly assigned to the control group but were able to obtain the treatment (e.g., enrolled in a treatment school), such children could affect the impact of the treatment on the children who were randomly selected to receive the treatment (e.g., by increasing class size in the treatment schools). Fourth, randomized trials may suffer from attrition bias. If the health intervention makes school more attractive to parents, the dropout rate among the treatment group may decline; if the study is based on a sample of schools, weaker students will be less likely to drop out of the treatment schools (and thus out of the sample) than weaker students in the control schools, and thus over time the impact of the program on student academic skills will be underestimated because the average innate ability of students in the treatment schools slowly drops relative to the average ability in the control schools.

A final disadvantage of randomized trials is that they can estimate only the reduced form relationship shown in equation (13). They cannot be used to estimate the structural (direct) impact of child health status on education in equation (1) because randomized trials yield only the change in the dependent variable, T_3, and do not indicate how the overall impact of the intervention can be decomposed into the effects of the H_i variables and of the PEI_i variables in that equation. For the same reason, randomized trials cannot be used to estimate the conditional demand relationship in equation (6); they can measure the overall effect but cannot decompose it into the impacts via the H_i variables and the impacts via the $P_{H,i}$ and HE_i variables. An important consequence of this limitation is that there may be a long time lag between the start of the intervention and the evaluation of its impact, as seen in the example above concerning an intervention that occurs in early childhood and thus requires 6–8 years to evaluate its impact on learning in primary school.

Randomized trials can be conducted with only one round of data collection—that is, by collecting cross-sectional data after the health policy or program has been implemented for the treatment group (and after enough time has passed to allow the intervention time to have some effect). Another approach, which may be more statistically efficient is to collect panel data that measure children's education outcomes for the treatment and the control groups both before and after the intervention has been implemented in the treatment group. This allows researchers to look at *change* in the outcome variable over time, which in some cases will provide an estimate of the impact of the program that has a lower standard error.

Empirical evidence

This section reviews several recent studies that examine the impact of child health and/or nutrition status on education outcomes. This is done for all three estimation methods (using cross-sectional data, using panel data and using randomized trials). For each method, the studies examined are among the best analyses done in recent years.

Retrospective estimates using cross-sectional data

Over the past 20–30 years, many studies have attempted to estimate the impact of child health status on education outcomes using cross-sectional data. Yet, as noted by Behrman [3], most of these studies, especially the earlier ones, have paid little attention to the possible biases that can arise when using cross-sectional data. This subsection examines a paper by Glewwe and Jacoby [4] that carefully investigated the impact of child nutrition on age of school enrollment and years of completed schooling using cross-sectional data from Ghana. Although the paper did not examine the impact of child nutrition on academic skills, the estimation issues encountered in the paper are virtually identical to those discussed above. Thus this paper is instructive in that it shows what can be done, and what cannot be done, using cross-sectional data.

Glewwe and Jacoby investigate delayed enrollment and (ultimate) grade attainment using cross-sectional data on 1,757 Ghanaian children aged 6–15 years in 1988–89. They use child height-for-age as their indicator of child health status; this variable reflects health status in all three time periods but is primarily influenced by child health in the first time period. As explained above, one problem with using cross-sectional data is that parental tastes for child health and child education outcomes (τ and σ, respectively) may be positively correlated. Glewwe and Jacoby propose a simple way to avoid such bias: use only variation *within* families, not across families to estimate the impact of child health on education outcomes. In particular, there is evidence that child health varies within families, but since parental tastes for child health and education outcomes do not vary within the family, within family correlation of child health and education outcomes cannot be caused by any such correlation in parental tastes. A family fixed effects estimation procedure can be used to provide estimates that are based solely on within-family variation in health and education outcomes. This is very similar to the fixed approach used in equation (14) of the section titled "Estimation: pitfalls and possible solutions," the only difference being that the differences are not over time for one child but instead are over two children in the same family at the same time. Since the two dependent variables, delayed enrollment and eventual years of schooling, reflect preferences and optimizing behavior, all the relationships estimated in this paper are conditional demand relationships similar to equation (6) in the section titled "Estimation: pitfalls and possible solutions."

Another approach used by Glewwe and Jacoby to avoid biased estimates of the impact of child health on education outcomes is to use instrumental variables that affect child health status but have no causal impact on education outcomes after controlling for child health status. The instrumental variables used are distance to nearby medical facilities and maternal height. This method can be used only when analyzing variation across households, since these instruments do not vary across children in the same family. Distance to nearby medical facilities, which can be thought of as one of the $P_{H,i}$ variables, should have a substantial impact on child height, while mother's height reflects the mother's, and thus the child's, innate (genetic) healthiness (η). Thus the assumption required for estimating the conditional demand relationships for delayed enrollment and years of schooling is that the $P_{H,i}$ variables and η can be removed from the list of exogenous variables for those relationships.

Yet both of these approaches are open to strong criticisms. The authors admit that the first approach (family fixed effects), has a serious problem: variation in innate child healthiness (η) or random health shocks (HS_i) across children within the same family may lead to reallocation of (unobserved) education resources across different children within that family. For example, suppose that parents recognize that their children who are relatively sickly will do worse in school. In response, they may allocate more (unobserved) education resources to that child to compensate for the disadvantage the child has in terms of his or her health. Family fixed effects estimation will not control for this intrahousehold allocation and, in this case, will tend to underestimate the impact of child health on education outcomes. Alternatively, if families decide to neglect sickly children and allocate most education resources to healthier children, then the impact of child health on education outcomes would be overestimated.

Turning to the second approach (instrumental variables), consider the conditional demand relationship for years of schooling. The following line of argument also applies to the conditional demand relationship for delayed enrollment, which is simply another parental choice made in the third time period; to save space the discussion here is limited to the years of schooling relationship. This is nothing other than equation (5). To focus on the fundamental estimation problem, assume that health prices (the $P_{H,i}$ variables) do not vary over time. The fundamental criticism of the IV approach in the Ghana paper is that equation (5) is not statistically identified because the two instrumental variables used to predict health status in the earlier time periods, mother's height (an indicator of η) and distance to the nearest health facility ($P_{H,i}$), are already in equation (5) and thus cannot be used as instruments. The intuition here is that parental decisions regarding years of school (and delayed enrollment) in time period 3 are made jointly with other decisions in that time period, notably decisions on providing health inputs in that time period (equation (12)). The parental decisions for each endogenous variable in the third time period are based on the values of all the exogenous and predetermined variables, including the P_H variable and η.

To address this criticism, Glewwe and Jacoby argue that almost all of the impact of child health on school outcomes is due to child health outcomes in time periods 1 and 2, and that child health status in the third time period is unchanged from that in period 2. This implies a sequential decision process on the part of parents: child health decisions are made in time periods 1 and 2, determining H_1 and H_2 (and thus H_3), so there are no health decisions to be made in the third time period (equation (12) does not exist) and therefore P_H and η (and τ and the HE_i variables) are irrelevant for *all* decisions in the third time period and thus can be removed from equation (5). Thus child education decisions made in time period 3 are based on H_1 and H_2 (the latter of which equals H_3) and P_H and η affect those decisions only through their impact on H_1 and H_2.

The assumption that child health does not change from the second to the third time period, so that no health decisions are made in the latter time period, is rather strong. A somewhat less strong assumption that has similar implications for instrumental variable estimation is that some health care decisions are made in time period 3, but health status in that time period has no effect on any education outcomes. Adding the assumption that health prices vary over time would allow $P_{H,1}$ and $P_{H,2}$ to serve as instruments for H_1 and H_2, retaining only $P_{H,3}$ in equation (5). (Note that this approach still does not allow mother's height to be used as an instrument, since η returns to equation (5) once health decisions are made in the third time period.)

Yet there is an additional implicit assumption with this approach: it amounts to assuming that parents make child health decisions in time periods 1 and 2 based on all exogenous variables but do not make any plans for years of schooling until time period 3, at which time the $P_{H,1}$ and $P_{H,2}$ variables are irrelevant and thus years of schooling decisions are made based on $P_{H,3}$ and child health status as permanently set in time period 2. If instead parents make decisions in the first two time periods to save funds for schooling in the third time period, and those savings reflect health prices prevailing in the first two time periods, the years of schooling decision made in time period 3 would depend not only on $P_{H,3}$, H_1 and H_2, but also on $P_{H,1}$ and $P_{H,2}$ via their role in determining funds saved for schooling in the first two time periods, which prevents $P_{H,1}$ and $P_{H,2}$ from being used as instruments for H_1 and H_2 in equation (5).

All of the above discussion applies with very little modification if one were to use cross-sectional data to estimate the impact of child health and nutrition on children's academic skills. In this case, one attempts to estimate equation (6) instead of equation (5), but both are conditional demand relationships that have very similar sets of explanatory variables. The addition of H_3 as an explanatory variable in equation (6) makes little difference since the IV estimation strategy used in the Ghana paper assumes that H_3 is either equal to H_2 or has no impact on any education outcomes.

After explaining the limitations of their empirical work, Glewwe and Jacoby estimate the impact of child health (as measured by height for age) on delayed school enrollment and final school attainment. They find strong negative impacts of child health on delayed enrollment using both the instrumental variable and fixed effects estimators. Indeed, they find little evidence for alternative explanations for delayed enrollment (credit constraints or rationing of limited spaces in school by child age). They find no evidence that child health increases school attainment (indeed, the point estimate has an unexpected negative sign, although only weakly significant), but this may reflect the small sample size (only about 7% of the children in the sample had finished their schooling).

Retrospective estimates using panel data

Two recent studies have used panel data to estimate the impact of child health on education outcomes. The first, by Alderman et al. [5], uses panel data collected from 1986 to 1991 for about 800 households in rural Pakistan. To avoid biased estimates due to unobserved parental tastes and children's innate ability and healthiness, the paper uses food prices (more precisely, deviations in prices from long-term trends) during time periods 1 and 2 as instrumental variables for child health status in those time periods. Education decisions in time period 3 are assumed to be made conditional on all outcomes at the end of time period 2, which reflect not only decisions made in the first two time periods but also various exogenous shocks that occurred after decisions were made in each of the first two time periods.

Alderman and his coauthors find that child health, as measured by height-for-age when 5 years old, has a strong positive effect on the probability of being enrolled in school at age 7, especially for girls. This finding is consistent with the results from Ghana that better health reduces delayed enrollment because part of the impact in Pakistan may operate through reducing delayed enrollment in that country. More generally, the results for the two countries are consistent in the sense that improved child health appears to have a positive causal impact on education outcomes.

Yet the Pakistan study can be criticized on several grounds. First, as explained above, health input prices (in this case, food prices) in the first two time periods can affect schooling decisions in the third period even after controlling for health status in the first two time periods because those prices also affects savings for education in the first two time periods that are available for use in the third time period. Thus, the use of price shocks as instruments for health outcomes in equation (5) violates the requirement that the instruments have no effect on years of schooling apart from the effect that operates via H_1 and H_2. The direction of bias is toward overestimation of the health effects; unusually high prices in the first two time periods probably not only reduce child health but also reduce savings for education inputs.

A second criticism is that the paper assumes that household income (as measured by consumption expenditures) is exogenous and measured without error. The former may not be true and the latter is almost certainly false, which implies biased estimates of the impacts not only of the consumption variable but also of other variables. A final criticism is that the paper presents almost no specification tests, such as overidentification tests and assessments of the strength or weakness of the instrumental variables.

The other recent paper using panel data is that of Glewwe, Jacoby, and King [6], which uses panel data from more than 2,000 households in the Philippines. Unlike the Ghana and Pakistan studies, this paper estimates the determinants of academic skills, and it attempts to estimate the production function in equation (1), as opposed to a conditional demand relationship. By making certain assumptions the authors are able to get around the problem that the instruments used could be correlated with unobserved parental education inputs in the first two time periods. The Philippines study claims that the largest effects of child health on school outcomes in equation (1) are in the first time period (from conception until the child is 24 months old), and that changes in child health in the second time period (e.g., H_2–H_1) are not correlated with child health in the first time period (H_1). Lastly, the authors cite psychological studies that conclude that parents cannot observe children's innate ability (α) until the second and third time periods.

The Philippines study is based on sibling differences, as was the Ghana study. As will be seen below, this differencing is useful because it removes family averages of α and of all school quality variables (virtually all siblings in the sample attended the same primary school), from equation (1). Yet it does not remove bias due to differences in α across different children in the same family. In particular, decisions regarding H_1, H_2, and H_3 (and PEI_1, PEI_2, and PEI_3) could be influenced by differences in α among siblings in the same family, which may lead to correlation between H_1 or H_2 and T_3 that is not causal. The authors argue that H_1 cannot be correlated with α because parents do not observe children's intelligence (α) until the second time period. Two implicit assumptions are that the impacts of parental education inputs in time periods 1 and 2 (PEI_1 and PEI_2) and of health status in time period 3 (H_3) on T_3 in equation (1) are negligible and thus can be ignored and dropped from that equation.

Together, these assumptions allow the authors to rewrite equation (1) as:

$$\begin{aligned} T_3 &= T(H_1, H_2, PEI_3, \alpha, SC, YS) \qquad (1') \\ &= \beta_0 + \beta_1 H_1 + \beta_2 H_2 + \beta_3 PEI_3 + \beta_4 \alpha + \beta_5 SC + \beta_6 YS \\ &= \beta_0 + \beta_1 Height_2 + \beta_3 PEI_3 + \beta_4 \alpha + \beta_5 SC + \beta_6 YS \end{aligned}$$

where the second line is a simple linear approximation of the first line, and the third line assumes that $\beta_1 = \beta_2$ and explicitly uses child growth (measured by height) as a health indicator. That is, if the impacts of bad health in time periods 1 and 2 are the same in equation (1), then $\beta_1 = \beta_2$, which implies that $\beta_1 H_1 + \beta_2 H_2 = \beta_1(H_1 + H_2)$. Further, if in both periods good health leads to fast growth and poor health leads to slow growth, then H_1 is summarized by $Height_1$ (growth from conception until 24 months) and H_2 is summarized by $Height_2 - Height_1$ (growth in time period 2). This implies that $H_1 + H_2 = Height_2$, so $\beta_1(H_1 + H_2) = \beta_1 Height_2$. Note that the last line in equation (1′) is also consistent with the hypothesis that $\beta_2 = 0$ (only health in the first time period matters) and $Height_2 - Height_1$ (growth in time period 2) is uncorrelated with H_1, which implies that $Height_2$ is simply a noisy indicator of H_1.

Equation (1′) is for one child. Differencing across two siblings from the same family who go to the same school yields:

$$\Delta T_3 = \beta_1 \Delta Height_2 + \beta_3 \Delta PEI_3 + \beta_4 \Delta\alpha + \beta_6 \Delta YS \qquad (15)$$

Equation (15) is difficult to estimate because α and virtually all aspects of PEI_3 are not observed and thus are likely to be correlated with the observed variables, $\Delta Height_2$ and ΔYS. One needs instrumental variables for $\Delta Height_2$ and ΔYS that are uncorrelated with $\Delta\alpha$ and ΔPEI_3, the differences in the innate intelligence and parental education inputs across the two siblings.

The authors use the differences in the date of birth of the two siblings as the main instrument for ΔYS, which is arguably uncorrelated with $\Delta\alpha$ and ΔPEI_3 (although someone with a vivid imagination can probably weave a story in which parents jointly plan birth spacing and the allocation of parental education inputs across siblings). Regarding $\Delta Height_2$, the paper argues that $Height_1$ of the older sibling is a valid instrument because it is uncorrelated with the α's of both siblings (since neither is observed until time period 2 for the older sibling) and it has strong predictive power for $\Delta Height_2$. Note that using instrumental variables also addresses the problem of bias due to measurement error in the $Height_t$ variables.

Despite the innovative method of finding instruments for $\Delta Height_2$ and ΔYS in equation (15), the estimation strategy is open to criticism. The main problem with the estimation strategy is that it is not clear that $Height_1$, the instrument for $\Delta Height_2$, is uncorrelated with differences in parental education inputs in the third time period (ΔPEI_3). By the third time period of the older sibling, parents may take H_1 (which is measured by $Height_1$) into account when making education input decisions. Indeed, H_1 explicitly appears as a variable that determines PEI_3 in equation (4). One could also quarrel with the implicit assumption that PEI_1 and PEI_2 do not have any effect on cognitive achievement, which will introduce more variables into equation (1) for which instruments will be hard to find. The assumptions that H_3 has no effect on child academic skills in period 3 (T_3) in equation (1) and that health (as measured by growth) in the second time period is uncorrelated with child health in the first time period could also be questioned. Overall, the approached used in the Philippines paper can be faulted, but the solutions to the criticisms raised here are far from obvious.

Using the estimation strategy explained above (modified to account for delayed enrollment and grade repetition—see the paper for details), the Philippines study finds strong causal impacts of children's health status in the first two years of life on several schooling outcomes. More specifically, better health leads to reductions in delayed enrollment, reduced grade repetition, and greater learning per year of schooling. The impacts appear to be large in that back of the envelope calculations based on the cost and impact (on child height) of an unrelated feeding program in India (and the relationship between wages and education calculated from the Philippines data) suggest that each dollar spent on a feeding program could provide a social return of at least three dollars, and perhaps much more.

In summary, panel data provide additional possibilities for overcoming the estimation problems that plague studies based on cross-sectional data, but many estimation problems remain. Undoubtedly, further data collection and innovative thinking will lead to improved estimates, but the extent to which the remaining estimation problems can be resolved is difficult to predict. On the other hand, it is possible that worries about estimation bias due to behavioral responses to health programs and policies may be exaggerated. Evidence in favor of this more optimistic viewpoint is found in a recent paper by Jacoby [7] based on the same Philippines data used by Glewwe et al. [6]; Jacoby found that parents did not reduce food given to their children at home in response to the availability of school feeding programs in Filipino primary schools. Even so, it would be imprudent to ignore the potentially very serious estimation programs that arise in estimates based on nonexperimental cross-sectional and panel data. Thus the next subsection considers another approach: randomized trials.

Estimates based on randomized trials

Nutritionists and public health researchers have a long history of examining the impact of health programs and policies on cognitive and education outcomes using randomized trials. More recently, the difficulties of estimating the relationship between education outcomes and child health and nutrition has led some economists to initiate and evaluate randomized trials in developing countries. This subsection examines recent studies by both types of researchers.

Many of the earliest randomized studies by nutritionists and other public health researchers focused on the impacts of specific nutrients that were lacking in child diets. Studies in India and Indonesia by Soemantri, Pollitt, and Kim [8], Soewondo, Husaini, and Pollitt [9], and Seshadri and Gopaldas [10] found large and statistically significant impacts on cognitive development and school performance of iron supplementation among anemic children, but a study by Pollitt and others [11] found no such impact in Thailand. Other studies have focused on parasitic infections, especially intestinal parasites. Kvalsig, Cooppan, and Connolly [12] examined whipworms and other parasites in South Africa and found that drug treatments had some effect on cognitive and education outcomes, but some impacts were not statistically significant. Nokes and others [13] evaluated treatment for whipworms in Jamaica and concluded that some cognitive functions improved from the drug treatment, but others, particularly those related to academic performance in schools, appeared not to have changed.

Other studies have focused on general food supplementation to supply calories and protein. The most well known of these is the INCAP study [14] initiated in four Guatemalan villages in 1969, two of which were randomly selected to receive a porridge (*atole*) high in calories and protein while the other two villages received a drink (*fresco*) with less calories and no protein. Follow-up studies over several decades appear to show sizeable effects on education outcomes of providing the *atole* to mothers and young children.

Yet these studies are also subject to criticism. Many have relatively small sample sizes, such as 210 children in the South African study and 103 in the Jamaican study. Other studies include education interventions combined with health interventions, so the impact of the health intervention by itself cannot be assessed. The INCAP study is also open to criticism. In one sense, it has a sample size of only four since the intervention did not vary within villages. Second, strictly speaking, the control group also received an intervention, the *fresco* drink, albeit one with a relatively small benefit compared with what was received in the treatment group. Third, within each village receipt of the *atole* or *fresco* was voluntary, which implies that those who were treated were not a random sample of the population within each village.

Two very recent studies by economists on the impact of health interventions on education outcomes are among the best randomized evaluations conducted in recent years. The first is that of Miguel and Kremer [15], which evaluates a randomized program in Kenyan schools of mass treatment for intestinal worms using inexpensive deworming drugs. The study focuses on areas where there is a high prevalence of intestinal parasites among children. The authors found that child health and school participation (i.e., attendance, where dropouts are considered to have an attendance rate of zero) improved not only for treated students but also for untreated students at treatment schools (22% of pupils in treatment schools did not receive deworming medicine) and untreated students at nearby non-treatment schools. The impacts on untreated schools appear to result from reduced disease transmission brought about by the intervention. The study finds that absenteeism in treatment schools was 25% (7 percentage points) lower than in comparison schools and that deworming increased schooling by 0.14 years per pupil treated. Somewhat surprisingly, despite the reduction in absences and the small increase in years of schooling no significant impacts were found on student performance on academics tests.

Bobonis, Miguel, and Sharma [16] conducted a randomized evaluation in India of a health program that provided iron supplementation and deworming medicine to pre-school children age 2–6 years in poor urban areas of Dehli. Even though only 30% of the sampled children were found to have worm infections, 69% of children had moderate to severe anemia. After 5 months of treatment, the authors found large weight gains and a one-fifth reduction in absenteeism. The authors attempted to obtain estimates after 2 years, but high sample attrition and non-random enrollment of new children into the preschools complicated attempts to obtain unbiased estimates.

Yet even these most recent studies have some problems. The main problem with the Kenya deworming study is the puzzle that increased school participation (primarily attendance, but also reduced dropping out) is not reflected in students' test scores. The authors present some cost-benefit analyses at the end of the paper that they claim show that the intervention is cost-effective, but it is unclear that these can be taken seriously if the intervention does not increase learning in basic skills. The Bobonis et al. study [16] encountered serious sample selection and attrition problems in the second year, which prevented a clear assessment of the long-term impact of the health intervention in India. It also collected no data on any type of learning, and thus is limited to examining enrollment and attendance. Finally, because all children received a combined treatment of vitamin A supplements and deworming medicine, the study cannot distinguish between the separate impacts of these two treatments.

Summary and concluding comments

This paper has reviewed estimation issues regarding attempts to measure the impact of child health and nutrition status on education outcomes. As explained in the second section, the relationships between child health and schooling are complex, and indeed there are three distinct relationships that are of potential interest. Studies that attempt to estimate any health-education relationship should explain clearly which relationship they are trying to estimate.

Perhaps the main message of this paper is that it is very difficult to estimate all three of the relationships mentioned in the previous paragraph. The two fundamental problems are the following: (1) It is impossible to obtain data on all variables that belong in the equations of interest, which raises very serious problems of omitted variable bias; and (2) The variables that one does have data on are often measured with error, which can lead to very serious problems of attenuation bias. These problems are not easy to fix, despite much richer data and the use of much more careful estimation methods in the past 10–20 years. Yet most of the best recent studies using cross-sectional data, panel data, or data from randomized trials have found sizeable and statistically significant impacts of child health on education outcomes, although it is possible that studies that find no effect are less likely to be published. Despite the litany of estimation problems discussed in this paper, there is no reason to think that these problems systematically tend to overestimate the impacts of interest; there does seem to be a strong causal link from child health to child education.

Future research on the links between child health and education outcomes should focus on two fronts. First, further analysis of panel data is warranted because it is important to understand the underlying processes behind these links in order to stimulate new thinking about possible policy interventions. This cannot be done using standard randomized evaluations. Fortunately, more panel data collection efforts are now being undertaken in developing countries, which will set the stage for such research. Second, more randomized evaluations should be conducted, especially by large aid organizations. The results of these evaluations should be broadly disseminated, which will not be easy for these organizations because many studies will find that their programs did not work as intended. Randomized studies should always compare their findings with standard cross-sectional or panel data estimates based on the control group data, making clear which of the three types of relationships are being compared. This will create a record of the likely bias of non-experimental methods. It may be that there are many situations in which nonexperimental methods do not suffer from substantial bias, but this will not become clear until a track record of results has been assembled.

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Height, weight, and education achievement in rural Peru

Santiago Cueto

Abstract

The education system in Peru and many other developing countries faces several challenges, including improving education achievement and increasing education enrollment in high school. It is clear from several indicators that rural students have lower education outcomes than do urban students. In this study we used cross-sectional and longitudinal analysis to determine the relationship between height-for-age z-scores (HAZ), weight-for-age z-scores (WAZ), body-mass index (BMI), and education outcomes. The sample was composed of students from 20 elementary public schools in two rural zones in Peru. The descriptive results show that there was no association between any of the anthropometric variables and achievement (mathematics and reading comprehension) or advancing to high school without repeating a grade. However, BMI was associated with dropping out of school: children with higher BMI in 1998 were more likely to be out of school by 2001. The hierarchical multivariate analysis also showed no relationship between anthropometry and achievement at the individual level, but students with relatively higher HAZ in 1998 were more likely to be drop-outs by 2001. These results contradict prior findings that showed a positive association between anthropometric variables (especially HAZ) and education achievement. The results might be explained by the fact that the study was carried out at very poor sites, at altitudes between 3,000 and 3,500 meters above sea level. The scarce studies about development in high altitudes suggest that the patterns for height and weight for children and adolescents are different than at sea level. Another possible explanation has to do with the fact that in the contexts studied, children who are perceived as relatively heavier (BMI) or taller (HAZ) might be expected to be out of school and start working (in fact, this was the primary reason given by children for dropping out of school).

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Key words: Anthropometry, educational achievement, Peru, high altitude, rural education, school dropout

Introduction

As in many developing countries, education is a major concern in Peru. For instance, Peruvian students age 15 enrolled in school performed last in reading comprehension, science, and mathematics among 41 countries in the PISA (Programme for International Student Assessment) evaluation [1]; more than 60% of Peruvian students fell below the basic level of reading. Although PISA was organized by the Organisation for Economic Co-operation and Development (OECD) countries, several developing countries also participated, including Argentina, Brazil, Chile, and Mexico. Also, while enrollment in primary education in Peru is near 100%, the percent of students enrolled in high school is much lower and decreases in higher grades [2]. The challenge posed to researchers in Peru and other developing countries with similar problems is to determine which variables are associated with low achievement, so that problems such as those mentioned above might be overcome through interventions that are both effective and efficient.

The following includes a brief review of the research literature on the relationship between weight, height, and education outcomes in basic education. Many researchers have argued for the relationship between health and nutrition variables and intellectual development (including academic achievement [3]). Among these are several studies on the relationship between undernutrition (i.e., weight-for-age z-score [WAZ] < –2 SD of international norms); wasting (i.e., weight-for-height z-score [WHZ] < –2 SD of international norms); and stunting (i.e., height-for-age z-score

[HAZ] < –2 SD of international norms). Stunting is usually considered an indicator of chronic malnutrition, wasting of acute malnutrition, and undernutrition a mix of the two. UNICEF has estimated that between 1995 and 2000, the percent of children 5 years old and younger who suffered from underweight, wasting, and stunting (as previously defined) in developing countries was 29%, 10%, and 33%, respectively [4].

Research has established fairly well that stunting in the first 2 years of life is related to lower school achievement (at least in primary education). For example, a longitudinal study in the Philippines [5] found that children who were stunted between birth and 24 months of age had lower scores in tests of cognitive ability (non-verbal intelligence test) than did non-stunted children. The effect was clearer for the severely stunted children (i.e., HAZ < –3 SD). The association was clearer at 8 than at 11 years of age. Severely stunted children also tended to enroll later in first grade.

A study in Peru [6] found that children with severe growth retardation (i.e., HAZ < –3 SD) between 12 and 24 months of age scored 10 points lower than did non-stunted children in the Wechsler Intelligence Scale for Children-Revised when they were 9 years old (results were adjusted for grade in school).

A few studies have assessed the relationship between low birthweight (i.e., < 2500 g) and intellectual development. A retrospective study in Scotland found that low-birthweight children scored lower than did normal-birthweight children at 11 years of age in tests of cognitive function [7].

A study in Malaysia [8] used a cross-sectional design to test the association of WAZ, HAZ, and WHZ with education achievement in primary schoolchildren (ages 6–8). The tests measured Malay language, English language, and mathematics. Only HAZ was associated with a combined achievement score. This relationship remained after controlling for several covariates (including socioeconomic status). This study used cut-off scores of < –2 SD of international norms.

The current study implemented a longitudinal design to explore whether height and weight for students enrolled in fourth grade in impoverished environments in Peru were related to or predicted any of the following: (1) concurrent achievement in standardized mathematics and reading comprehension tests; (2) achievement in the same areas 2 years after the first measurement; (3) being promoted to high school in ideal time (i.e., without repeating a grade); and (4) staying in school (i.e., not dropping out).

This study is similar to some of the aforementioned studies in that it is longitudinal. It differs from many of these in that the initial measurements were not taken in the first years of life. It also differs from prior studies in that continuous z-scores were used rather than the international categories of moderate or severe undernutrition, wasting, and stunting. The justification for this is that all sites included in the study were between 3,000 and 3,500 meters above sea level. A recent review of the literature on high altitude and development [9] concluded, among other things, the following:

» Height and weight at birth are usually lower in high altitude.
» Puberty is delayed in high altitude.
» Velocities in height and weight gains are smaller and more prolonged in high altitude.

Given the few studies on these topics, it is difficult to argue that there is a causal mechanism between hypoxia or any other factor occurring at high altitude and development, but it is very likely that anthropometric gains differ if one lives at sea level versus high altitude (problems with hypoxia usually appear in areas 2,500 meters above sea level [10]). Given this, in this study the continuous scores were used, although the distribution of the sample in height and weight will also be shown.

Methods

Design

The first round of data was collected in 1998, when all students were enrolled in fourth grade. At this time, data on achievement, anthropometry, school, and socioeconomic status was collected. In 2000 the children were revisited (at school or at home if they had dropped out) and administered the same tests. In 2001 the children were revisited to determine whether they were in school and if so in which grade (since elementary schools in Peru include six grades, ideally all children should be in first grade of high school). The transition to high school is especially difficult in Peru, because while there are many rural elementary schools, students often have to move to urban areas to attend high school.

Locations and subjects

The original sample was composed of 588 students from fourth grade in 20 elementary schools in the rural areas in neighbor provinces in the Departments of Cusco and Apurimac (Peru). All children enrolled and attending the sampled schools were included in the study. The communities where the students lived and studied were mostly rural and poor according to Peruvian standards (i.e., three or more basic needs not met by the family, such as no access to water, electricity, or sewage; parents with no education; and more than three persons per room at home). The community residents spoke Quechua (the most popular indigenous language, whereas the dominant language in Peru is Spanish). **Table 1** presents descriptive information about the sample studied.

TABLE 1. Characteristics of students in the sample

	Mean	SD
Students' age (in years)	12	2
Percentage of females	51	50
Percentage of students who had preschool	67	47
Students' proficiency in Spanish[a]	2	1
Number of siblings	3	1
Fathers' education	5	3
Mothers' education	2	3
Mother communicates in Spanish with her child (percentage)	53	50
Height-for-age (z-score)	–2.2	1.0
Weight-for-age (z-score)	–1.4	0.7
Body-mass index (BMI)	17.3	1.8

a. Proficiency in Spanish: 1 = low, 2 = regular, 3 = high (assessed by the classroom teacher in 1998).

It is important to note that Peruvian law requires that by age 6 students are enrolled in first grade. Thus, the students should have been between 10 and 11 years of age in fourth grade (when the 1998 data were gathered). The fact that the average age is 12 indicates that many students either enrolled late, repeated one or more times, and/or temporarily dropped out of school.

Of the 588 students in the original sample, 576 were located and interviewed in person in 2001 to identify grade in school (or drop-out status); a math test was administered to 474 students in 2000 (504 took it in 1998); and the reading comprehension test was administered to 525 students in 2000 (569 took it in 1998). In other words, longitudinal information was available for more than 90% of the sample for which 1998 data were available.

Instruments

Achievement was measured through reading comprehension and arithmetic tests. The reading comprehension was composed of 40 items with sentences of increasing length (the same test was administered in 1998 and 2000). The task of the students was to answer a question choosing from four options (different options for each question). The mathematics test was composed of 27 open-ended questions, requiring students to perform additions, subtractions, multiplications, and divisions of whole numbers and fractions. In 2000, the 13 mathematics items that differentiated the best students were administered again. Thus, the comparisons are only made for the items administered both in 1998 and 2000. Each correct answer was given one point, with zero points given for incorrect answers or unanswered questions. The instructions for the tests were given in Spanish. In all schools in the sample instruction was monolingual in Spanish, because although many students spoke Quechua as their maternal language, they could not read or write it. The tests were administered in the classrooms to the whole group, or individually at home (only to students who had dropped out). The reading comprehension test was adopted from the Inter-American Series (grade 3), and the math test was developed as part of a previous study. Both tests had been used successfully in the past in similar areas in Peru [11]. In this case internal reliability of the four tests was above 0.7, which was considered acceptable.

Height and weight were measured using portable equipment that was calibrated by an expert in anthropometric measurements. This person trained two nurses until agreements above 0.9 were achieved. The two nurses visited together all schools to collect height and weight information (a single weight bathroom scale was calibrated with a 5-kg weight after every five students).

Finally, one of each student's parents (usually the mother) was interviewed to collect socioeconomic information. The interview was carried out in Spanish or Quechua, depending on the preferences of the interviewee.

Procedures

The first round of data was collected as part of an impact evaluation of a school breakfast program [12]. No main effects were found for this program, and the contrast group started receiving the breakfast right after the first measurement (1998). Both groups continued receiving the breakfast at school while they were in elementary school. Thus, the distinction between contrast and treatment group used in the original study was not included in the analysis reported here. HAZ and WAZ scores were calculated using the Epi Info version 6 program (Centers for Disease Control and Prevention [CDC], Atlanta, Ga., USA). Given the age of the students, it was not possible to estimate WHZ for many of them. Therefore, BMI (kg/m^2) was used instead.

Results

Table 2 presents the number and percent of students attending school (at each grade) and drop-outs by 2001. By 2001, 20% of the original sample was no longer enrolled, and 43% had advanced to high school without repeating a grade.

Table 3 presents the distribution of the students according to several cut-off scores for HAZ and WAZ; 60% of the students in the sample would be classified as "stunted" using international norms, and 19% as severely stunted (although, as mentioned before, the meaning of such norms is called into question for the highlands). Only 9% of the sample had scores > –1 SD

TABLE 2. Number of the students and status in 2001

	4th grade (elementary)	5th grade	6th grade	1st grade (high school)	Total	%
Attending school	4	57	147	250	458	80
Dropouts	60	42	16		118	20
Total	64	99	163	250	576	100
%	11	17	28	43	100	

TABLE 3. Distribution of students by HAZ and WAZ

	Height-for-age (HAZ)		Weight-for-age (WAZ)	
	Cases	Percent	Cases	Percent
z ≥ 0	44	8	112	22
0 > z ≥ –1	7	1	22	4
–1 > z ≥ –2	154	30	285	55
–2 > z ≥ –3	215	41	97	19
z < –3	99	19	4	1
Total	519	100	520	100

HAZ, height-for-age z-score; WAZ, weight-for-age z-score

of international norms in HAZ. On the other hand, only 20% of the students in the sample would be classified as undernourished.

Table 4 presents the cut-off scores for BMI by age. The cut-off scores were based on the growth charts developed for the Centers for Disease Control and Prevention [13]. For the cut-off scores it was necessary to consider the age and sex of each student. The results are in agreement with findings for younger children in Peru, which show that there is very little prevalence of acute malnutrition even in very poor areas, but high prevalence of stunting [4].

The first two research questions were related to the relationship between anthropometry and achievement. **Figures 1 through 6** show the relationship between HAZ, WAZ, and BMI in 1998 with achievement in 1998 and 2000; they show no sign of any kind of trend, linear or non-linear. All the R^2 are close to 0, which indicates that there is very little relationship between the variables anthropometry and achievement in this sample.

The third and fourth research questions referred to the probability of advancing to high school in ideal time or dropping out of school. **Table 5** presents the z-scores, in HAZ and WAZ, and BMI for students who had dropped out of school, advanced to high school without repeating a grade, or stayed in school but repeated one or more times. **Table 5** shows that while there are no differences in HAZ or WAZ, students who had dropped out had higher BMI scores. In other words, they were relatively heavier than their counterparts who had stayed in school.

Table 6 presents the Pearson correlations among the three anthropometry variables. As expected, WAZ was highly correlated to both HAZ and BMI. Thus, WAZ was dropped from the multivariate analysis presented later.

The multivariate analysis utilized hierarchical models that allowed us to control for the individual and school levels of standard error [14].

In **table 7** the dependent variables were achievement in reading comprehension and mathematics (in 1998 and 2000). The main difference between the models for 1998 and 2000 is that in 2000 the variables *student had dropped out, achievement in the same test in 1998,* and *grade in school** were included, whereas the analysis for 1998 is cross-sectional.

The results show no association between HAZ, WAZ, or BMI at the individual level with achievement in mathematics or reading comprehension in 1998 or 2000. At the classroom level (i.e., average of the classroom) there are two significant coefficients (trend

* For drop-outs, the grade in school they were studying when they left school was used.

TABLE 4. Distribution of students by body-mass index (BMI, adjusted for age and sex)

	Cases	Percent
Underweight (BMI ≤ 5th percentile[a])	17	3
Normal (5th percentile < BMI ≤ 85th percentile)	486	94
At risk of overweight (85th percentile < BMI ≤ 95th percentile)	14	3
Overweight (BMI > 95th percentile)	0	0
Total	517	100

a. Categories were assigned based on the growth charts of the US Centers for Disease Control and Prevention [13].

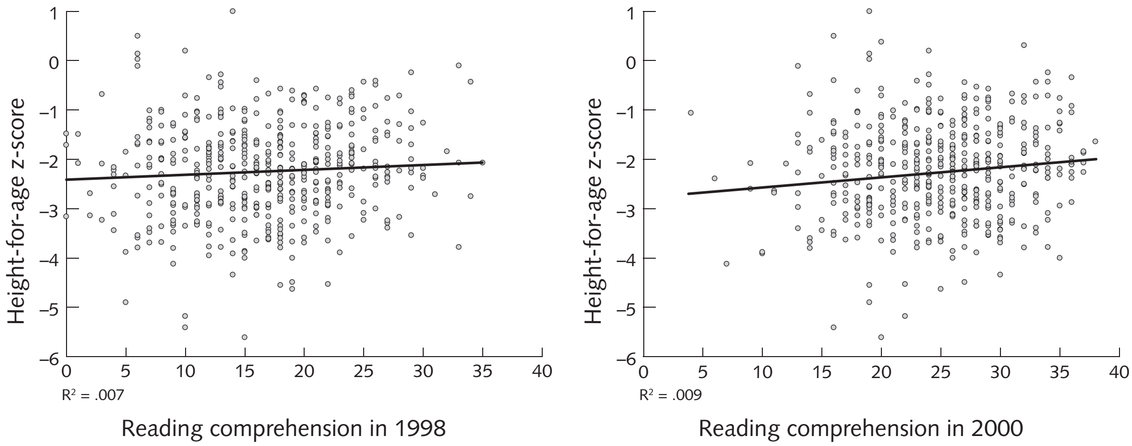

FIG. 1. Scatter between height-for-age z-score (1998) and reading comprehension in 1998 and 2000.

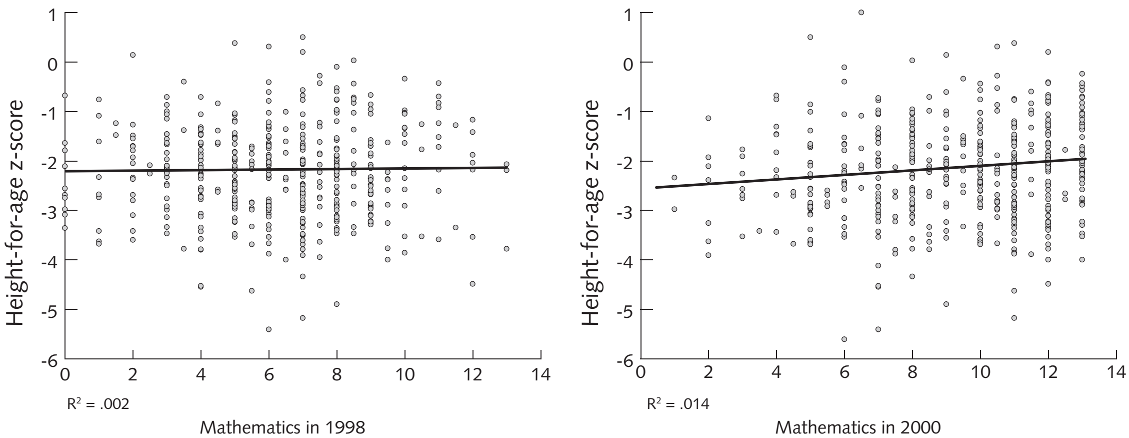

FIG. 2. Scatter between height-for-age z-score (1998) and mathematics in 1998 and 2000

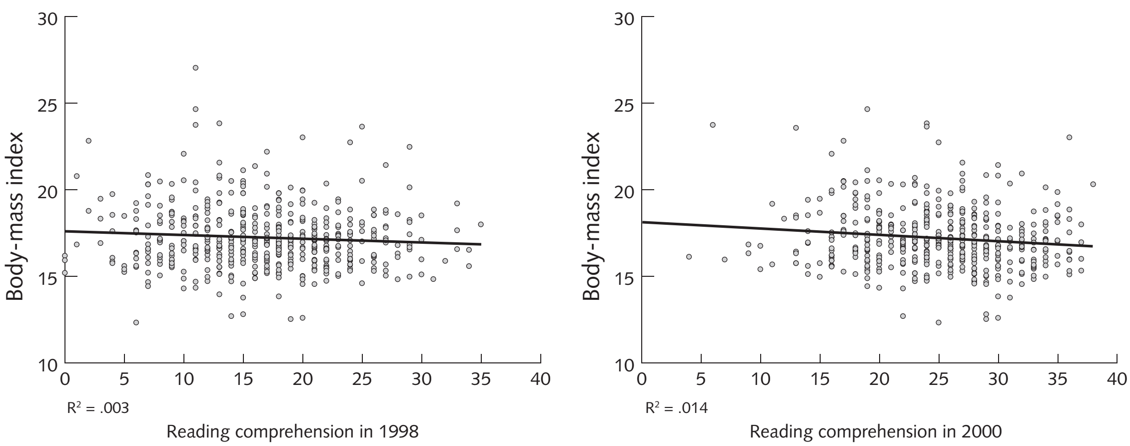

FIG. 3. Scatter between body-mass index (BMI; 1998) and reading comprehension in 1998 and 2000

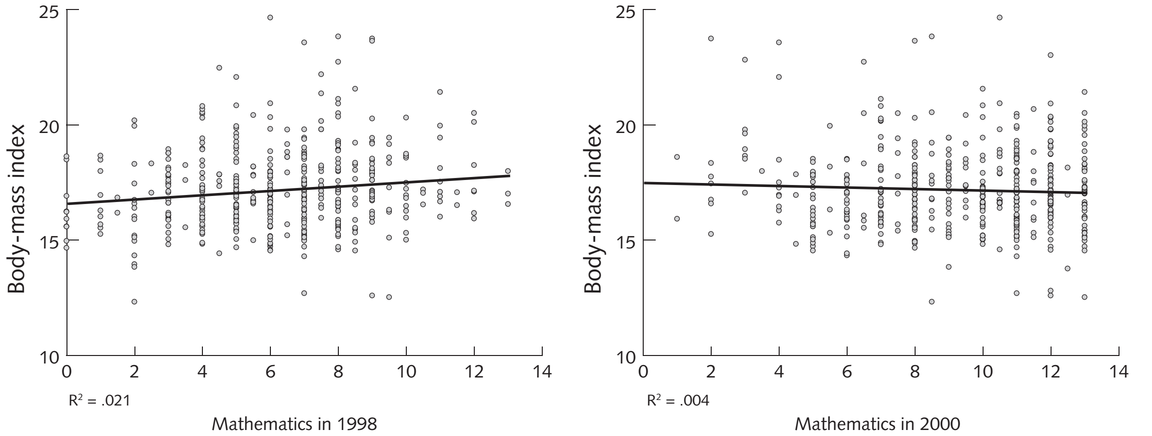

FIG. 4. Scatter between body-mass index (BMI; 1998) and mathematics in 1998 and 2000

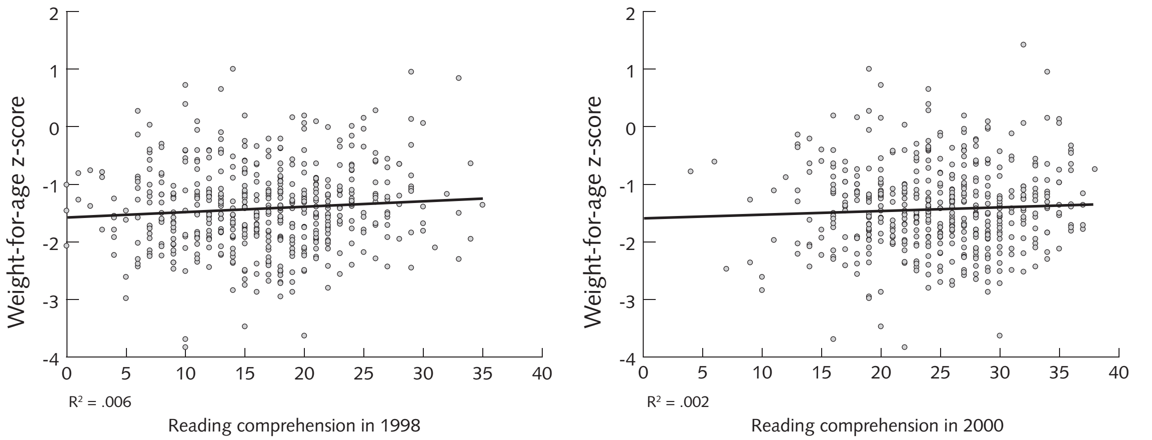

FIG. 5. Scatter between weight-for-age z score and reading comprehension in 1998 and 2000

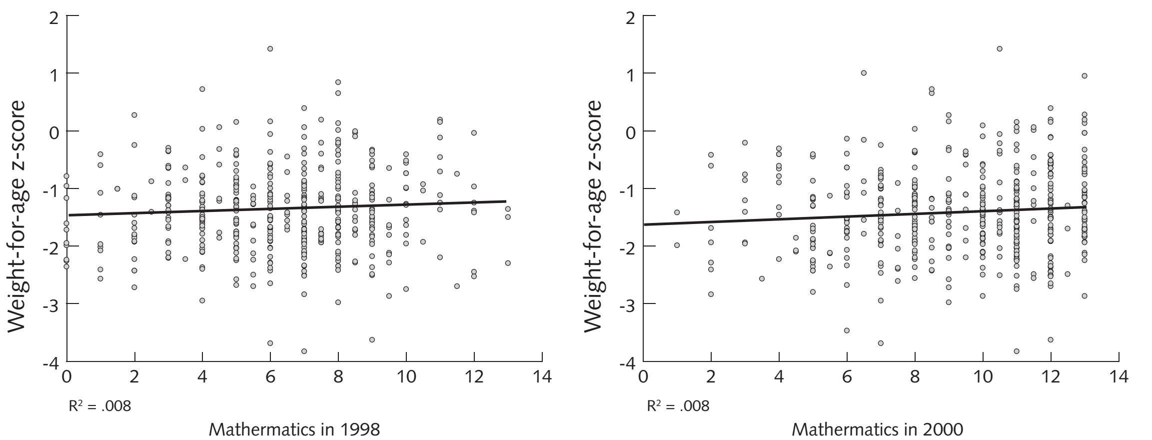

FIG. 6. Scatter between weight-for-age z-score (1998) and mathematics in 1998 and 2000

TABLE 5. HAZ, WAZ, and BMI for each group in 1998*

		Height-for-age (HAZ)	Weight-for-age (WAZ)	Body-mass index (BMI)
In high school	Average	–2.23[a]	–1.42[a]	17.09[a]
	SD	(0.96)	(0.78)	(1.72)
	n	234	235	233
Repeated one or more times	Average	–2.17[a]	–1.41[a]	16.85[a]
	SD	(0.93)	(0.69)	(1.44)
	n	181	181	181
Dropped out	Average	–2.26[a]	–1.32[a]	18.47[b]
	SD	(1.03)	(0.75)	(2.27)
	n	95	95	96

HAZ, height-for-age z-score; WAZ, weight-for-age z-score; BMI, body-mass index
* Means with different superscripts in each column indicate differences are significant ($p < .05$).

relationships), for BMI in 1998 and achievement in mathematics the same year and for HAZ in 1998 and achievement in mathematics in 2000. It is interesting that drop-outs had relatively higher scores than did students in school. Because many of the drop-outs went on to work, one alternative to explore further is that on-the-job reading resulted in more learning than did academic activities in school for the rest of students (although grade in school also had a positive effect). In 2000, achievement in both areas is mostly explained by baseline scores on the same tests.

Table 8 presents the nonlinear analysis for the probability of dropping out of school and for passing to high school in ideal time.

The results show that there is a trend relationship ($p < .1$) between HAZ and dropping out of school at the individual level, but the coefficient is positive. In other words, it is more likely that relatively taller students (at each age group) would drop out of school (adjusting for the covariates included in the model). HAZ was not significant for explaining advancing to high school at the individual or classroom level or with dropping out at the classroom level. Dropping out of school is also significantly associated with age (i.e., the older the student the more likely s/he will drop out) and being female, while advancing to high school is significantly associated with language (use of Spanish at school and home) and the scores in the tests administered in 1998 (i.e., the higher the scores, the more likely the students would not repeat a grade).

Discussion

The current study discusses the association between HAZ, WAZ, and BMI with several education outcomes (readers interested in more details on the education achievement of the students should consult Cueto [15]). Contrary to expectations, there were no associations between HAZ, WAZ, or BMI and education

TABLE 6. Pearson correlation among anthropometry variables

	WAZ		HAZ
HAZ	0.791	*	
BMI	0.503	*	0.018

HAZ, height-for-age z-score; WAZ, weight-for-age z-score; BMI, body-mass index
*$p < .01$

achievement in mathematics or reading comprehension at the individual level. The above is true for the cross-sectional and longitudinal analysis. There was an association between BMI and mathematics achievement (cross-sectional) and between HAZ and achievement (longitudinal) at the classroom level. These findings are difficult to interpret given the scarcity of knowledge on children's development at high altitudes (see discussion below).

None of the anthropometric variables helped to explain advancing to high school without repeating. The variable that better explained this was prior achievement in the tests. However, there was an association between BMI and dropping out in the bivariate analysis (i.e., students with higher BMI tended to drop out of school more frequently). The multivariate analysis showed an association at the individual level between HAZ and dropping out of school (i.e., students with relatively higher HAZ were more likely to drop out).

We propose two possible areas for further research. The first one is related to development of anthropometry in high altitude (i.e., 2,500 meters above sea level). Very few studies exist on this topic, but the conclusions suggest that development is different in high altitude compared with sea level. For example, puberty tends to start later and growth tends to last longer [9, 10]. It is difficult to argue that there is a causal mechanism (e.g., related to hypoxia), because of potential confounders that would need to be controlled in future studies (the population in high altitude areas in Peru tends to be

TABLE 7. Hierarchical linear model analysis for mathematics and reading comprehension, 1998 and 2000 (common items)

	Reading 1998			Reading 2000			Mathematics 1998			Mathematics 2000		
	Coef.	SE		Coef.	SE		Coef.	SE		Coef.	SE	
Level 1—individual level												
Gender (male vs female)	1.395	(0.513)	***	0.162	(0.423)		0.351	(0.240)		0.346	(0.212)	*
Proficiency in Spanish (1 bad, 2 regular, 3 good)	2.372	(0.452)	****	–0.147	(0.385)		0.598	(0.213)	***	0.200	(0.194)	
Language used by the mother to comunicate with her child (Spanish vs other)	1.427	(0.571)	**	0.417	(0.475)		0.854	(0.269)	***	0.118	(0.242)	
Student's age in 1998 (yr)	–1.184	(1.531)		–0.032	(1.263)		0.606	(0.704)		0.391	(0.632)	
Student's age in 1998—square (yr)	0.043	(0.063)		–0.017	(0.052)		–0.017	(0.029)		–0.024	(0.026)	
Height for age (z-score)	0.192	(0.290)		–0.098	(0.238)		0.027	(0.136)		0.078	(0.121)	
Body-mass index	–0.094	(0.172)		–0.071	(0.141)		0.047	(0.078)		–0.033	(0.069)	
Mother educational level (0 none, 1 primary, 2 secondary, 3 higher education)	0.313	(0.458)		0.595	(0.375)		0.318	(0.215)		0.063	(0.190)	
Student dropped out (yes vs no)				2.932	(0.951)	***				0.043	(0.467)	
Highest grade reached (3 sixth grade, 2 fifth grade, 1 fourth grade)				2.676	(0.393)	****				0.747	(0.193)	****
Reading comprehension in 1998				0.288	(0.043)	****						
Mathematics in 1998										0.343	(0.047)	****
Level 2—classroom Level												
Intercept Bo	14.347	(0.963)	****	22.793	(0.836)	****	6.082	(0.269)	****	8.670	(0.324)	****
Body-mass index (mean by school)	0.325	(1.436)		–0.769	(1.246)		0.800	(0.406)	*	–0.411	(0.484)	
Height for age (mean by school)	–0.066	(3.551)		2.660	(3.084)		0.325	(0.972)		2.056	(1.180)	*
Variance components												
Level 1	29.425	****		19.645	****		5.675	****		4.400	****	
Level 2	13.499	****		10.341	****		0.804	****		1.407	****	
Sample												
Students	484			484			438			438		
Schools	17			17			17			17		

* $p < .10$; ** $p < .05$; *** $p < .01$; **** $p < .001$.

TABLE 8. Hierarchical generalized nonlinear model analysis for entering high school or dropping out

	Dropping out				Entering high school			
	Coef.	SE		Odds	Coef.	SE		Odds
Level 1—individual level								
Gender (male vs female)	–0.957	(0.459)	**	0.384	0.217	(0.273)		1.243
Proficiency in Spanish (1 bad, 2 regular, 3 good)	0.135	(0.409)		1.144	0.538	(0.248)	**	1.713
Language used by the mother to comunicate with her child (Spanish vs other)	0.354	(0.508)		1.425	0.617	(0.301)	**	1.854
Student's age in 1998 (yr)	0.755	(0.155)	****	2.128	–0.059	(0.097)		0.943
Height for age (z-score)	0.392	(0.239)	*	1.479	–0.223	(0.164)		0.800
Body-mass index	0.123	(0.135)		1.131	–0.010	(0.093)		0.990
Mother educational level (0 none, 1 primary, 2 secondary, 3 higher education)	–0.467	(0.416)		0.627	–0.261	(0.244)		0.770
Reading comprehension in 1998 (standardized score)	0.057	(0.328)		1.058	1.225	(0.219)	****	3.406
Mathematics in 1998 (standardized score)	–0.239	(0.262)		0.788	0.799	(0.190)	****	2.223
Level 2—classroom level								
Intercept Bo	–2.126	(0.492)	**	0.119	–1.775	(0.630)	**	0.169
Body-mass index (mean by school)	0.469	(0.659)		1.598	–0.228	(0.401)		0.796
Height for age (mean by school)	0.016	(1.697)		1.017	–0.852	(0.949)		0.426
Variance components								
Level 2	2.327	****			0.712	****		
Deviance	501.1				707.9			
Sample								
Students	548				548			
Schools	19				19			

* $p < .10$; ** $p < .05$; *** $p < .01$; **** $p < .001$.

poorer than that at ocean level). In this line of research, it might be interesting to relate anthropometric measurements and education outcomes slopes at several time points.

The second area for further research does not have to do with biologic mechanisms but with local culture. We suggest that the reason why students with higher BMI and HAZ were more likely to drop out of school was because of cultural expectations: given a certain age, gender, body weight, and height, a child might be expected to drop out of school and start working. When asked, 54% of the students that were not in school said that the reason they had dropped out was because their parents had no money, and 43% said that they had to help at home. These two were the more likely reasons. Only 13% of the students said that they had dropped out because they thought they had learned enough, and 18% said that they were not doing well in school. Furthermore, 96% of the drop-outs said they liked school. The reason most often given by the parents of drop-outs was that their children left school because they had to work.

The results shown could also have practical implications: we suggest that further studies be performed on the probabilities that relatively older, female, heavier, and taller students drop out of school without finishing elementary school, so that preventive programs may be targeted at these children in areas similar to those studied here.

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Obesity among schoolchildren in developing countries

Osman M. Galal and Judie Hulett

Abstract

The threat of worldwide obesity in children is a reality and has become pandemic. Previously a concern of only developed countries, rapid, escalating rates of overweight children now dominate the public health concerns of middle-and low-income nations as well. There are, of course, many influences that have literally shaped the global population, but there is also a recent observable pattern that is shared by those developing countries with increasingly obese children: a grand structural shift in diet and activity levels on every continent and in every region has occurred in the last quarter century, accompanied by rising rates of obesity. Two central public health concerns drive the need for effective interventions: the immediate health of children and the imminently crushing blow that is coming to health care systems and developing economies due to high rates of chronic disease. In developed nations, the role of gatekeeper has shifted to childcare providers, media, and schools, but in the developing world the traditional role of the mother as home manager has remained intact. Accepting the mother as the primary care provider within the child's nuclear environment places the mother as the guardian of the family's resources, which may be a viable alternative to the types of health-promotion efforts found in past ineffective models.

Key words: Childhood obesity, mother, developing countries, schoolchildren

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Introduction

The threat of worldwide obesity in children is a reality and has become pandemic. Previously a concern of only developed countries, rapid, escalating rates of overweight children now dominate the public health concerns of middle- and low-income nations as well [1]. There are approximately 17.6 million overweight children worldwide [2]. Among schoolchildren, one in six is overweight; and one in four overweight children is obese [3]. The prevalence for obesity in preschoolers aged 2 to 5 years has more than doubled and for schoolers ages 6 to 11, it has tripled [4].The prevalence of obesity in US children ages 6 to 11 has tripled since the 1970s to a level of 15%, or more than 9 million young people. One in four of the obese children are likely to become obese adults, continuing the intergenerational effects of this condition [5]. Similar rates are being reported by other countries such as Haiti, Brazil, Ghana, Australia, and Egypt, showing increasing trends in youth weight gain (see **fig. 1**) [6]. The conditions that promote excess body fat have affected some populations more than others and within regions there are different rates of change, but if interventions are to reverse the current trends, an understanding of the common driving forces that underlie this serious health threat must occur.

The mechanisms that connect child obesity to specific risk factors are still somewhat speculative. Theories that follow traditional paths reduce causes to a simple dichotomy of diet and inactivity; considering the healthy body a balanced equation of input and output. Other approaches focus on the role of genetics or the role of low socioeconomic status (SES) as a catalyst for weight gain. In the first case, specific genes are proposed to function as determinants of an individual's weight status; a proposal that may account for a small proportion of overall obesity. Obesity has taken over in a relatively short amount of time in fairly stable populations which indicate that it is not likely that the roots of weight gain are genetic. On the other hand, the

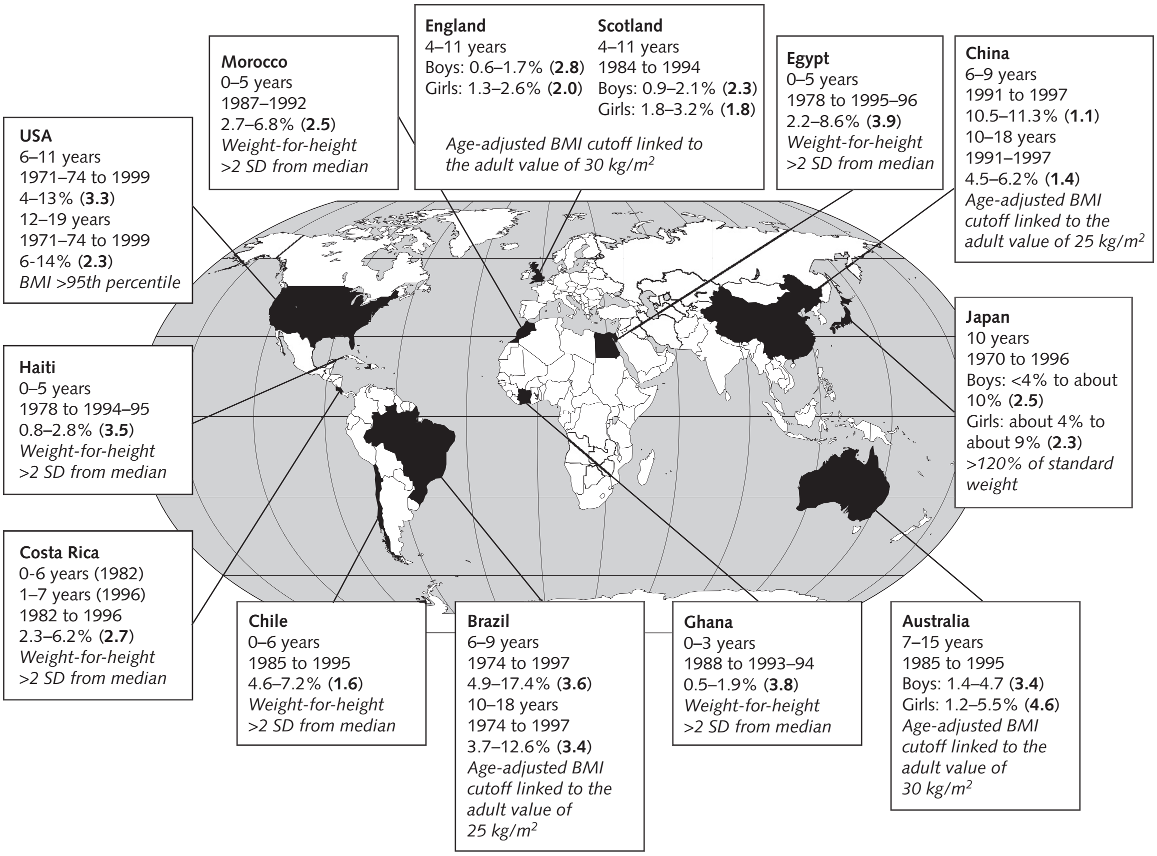

FIG. 1. Global increases in prevalence of childhood obesity. (Change factors are listed in bold for increases in prevalence over specified time intervals. Definitions of overweight and obesity are in italics.)
Source: Reprinted with permission from Elsevier. The Lancet 2002; 360(9331):473–82.

relationship of poverty (and undernutrition) to obesity is significant to the problem, particularly in relation to stunting. Stunting affects approximately one-third of the world's children [7].

Nutrition deficiency as a basis for stunting may explain how early nutrition insults are linked to obesity through changes in growth and metabolic processes, increasing the risk of becoming obese [8]. Hoffman's work on fat metabolism identifying the consequences of fetal nutrition insults emphasizes the vulnerability of the undernourished child to become obese [9] [10]. These relationships are crucial to understanding the relationship of undernutrition to overnutrition. However, physiologic approaches appear to offer only partial explanations for such a worldwide phenomenon and do not help us understand why it is happening now [11]. Historically, childhood stunting has occurred for centuries without being accompanied by obesity [12] and the human gene pool has not changed substantially in the 25 years during which the world became two to three times fatter [13]. There are, of course, many influences that have literally shaped the global population but there is also a recent observable pattern that is shared by those developing countries with increasingly obese children: a grand structural shift in diet and activity levels on every continent and in every region has occurred in the last quarter century, accompanied by rising rates of obesity [1]. The World Bank estimates that 93 countries are undergoing evolutionary changes that qualify them as middle-income countries [14]. Grave and important shifts in the causes of death and morbidity are occurring in most every country and at younger ages. Populations that have high obesity rates also consume foods that are unhealthy, suffer from elevated rates of chronic disease, and have become less active [15]. Before the recent effects of industrialization and development, poverty and deprivation in developing countries were hardship environments that prevented children from becoming obese. Now, the forces of modernization have altered resources, environments and behavior on a global scale; changes that have provoked shifts in dietary consumption and activity levels in adults and their children [16].

Global shifts

Researchers seeking to explain the surge in childhood obesity have identified similar, basic patterns linking behavior and available resources. Like demographic and epidemiologic transitions, nutrition patterns are adjusting to the current globalization pressures, becoming nutrition transitions on a massive scale. Asia, Latin America, urban centers of sub-Saharan Africa, and the Middle East have all at least in part experienced a nutrition restructuring to include calorie-dense, high-fat processed foods much like what is already custom in North America and Europe [15]. With the current global changes toward industrialization and consumerism, refined, fatty, sugary foods are becoming available to everyone at any time, anywhere [11]. The availability of inexpensive fats of all kinds has increased and with it consumption [1]. Vending machines are full, vendors' shelves are stacked, and calorie-rich foods that are low in fiber and in nutrients can be found as easily in Sao Paulo, Brazil or Bombay, India as in Irwin, Iowa, U.S.A.

Shifts resulting from globalization, industrialization, and new-found choices affect regions and peoples differently and can be both quantitative and qualitative in scope. On one hand, the qualitative differences show lifestyles more oriented to cheap, rapid transportation, capital-intensive jobs instead of labor-intensive jobs, and convenient communication modes [1]. These changes fit into a faster paced world and effectively suppress a practical need or desire to be physically active through, for example, walking or bicycling, and are material to the underlying causes of international obesity [13]. Physical activity for children is more limited since communities often lack the facilities or space to exercise or play sports. In cities, the parks and streets are less safe than they once were so children become essentially sequestered in their homes focusing on television, video-games, or the computer while at the same time increasing their susceptibility for obesity. On the other hand, to quantify the effect of obesity on various populations, one need only look as far as the rates of illness and chronic disease in adults and children for some indication of the extent of the current and future impact.

Consequences for health

Obesity in childhood carries with it considerable threat through to adulthood [17]. Although for many children the chronic diseases related to obesity do not become apparent for a decade or more, there are physiologic changes in the young that affect virtually every organ system in the body including orthopedic, neurologic, pulmonary, gastroenterologic, and endocrine [5]. It used to be that obesity and its correlates were considered rare in children. But in recent decades cardiovascular risk factors [18], diabetes [19], and various irregularities have come to be reported with more frequency. Today they are common [3]. In their study on the impact of childhood obesity on health costs, Wang and Dietz [20] demonstrate the increasing numbers of children that have been in hospital care for obesity-related conditions. The economic impact on a national health care system is significant as it cares for an overweight population. The authors report that over the last two decades in the United States, discharges related to diabetes have doubled, gallbladder- and obesity-related discharges have tripled, and sleep apnea has quintupled among children between the ages of 6 and 17 years. At the same time, hospital costs have risen to \$127 million from \$35 million, representing a tripling of health care expense owing to children gaining weight [20]. The health consequences of overweight in children are costly and have long-term bearing on national economics. In the United States, obesity-related costs reached more than 9% of total medical expenditures in 1998 (\$92.6 billion), exclusive of indirect costs [21]. The demand will continue on health services as the proportion of the population affected grows.

It has now become evident that obese children are at risk for developing elevated cholesterol, blood pressure, and atherosclerosis—all precursors of heart disease [21]. Obesity in children can no longer be considered benign. It is associated with chronic diseases such as hyperinsulinemia, poor glucose tolerance (raising the risk for type 2 diabetes), hypertension, social exclusion and isolation, and depression [3]. As the rates of childhood obesity continue to rise, chronic disease will occur in increasing proportions in adults as the population gets older. Health systems and the support networks are likely to be in far greater demand, placing new burdens on already strained international economies [20].

Furthermore, there are some preliminary data that obesity adversely affects children's school performance [22]. There is only one longitudinal study by Datar and colleagues on US kindergartners that has attempted to address this issue [23]. Their results show overweight has a significantly negative role to play on young students and can interfere with their learning. The authors point out that at the end of 2 years other factors became more important, such as mother's education and SES, but they also state that later effects on learning and academic success are in need of further study. Because the relationship between scholastic achievement and obesity is so poorly investigated, there is significant work to be done in this field. The experience of children learning in school is complex and an obese child faces biologic and social barriers which add to the already challenging dynamics in schools.

However, there are very little data available in the area of school performance and the influence of weight-related factors.

Point of intervention

Two central public health concerns drive the need for effective interventions: the immediate health of children and the imminently crushing blow that is coming to health care systems and developing economies due to high rates of chronic disease. There is intense interest in which leverage points will reverse the current upward trends. Programs designed to prevent obesity must be structured at a variety of levels, from local to global in application, but considering the increased rates, efforts thus far have returned weak results. Although the prudent management, utilization, and allocation of a nation's health care services play an important role in the prevention of illness and disease and the promotion of individual and community well-being, they may not be the primary factors that will contribute to reducing this particular epidemic [24]. Consequently, governments and policy makers who have focused resources solely on healthcare systems as the means of improving the health, should weigh the practical alternative of the family unit as a potential health-promoting entity [3]. The significant difference at the local level is that the family unit that offers a physically and emotionally protective environment for children and it plays a central role in promoting a healthy lifestyle [2]. This is, however, a multilevel approach as well; for the family unit to be productive, it requires substantive inputs at the societal and governmental levels [13]. The difficulty, however, lies in how to convince policy makers of the major contributions it can make to the health of families and the nation.

The mother/manager

Innovative interventions are needed that are specifically designed to reach and change children's lifestyle behaviors. The habits, actions, and environment of the family perhaps have the most leverage in this regard [25]. In developed nations, the role of gatekeeper has shifted to childcare providers, media messages, and schools, but in the developing world the traditional role of the mother as home manager has remained intact [26]. Policies and guidelines at national and global levels have important impact on setting tone and standards which support family efforts but are more indirect in their effect [3]. It is, however, the immediate day-to-day experience of children that provides the foundation for nutrition habits and practices [27]. Parents themselves can be predictors of overweight in their children without being aware of it [28]. Children are at greater risk for obesity if their parents are obese [29, 30], not owing to genetic factors, which are thought to be less significant, but because families tend to share eating and activity habits [28].

Accepting the mother as the primary care provider within the child's nuclear environment places the mother as the guardian of the family's resources which may be a viable alternative to the types of health-promotion efforts found in past models [31]. This framework may be most relevant in the context of changes in a developing nation since it is inherently tailored to local needs of health promotion based on the household input. Most developing nations are adapting institutions to modern times and changing health care needs and it is the time to integrate a family-based approach as an efficient method for stemming and preventing childhood obesity. The mother as manager will need to be supported in skill acquisition for constructive parenting and effective use of her resources and choices [32]. Mothers as central figures of change will have the strongest result when partnered by government and community in legislation, information, and education.

The concept of reinforcing the power of mothers as managers of the household strengthens the already existing cultural and social structure, but is not without challenges. The status of women in many countries is an important issue. In many countries, women continue to be viewed as unequal members of the society, are less likely to be educated, and have limited participation in the decisions that affect the running of households. Additionally, males in some cultures in the developing world may control a woman's access to money, food, healthcare, and management of her children [33]. Yet, this hierarchical system does not successfully promote the health of families. A great deal of headway can be made in both obesity and the burden of communicable diseases by formalizing the already informal role women fill. For example, a 25-year study in 63 developing countries found that the social status of women and education explained more than 50% of the reduction in childhood malnutrition [34]. In concert with the principles of Education for All, educating girls and women is central to the potential for breaking the cycle of deprivation and marginalization that helps to keep women and their children in poverty and ill health, particularly in developing countries [35]. The data are not so extensive for obesity in children at this point but the research on family-based approaches is promising. Policies designed to address health at the family level by recruiting the mother as manager, and the participation of all family members, can only have a meaningful and long-term effect on the health of children and families, and benefit the nation overall. As recognized authorities in their own homes, with training and knowledge as tools for reducing obesity in their own environments, mother/managers have the potential for making a dramatic difference in obesity rates in children.

Conclusion

The twentieth century can be credited with many successes toward improving the health of schoolchildren; however, the new century brings with it the challenge of increasing rates of obesity and chronic disease for all ages. Many countries continue to face undernutrition and nutrition deficiencies as well. These must be dealt with simultaneously, not be minimized by the overwhelming size of the epidemic, for they too are an important part of the obesity crisis. Malnutrition in the form of overnutrition in children is now the major public health concern of our time.

The impact of weight gain is not only associated with immediate consequences at young ages, but in the long term as well, because risk factors likely persist into adulthood, leading to poor health associated with chronic disease and premature death [30]. To turn rising rates around, prevention is the key. Nutrition appears to be the most modifiable determinant of overweight problems and chronic disease. The risk factors for weight gain center on energy intake and expense, but have a complex relationship with the environment. If children can be reached early, in their homes, and supported by community and government strategies, it may be possible to reduce the rates on a grand scale. Obesity in children is not well researched, especially in developing countries. One strategy that appears to have effect is a family-based approach. A systemic recognition of mothers as managers of household matters strengthens existing local and cultural structures and provides intimate, informed influence over even the youngest child's diet, habits, and activity. With preparation and investment at micro and macro levels, obesity rates may be curbed and healthy lifestyles promoted. A clear policy objective should be one that enhances the role of women as producers of a healthy family unit, and assures them a greater participatory role in the management, allocation, and utilization of household and state resources.

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Nutrition education: It has never been an easy case for Indonesia

Judhiastuty Februhartanty

Abstract

The root of Indonesian education can be traced back to the Dutch colonial period. The country adopts the 6-3-3-4 system of education, which consists of public schooling, Islamic schooling, and out-of-school education. In addition, the country has also been exposed to distance education. The call for this type of education was due to the geographic condition of Indonesia where face-to-face instruction has become limited. Studies on nutrition education in Indonesia covered various topics and teaching methods that were delivered mostly in after-class sessions. Effects on improved knowledge and attitudes were more marked than that of practices in relation to each nutrition topic. Nutrition and its related topics are delivered separately in different school subjects, such as biology, sport, health science, and home economics. Moreover, as the country keeps developing malnutrition problems, the Indonesian government through the Ministry of Health has run a feeding program that covers only children in elementary school aged 6–12 years old both in urban and rural areas. Efforts from private sectors and NGOs on the feeding program for schoolchildren seem to give complementary effects to the existing program. Human resources development of nutrition professionals was started in the early 1950s when a school for food scientists was first established. However, the professionals responsible for delivering nutrition-related topics in the school are the schoolteachers who mostly have never received relevant training for delivering such topics. For achieving effective children's nutrition education through schools, a solid partnership among stakeholders must be encouraged.

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Key words: Nutrition education, children, partnership, Indonesia

Indonesia profile

Indonesia is a country made up of about 17,000 islands, stretching across some 3,200 miles of equatorial oceans. It is the fourth most populous country in the world, with 209 million citizens of whom approximately 36% are children under 15 years of age. The education attainment of the people is relatively low. Approximately 70% of residents have attained only a primary school education or lower. Approximately 60% of the population lives in Java Island. The range of human development of more than 500 ethnic groups of the country is very wide. It ranges from children in big cities who play computer games and even have Internet access, to those who still live in traditional ways in the middle of tropical rain forests [1]. And in 2002, Indonesia's Human Development Index ranked 110th out of 173 countries assessed.

The most common nutrition disorders in Indonesia are presented in **table 1**. The most common nutrition problem encountered by school-age children is stunting [2].

TABLE 1. Common nutrition disorders among children in Indonesia [2]

Affected groups	Type of problem
Newborn babies	Low birthweight
Children under 5 years of age	Underweight
School-age children	Stunting
Teenager, reproductive-aged	Chronic energy malnutrition
All groups at emergency	Wasting

Education system in Indonesia

Figure 1 shows the system of formal education in which Indonesia adopts the 6-3-3-4 system of education that includes 6 years in the elementary, 3 years in the junior secondary, 3 years in the senior secondary, and 4 years in the university/tertiary levels. This system consists of public schooling, Islamic schooling, and out-of-school education [1].

Table 2 suggests that approximately 70% of the population is not in school anymore. It also shows that the ratio of male to female students is almost equal although it tends to decrease as education level increases [3].

Private institutions contribute significantly to the provision of education. The share, however, varies according to the level of education. Data shows that starting from primary education, the higher the level of

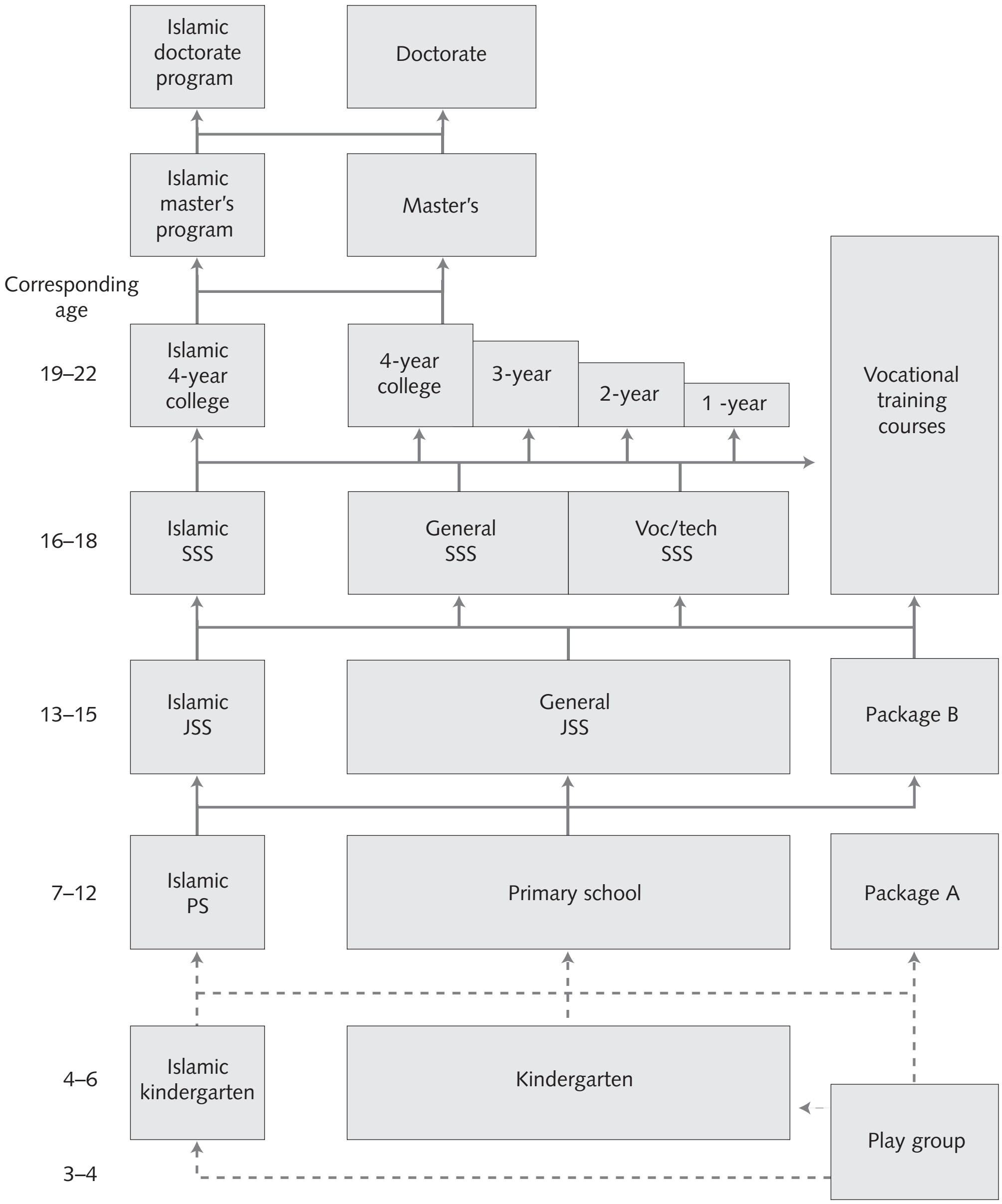

FIG. 1. The system of formal education in Indonesia. Paths indicated by --▶ are not prerequisites for access to a higher level of education. PS, primary school; JSS, junior secondary school; SSS, senior secondary school.

education, the bigger is the share of the private institutions (**table 3**).

Furthermore, preschool education consists of early childhood development programs and kindergarten. Early childhood programs are provided through government-sponsored Integrated Health Service Posts (in Indonesian language: Pos Pelayanan Terpadu, abbreviated as *posyandu*) and Learning Activities Center (BKB) for less fortunate children, and privately initiated play groups for more affluent ones. The *posyandu*, however, are more focused on providing health and nutrition-related services to children under 5 years old and to their mothers. The BKB and play groups, the services of which are more related to education, are still in their infancy. It is reported that the BKB provided service to a few million children in 1996 and play groups to slightly more than 6,000 children in 1997 [1].

Kindergarten has an older history than BKB and play groups. The role of private sectors in providing this type of education was very significant. However, the availability of kindergartens is limited. They are less likely to be available in the rural area.

Indonesia applies one national curriculum to ensure that all students receive similar education at each level of education. In the past few decades, curriculum improvement was done about every 10 years. However, owing to rapid changes in the education environment, starting with Curriculum 1994, the improvement is done gradually and continuously, and does not have to wait for 10 years [1].

To address the diverse local needs, a local content of the curriculum of approximately 20% was introduced in 1994. An example of this is the introduction of a subject on local language. Because there are limited curriculum developers, appropriate textbooks, and qualified teachers, most local content is developed at the provincial level. Therefore, the local content is under the supervision and decision of the local education offices [1].

A parallel system to primary and lower secondary schooling was developed to provide education opportunities for geographically and/or economically less fortunate children. It consists of the Package A program (previously designed for adult literacy) and Package B

TABLE 2. Percentage of population over 10 years old by areas, sex, and educational level [3]

Area	Never/not yet attended school	Attending school				Not currently attending school
		Primary[a]	Junior[b]	Senior[c]	University[d]	
Urban						
Male	2.56	8.39	7.60	6.57	3.27	71.62
Female	7.34	7.42	7.27	6.18	2.69	69.11
Total	4.99	7.89	7.43	6.37	2.97	70.34
Rural						
Male	8.27	11.03	6.02	2.54	0.37	71.78
Female	17.78	9.72	5.41	2.22	0.30	64.57
Total	13.08	10.36	5.71	2.38	0.34	68.13
Urban and rural						
Male	6.10	10.03	6.62	4.07	1.47	71.72
Female	13.79	8.84	6.12	3.73	1.21	66.30
Total	10.00	9.42	6.37	3.90	1.34	68.97

a. 6-year elementary school, including Islamic education system (Madrasah Ibtidaiyah)
b. 3-year junior high school, including Islamic education system (Madrasah Tsanawiyah)
c. 3-year senior high school, including Islamic education system (Madrasah Aliyah)
d. Including non-degree and degree programs

TABLE 3. Number of students and the proportion of private institutions' enrollment in 1998/1999 [1]

Type	Enrollment number	Private school enrollment (%)	Number of schools	Private school (%)
Kindergarten	1,585	99.1	40,669	99.5
School for the handicapped	38	92.4	876	96.7
Primary education	25,688	7.2	151,042	8.8
Junior secondary	7,565	30.5	20,960	50.5
Senior secondary	4,689	52.7	12,009	70.4
Tertiary education	2,691	56.5	1,526	95.0

program, which are equivalent to primary and junior secondary education respectively. Teaching-learning processes are mostly replaced by self-studies in these programs [1].

Out-of-school vocational training consists of three types: private vocational training courses, vocational training centers, and apprenticeships. The length of these programs varies from 1 month to 2 years and covers a wide variety of vocations, such as art/crafts, English, culinary, and motorcycle repair. It is reported that there were 22,215 private courses and 119,421 apprenticeship programs in 1998 [1].

Since 1950, Indonesia has been exposed to distance education. There are five government institutions that are responsible for the development and implementation of distance education [4]. They consist of the following institutions:

1. *Pusat Penataran dan Pengembangan Guru or PPPG-Tertulis* (National Center for Teacher Training and Development by Correspondence) established in 1950.
2. *Pusat Teknologi dan Komunikasi untuk Pendidikan or PUSTEKKOM* (National Center for Communication Technology and Information for Education) formed in 1974.
3. *Universitas Terbuka or UT* (The Indonesian Open Learning University) established in 1984.
4. The SEAMEO Regional Open Learning Center or SEAMOLEC officially formed in 1997.
5. The Indonesian Distance Learning Network or IDLN formed in 1993.

TABLE 4. Nutrition status of children under 5 years of age based on weight-for-age z-score (WAZ) [5]

Year	Severe underweight (WAZ < –3 SD)	Moderate underweight (–3 SD ≤ WAZ < –2 SD)	Normal (–2 SD ≤ WAZ < +2 SD)	Overweight (WAZ ≥ + 2SD)	N
1989	6.30	31.17	61.76	0.77	14,101
1992	7.23	28.34	63.17	1.26	33,744
1995	11.56	20.02	65.21	3.21	26,188
1998	10.51	19.00	67.33	3.15	25,620
1999	8.11	18.25	69.06	4.58	78,854
2000	7.53	17.13	72.09	3.25	70,602
2001	6.30	19.80	71.10	2.75	11,693
2002	8.00	19.30	70.50	2.20	74,537

SD, standard deviation

TABLE 5. Nutrition status of children under 5 years of age based on height-for-age z-score (HAZ) from limited studies [5]

	< –2 SD				< –3 SD			
Source	1990	1992	1995	1999	1990	1992	1995	1999
IBT (4 provinces)	44.8				18.6			
Boys	47.3				20.1			
Girls	42.3				17.1			
Suvita (15 provinces)		41.4				15.4		
Boys		42.5				15.6		
Girls		40.3				15.1		
SKIA (national)			46.9				25.1	
Urban			37.6				18.2	
Rural			50.2				27.6	
Boys			47.5				25.9	
Girls			46.3				24.3	
Evaluation study of Social Safety Net on Health (5 provinces)				49.3				23.7
Urban				43.9				20.2
Rural				51.3				25.0

SD, standard deviation

Children's nutrition situation in Indonesia

Table 4, **table 5**, and **table 6** show the prevalence of underweight and stunting among children under 5 years of age and among school-aged children. Indonesia applies weight-for-age index as the national indicator for nutrition status in children under 5. However, based on limited studies, nutrition status of these children based on the height-for-age z-score (**table 5**) reflects that the prevalence of moderate stunting was approaching 50% in 1999.

Furthermore, school-age children who were experiencing moderate chronic malnutrition (stunting) decreased only by 3.7% from 39.8% in 1994 to 36.1% in 1999 (**table 6**). This suggests that the problem is less correctable; therefore, it calls for comprehensive preventive efforts.

Total goiter rate (TGR) among children aged 6–9 was 30% in 1980 and decreased to 9.8% in 1998. However, the percentage households consuming adequate iodized salt (> 30 ppm) was reported to be 68.4% in year 2002. Iron-deficiency anemia among 6- to 12-year-old children was 47.2% in 1995 based on the results of Household Health Survey in 1995 [5].

The causes of macronutrient and micronutrient deficiencies are mainly the following: (1) household food insecurity where 40% of the households consumed less than 70% of the recommended dietary allowance (RDA) for energy; (2) poor exclusive breastfeeding practices (by early introduction of other food) in 12%–54% of the population according to an Indonesian national survey; (3) low quantity and quality of complementary feedings, e.g., low energy, low micronutrients, low vitamin A; and (4) poor child-caring behavior as indicated by low rate (approximately 33%) of mother participation in *posyandu* [2].

What has been done?

Posyandu, as mentioned earlier, is the foremost community empowerment program in terms of health and nutrition, and it is designed to be available at the sub village level with all cadres (volunteer health workers) coming from the community itself. At the beginning of this program, *posyandu* is designed to have a five-table-service system, in which table 1 covers registration activity, table 2 weighs children under 5 years of age, table 3 records measurement results, table 4 provides nutrition counseling to mothers, and table 5 covers activities such as immunization, family planning, and/or other health services. However, these services are diminishing notably, especially services in table 4 and 5. This is probably owing to a lack of intensive training for volunteers to improve their nutrition counseling skills. In addition, people tend to go to private doctors or other private health providers to get consultation on immunization and family planning. Data from the Department of Health in 1998 shows that the number of *posyandu* across districts diminished from 250,025 in 1995 to 244,107 in 1997, and the percentage of active *posyandu* was only 22.3% [6]. This situation is quite shocking, because within a 2-year period approximately 5,000 *posyandu* were considered collapsed. However, law no. 411.3/1116/SJ, developed by the Department of Internal Affairs and Regional Autonomy (dated June 13, 2001) is focused on *posyandu* revitalization and includes the development of a training handbook for *posyandu* volunteers developed jointly by Department of Internal Affairs, Department of National Education, Department of Health, National Family Planning Coordination Board, and UNICEF. The refreshment trainings for *posyandu* cadres are reinforced at village level. There are four supportive elements to *posyandu*: (1) the *posyandu* itself; (2) volunteers or cadres (voluntary health workers); (3) *posyandu* motivator (e.g., from health centers and community leaders); and (4) community as *posyandu* users. These four elements are interrelated and must be in place to achieve a successful *posyandu*. However, the issue now is that the volunteers feel overburdened with the tasks they have in *posyandu* since their tasks cover a wide range of activities on and beyond the day of *posyandu* service.

The school-feeding program is a program under presidential regulations; therefore, it uses the government's budget. In general, the program is aimed at improving the nutrition status of the schoolchildren and improving the economic situation of the community. The requirements on the form of the food given to the schoolchildren are the following: (1) the food should be in the form of a snack, not a complete meal, (2) the food should use local foodstuffs, and (3) the food should be a snack commonly consumed by the community. In the preparation of the snacks, the program involves community, schoolteachers, and nutritionists from health centers. The program covers only children in elementary school who are aged 6–12 years, from both urban and rural areas and provides the following: deworming tablets twice a year and a snack twice a week. The snack was initially planned to be distributed to the children minimally for 108 days in a year, but due to budget constraints it is distributed for 90 days in a year. It must have 300–400 kcal

TABLE 6. Nutrition status of 5- to 9-year-old children based on height-for-age z-score (HAZ) [5]

	< –2 SD		< –3 SD	
Sex	1994	1999	1994	1999
National	39.8	36.1	10.7	9.1
Boys	43.1	40.1	13.0	11.1
Girls	36.3	32.5	8.2	6.9

SD, standard deviation

and at least 5–9 grams of protein. However, in reality only 60% of these requirements are met. In the year 2000, the school-feeding program covered 9.8 million schoolchildren in Indonesia. But since 2001, only 30% of districts across Indonesia implement the program. This might be due to economic constraints in which the budget for such a program is decreasing so that the community cannot continue the program by itself. And no further action seems to be taken yet.

A school-feeding program from an American NGO in collaboration with the Department of National Education Republic of Indonesia provides the Milk for School Health Program (*Program Susu UKS)*, which in 2003 distributed nutrient-enriched milk and/or biscuits to 580,000 schoolchildren, three times a week to approximately 2,900 primary schools (public and Islamic) in 70 districts in nine provinces.

To monitor schoolchildren's nutrition status, the Department of Health, since 1994, has administered a program called "schoolchildren's height measurement." The measurement is conducted by schoolteachers in a sample of schools and among first grade elementary students. A pilot project has been made to strengthen this schoolchildren's height monitoring activity with the involvement of the Center of Physical Quality Development, Department of National Education Republic of Indonesia, and the private sectors. This group has attempted to develop growth charts for children entering school.

Some limited studies address iron supplementation [7] and/or fortification [8], which have not led to a significant decrease in the prevalence of anemia among schoolchildren. A recent study is using the supplementation of multi-micronutrient regimens among schoolchildren in Jakarta and the intervention is still going on at the current time.

Overall, the government of Indonesia through the Ministry of Health established a mechanism for achieving Healthy Indonesia year 2010, as shown in **figure 2**. The foremost aspect of this approach is the family called *Kadarzi* for *Keluarga Mandiri Sadar Gizi* (household that cares for the nutritional status of its family members). The concept is that families are empowered to be able to identify their own nutritional problems and find possible solutions within their own resources. The forces for family empowerment are directed from community mobilization, *posyandu* and other existing channels (e.g., community gatherings, religious meetings) in the community. In this sense, the roles of community leaders, cadres and other volunteers (considered the "insiders") become crucial and expected to more dominant compared to the roles of the health service providers (the "outsiders").

Nutrition education

With regard to nutrition education in formal school, the Department of National Education usually asks for inputs from other related sectors when developing a curriculum. Specifically for nutrition education, the Department of Health is the relevant sector to give suggestions. However, the final decision is the responsibility of the Department of National Education. From informal interviews, it was found that topics covering nutrition for children are included in various school subjects, such as biology, sport, health science, and home economics, and given in small portions. This fact is more evident after the establishment of the Law no. 22 in 1999 on Local Government. This mandates

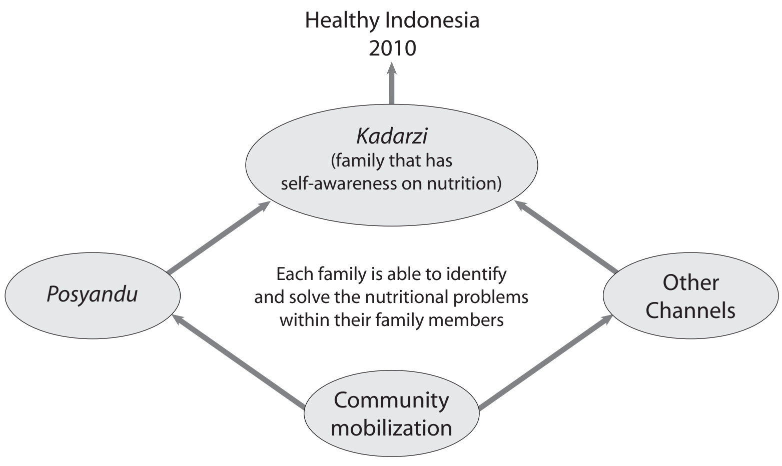

FIG. 2. Nutritional improvement program for Healthy Indonesia 2010. *Kadarzi, Keluarga Mandiri Sadar Gizi* (household that cares for the nutritional status of its family members); *Posyandu, Pos Pelayanan Terpadu* (integrated health post available at sub village level).

that central government has less influence than governments at provincial levels, as they are encouraged to utilize an optimum level of their local resources. This law also affects physical education lessons. Basically, from grades 1 through 9, physical education lessons are included in each school's curriculum, whether in the form of classroom theory or outdoor practices.

With regard to personnel who deliver nutrition- and health-related topics in the aforementioned school subjects, interestingly, they are the schoolteachers who mostly have never received relevant training for delivering such topics. This is an alarming situation to which the government of Indonesia should give consideration and take action.

Some limited studies in many countries have found that nutrition education was proven to be effective in influencing knowledge and attitude, but was less effective in influencing practice among the school-aged subjects. A limited study among female adolescents in Indonesia yielded similar findings [9]. Unfortunately, these studies were employing nutrition education sessions conducted after class. This explains that such impact on practices requires more integrated and continued efforts.

Furthermore, professionals who are working in the field of nutrition education are normally those with communication backgrounds. It is fortunate that in some cases they also pursue higher study or take short-term courses in the field of nutrition and health, so that the knowledge can be combined or merged. Many graduates from the communication field are pursuing master's degrees in community nutrition or public health. In other cases, those with community nutrition or public health backgrounds continue their studies in the field of nutrition and health promotion. This would only happen when their job is related to nutrition and health education.

Interestingly, the human resources development of nutrition professionals in Indonesia was started in the early 1950s when a school for food scientists was first established. The development of the education system for this field of expertise is observable through two streams, i.e., vocational training and formal courses in the university. The nutrition science is fragmented into three disciplines: clinical nutrition, community nutrition, and dietetics [10]. Some vocational training in health-related subjects is available in government institutions. They range from training in the level of senior secondary school to 1- to 2-year academies. The subjects cover nursing, dental nursing, nutrition, electro-medic techniques, pharmaceuticals, physiotherapy, mental nursing, midwifery, anesthetics, and others [11].

How nutrition education can be effective for combating nutrition problems among schoolchildren

Nutrition education should operate on the basis that new ideas, services, or products can best be introduced if the intended beneficiaries see them as fulfilling their own aspirations and well-being. People will not accept new ideas and technologies designed solely from the experts' concepts [7]. A thorough understanding of why beneficiaries do not accept new ideas should be in place. The perception that every target beneficiary is unique, and, therefore, the program requires a unique approach, should also be borne in mind. For schoolchildren, teachers, parents, and peers are the best known gatekeepers. Training on facilitation skills for schoolteachers in delivering nutrition and its related topics should also be addressed.

Nutrition education through communication for behavior change may be directed to several nutrition-related objectives, such as improved feeding or caring practices and compliance with supplementation regimens, among others. It may also be employed as a complementary strategy alongside, for example, supplementary feeding or growth monitoring [7].

Furthermore, sustained and constructive collaboration among nutrition education stakeholders, i.e., Department of Health, Department of National Education, NGOs working for the improvement of the schoolchildren's well-being, schoolteachers, community leaders, and, most important, family, should be strengthened and given priority for nutrition education to work best. School management, on the other hand, should be encouraged to provide a school environment that is conducive to healthful behaviors.

Conclusion

In Indonesia, nutrition education delivered in formal schools needs further review specifically in terms of (1) the topics and school subjects in which nutrition is a component, (2) the personnel delivering the topics, (3) the readiness of the school management for providing a conducive teaching-learning process, (4) coordination between the Department of Health (as the stakeholder that provides relevant topics) and the Department of National Education (because the schools are under this department's authority), and, lastly, (5) the commitment of the government of Indonesia to establish health-promoting schools in Indonesia. All of the above components are more easily said than done. However, with one objective of achieving effective nutrition education for children through schools, a solid partnership among stakeholders should really be encouraged.

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Schoolteachers' awareness about scholastic performance and nutritional status of Egyptian schoolchildren

Osman M. Galal, Ibrahim Ismail, Azza S. Gohar, and Zoë Foster

Abstract

Malnutrition disorders affect more than 30% of schoolchildren in Egypt. This problem appears to be largely attributable to poor dietary quality and micronutrient deficiencies, such as iron and vitamin A. Inadequate nutrition intake has important implications because malnutrition has been shown to negatively affect the cognitive development of primary schoolchildren. This study assesses the awareness of schoolteachers about the impact of malnutrition on the scholastic performance of primary schoolchildren living in Egypt. Two focus group discussions were conducted with Egyptian schoolteachers from the Quena and Kharbia Governorates. The study indicates that schoolteachers consider low body weight and thinness as the primary signs of malnutrition. They do not prioritize malnutrition as a factor for poor scholastic performance. They also suggest that unhealthful eating habits, especially a lack of breakfast, negatively affect children's interaction with schoolteachers and their ability to excel in their studies. Schoolteachers endorse a more reliable and nutritionally valuable school-feeding program as a way to increase the scholastic performance of their students. The teachers advocate developing integrated programs between the Ministry of Education, the Ministry of Health and Population, teachers, children, and parents that provide nutrition education. A lack of awareness among teachers about the relationship of nutrition and cognitive function can lead to the misdiagnosis or delayed management of malnourished and scholastically challenged schoolchildren. This paper suggests that proper school-feeding programs and nutrition education programs, which integrate government ministries, teachers, children and parents, should be developed to improve the physical and cognitive health status of Egyptian schoolchildren.

Key words: Schoolteachers, malnutrition, cognitive development, Egypt, scholastic performance

Introduction

Malnutrition disorders affect more than 30% of schoolchildren (ages 6–12) in Egypt [1]. Poor dietary quality among children is rapidly becoming a bigger concern because Egypt is characterized by a young age structure, with approximately 43% of the population less than 18 years of age [1]. Iron-deficiency anemia is the most common nutrition problem; however, sub-clinical vitamin A status and other micronutrient deficiencies are also prevalent. This reality has important implications because malnutrition has been shown to negatively affect the cognitive and intellectual development of children [2]. The physical effects of nutrient deficiencies in schoolchildren have been documented, yet very little is known about the cognitive and psychologic abilities of young Egyptian children [3]. Moreover, while there exists some evidence that the education of parents about proper nutrition will lessen rates of malnutrition among their children, there have been relatively few studies that explore the perceptions of schoolteachers about the cognitive development of primary schoolchildren. This oversight is significant because, like parents, schoolteachers may also be in a position to promote positive health practices in their classrooms. Thus, there is a critical need to document schoolteachers' current base knowledge and perceptions of nutrition as they relate to the cognitive function of primary schoolchildren. In doing so, education programs for teachers may be designed and implemented to enable them to detect the first signs

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of delayed cognitive development that their students may exhibit.

The purpose of this paper is to present data on the perceptions and opinions of schoolteachers living in the Quena and Kharbia Governorates of Egypt, about the impact of malnutrition disorders on the scholastic performance of Egyptian primary schoolchildren. It employs focus group discussion (FGD) techniques to gain a broad understanding of schoolteachers' attitudes about the health of schoolchildren. The methods and target population will be presented first. This will be followed by a description of results from the FGDs, focusing on the perceptions of Egyptian schoolteachers about the following eight subjects: (1) the main causes of learning disabilities among schoolchildren; (2) breakfast-leave (not having breakfast before going to schools); (3) current school-feeding programs; (4) nutrition knowledge of schoolteachers; (5) child activity and scholastic performance; (6) signs of childhood malnutrition; (7) causes of school absenteeism; (8) the role of schoolteachers in nutrition education programs. The results from the focus group discussions will then be discussed. Finally, recommendations will be made regarding future steps in the effort to address the issue of malnutrition and cognitive development in school settings.

Background

One-third of women and children living in Egypt fail to meet 50% of the recommended dietary allowance (RDA) for iron, calcium, vitamin A, serum retinol, and other micronutrients [4]. In 1998, the National Nutrition Institute (NNI) conducted a nationwide study to identify the nutrition deficiencies among the primary schoolchildren. While the study indicated numerous micronutrient deficiencies, iron intake stood out as the most serious. This is of concern as data indicates that low iron stores are the likely cause of anemia in most individuals [5]. In fact, a study found that 42.6% of boys in both rural and urban areas, 44.5% of girls in rural areas, and 38.2% of girls in urban areas were suffering from anemia. In addition, deficiencies in serum retinol were found to be more common among girls than boys, with percentages ranging from 6.4 in capital areas to 14 in the Upper and Lower Egypt governorates [6].

Nutrition is a major environmental influence on physical and mental growth and development in early life. Poor dietary quality during early childhood can stunt the basic cognitive and physical abilities from developing properly. This is a serious problem because these abilities create a foundation upon which the development of skills in later stages of childhood rest [2]. For many years, scientists have considered the connection between nutrition and intellectual development to be straightforward [7]. Numerous studies support the idea that proper nutrition contributes to a child's ability to learn and demonstrate superior scholastic performance [2]. One such study suggests that maintaining high levels of three micronutrients—vitamin A, iron, and iodine—is vital for the development of normal learning and cognitive functions [8]. Another argues that iron-deficiency anemia is a risk factor for poor education performance in schoolchildren [9]. Finally, in addition to malnutrition, children who skip breakfast regularly and feel hungry at school also demonstrate inadequate scholastic achievements [10].

To combat malnourishment among schoolchildren, there exist three areas for nutrition intervention in schools: direct nutrition care in a school-based health clinic, school meals, and nutrition education in the classroom and of school staff [11]. Health promotion in all three areas can enhance knowledge about proper nutrition and endorse a change in the eating habits of school-age children. However, to do so, it is necessary for health workers, schools, and communities to work together. A range of options needs to be considered when designing an effective and appropriate school-based program [12]. Numerous studies suggest that multiple intervention components, such as behavioral education in schools coupled with community-wide health promotion strategies, can produce modest but lasting improvement in adolescent knowledge [13]. However, the success of school health education programs is often dependent on schoolteacher implementation [14]. Therefore, to encourage long-term behavioral change in the nutrition intake of children, it is essential that schoolteachers be educated in the areas of childhood health and nutrition, as well as in how to teach nutrition education classes to their students [15].

Methods and target population

The FGD method is unique in terms of its purpose, size, composition, and procedures. FGD attempts to tap into the participants' attitudes and perceptions relating to concepts, products, services, or programs, in part through their interaction with others in the group [16]. The FGD is effective because it encourages participant interaction which often brings forth ideas, reactions, opinions and comments that may not be obtained through a process of individual interviewing [17]. This study employed FGD and was led by a moderator who used a pre-designed set of questions (the moderator guide). Two focus groups were interviewed (each group $n = 11$), one in Quena governorate, which represents the southern area of Egypt, and one in Kharbia governorate, located in the northern part of Egypt. The teachers were selected randomly from different primary schools in both urban and rural areas of each governorate. Male and female teachers took part in the discussions (70% and 30%, respectively). The teachers taught various subjects including math, the Arabic language, science, physical education, music, and art. Their ages varied from 25 to 45, and their number of years teaching ranged from approximately 3 to 15. The FGD in Quena governorate was conducted in a primary school classroom, and the FGD in Kharbia governorate was conducted in a Program Planning and Monitoring Unit (PPMU) office. The discussions were tape recorded, after each participant gave his or her consent. Each discussion took approximately two and one half hours.

Results

(1) The main causes of learning disabilities among schoolchildren

The majority of the schoolteachers did not consider malnutrition to be related to poor scholastic achievement of primary schoolchildren. Rather, they maintained that the main causes of poor scholastic achievement were overcrowded classrooms, badly maintained school environments, the education level of the parents (especially the mothers), and parent interest and interactions with teachers. Nutrition causes were the last to be mentioned by the schoolteachers.

(2) Breakfast-leave

The schoolteachers believed that breakfast-leave (not having breakfast before going to school) was the main connecting factor between nutrition and the scholastic achievement of schoolchildren. When the moderator suggested malnutrition as a possible cause of poor scholastic achievement, the first thing that the schoolteachers mentioned was the effect they noticed in their children who skipped breakfast before school. The teachers all agreed that the students who go to school without breakfast, (compared with those who do) are more lazy, inactive, and less participatory in class. Most of the teachers agreed that the children who feel hungry in the first class, especially the younger ones, become irritable and attempt to eat, which, the teachers felt, disturbed their focus on the lessons.

From the teachers' point of view, one of the causes of breakfast-leave was due to lack of awareness among parents regarding the relationship between the breakfast and scholastic achievement. The teachers reported that rural schoolchildren eat breakfast more regularly than urban ones because the rural mothers generally care more and have more time to feed the children in the morning compared with working mothers.

When asked by the moderator if the teachers had any suggestions for encouraging children to eat breakfast, some recommended that 10 minutes every morning should be set aside to allow the children time to eat their breakfast. The rest agreed that this time should only be taken if a school-feeding program exists so as to overcome the economic differences between schoolchildren.

(3) Current school-feeding programs

Most of the teachers believed that the current school lunch program (fortified school biscuits) was insufficient, inadequate, and ineffective in providing children with sufficient dietary needs. They speculated that the school biscuits were not nutritionally valuable and of poor quality. In addition, these teachers doubted the distributor's procedures and motives regarding the provision of biscuits.

Despite the vast majority of teachers agreeing with the previous opinions, some disagreed, saying that they felt that the biscuit was a good idea and that it was acceptable to students. An interesting observation was made by the teachers working in rural areas. They explained that they appreciated the provision of school biscuits because they noticed that the absentee rate of the schoolchildren decreased when they were regularly distributed. To cover the problem of irregular distribution and insufficient resources to supply school biscuits to all schoolchildren, the schoolteachers suggested providing the school biscuit to primary schoolchildren only, because they thought that eating a school lunch was more important for this age group.

The disagreement between those who encouraged the school biscuit and those who did not was further exemplified when the moderator suggested that home economic teachers could prepare fresh daily meals for the students. This opinion was encouraged by those who opposed the school biscuit and was discouraged by those who believed that the fortified school biscuit was safe, clean and effective. Some teachers suggested the option of distributing other foods, such as cheese and bread.

(4) Nutrition knowledge of schoolteachers

Regardless of those with a background science, the schoolteachers' overall knowledge of nutrition was very limited and nonspecific. The two groups were unable to identify any of the nutrition needs of schoolchildren, nor an appropriate diet for them to consume regularly. Despite their limited nutrition knowledge, the schoolteachers did demonstrate a willingness to improve their understanding through specific training programs and school activities.

When asked about general dietary patterns of people in both governorates, the teachers explained that the meals were relatively simple, with little variety or variability (one-dish meals). They added that the dietary habits differ between urban and rural communities in both governorates. The breakfast in rural areas always included drinking milk (when it was accessible) and the meal usually consisted of leftover suppers, including cooked vegetables or rice.

(5) Child activity and scholastic performance

All teachers agreed that there are two types of hyperactive child, hyperactive with good behavior in schools and hyperactive with bad or naughty behavior. They found that, generally, "the hyperactive child was usually the most intelligent." In fact, several teachers from Quena governorate reported that one of the best students in that governorate was naughty and hyperactive, but was also disciplined, polite, and showed no aggression towards his classmates. The teachers of music and arts claimed that the hyperactive children in their classes were particularly competent in music and arts. Some teachers observed that the quiet child in class usually had some family problems or were hungry, and that they often became active when they ate. Nevertheless, none of them believed that there was any relationship between malnutrition and the activity levels of the schoolchildren.

(6) Signs of childhood malnutrition

When the moderator requested that the schoolteachers enumerate physical signs or symptoms of malnutrition, they described thinness or loss of weight. They believed that other signs, such as pallor white spots, were caused by other factors. The teachers described the characteristic features of malnutrition in schoolchildren as easily fatigued, inactive in class, showing general weakness and loss of concentration, as well as experiencing recurrent headaches.

(7) Causes of schoolchild absenteeism

The most common causes of school absenteeism the schoolteachers noted were family poverty ("the child works to get money for his family"), being afraid of his or her teacher or of an exam, learning difficulty, and sickness. The teachers did not mention malnutrition as a direct cause of school absenteeism.

When asked what the most common diseases affecting children were, the teachers mentioned parasites, eye inflammation, hepatitis, and recurrent headaches. Again, they did not list malnutrition as a direct cause affecting school absenteeism.

(8) Role of schoolteachers in nutrition education programs

The moderator asked both focus groups to discuss how they envisioned their role as schoolteachers in the prevention of malnutrition among children. They agreed that their role was essential because the teacher is a model for his or her students. In fact, they felt that their position was often more influential than the children's parents and that they could easily encourage the schoolchildren to maintain good nutrition habits, such as eating breakfast daily. However, the teachers were aware that some parents may be reluctant to diagnose their children as malnourished, and while the teachers could advise the family, the parents may not cooperate for several reasons, such as a lack of money for food.

The schoolteachers suggested that to improve the nutrition status of schoolchildren teacher training, parent awareness, nutrition education for schoolchildren, and a dependable and nutritionally valuable school-feeding program would be effective. However, they did express concern that such programs would be burdensome to the school curriculum.

Discussion

The focus group discussions with the schoolteachers of both governorates in Egypt demonstrated that they did not consider malnutrition as a primary cause for poor scholastic performance. While the teachers were able to describe some physical and characteristic signs and symptoms of malnutrition (weight loss, general weakness, loss of concentration, and recurrent headaches), they did not seem to think those signs applied to the symptoms some their students exhibited. For example, the teachers listed recurrent headaches as a main cause of absenteeism, yet did not consider this symptom to be a result of malnutrition. It appears that this discrepancy may be due to insufficient nutrition education on the part of teachers.

Despite their lack of information about the role of malnutrition in cognitive development, the observations of schoolteachers regarding other factors contributing to poor scholastic performance proved astute. The teachers believed that any interaction difficulties they encountered with students were a result of other problems, such as breakfast-leave and overcrowded classrooms. Indeed, a lack of breakfast has been implicated as a factor contributing to the poor diets of children and their school performance according to a study conducted by Belderson et al. in 2003 [18]. The teachers also reported that the children who did not receive breakfast could often write, but avoided talking or interacting with their teachers. Verbal fluency tests of undernourished children improved when they were given breakfast [10]. In regards to an urban-rural comparison, the schoolteachers reported that rural schoolchildren eat breakfast regularly more than urban ones. A study in conducted in Maryland in 2004 found similar results. They report that the urban students were more than twice as likely to skip breakfast as suburban and rural students [19].

In addition to breakfast-leave, the schoolteachers suggested that overcrowded classrooms were a primary cause for the poor scholastic performance of their students. Interestingly, some studies have reported a correlation between both breakfast-leave and overcrowded classrooms. Evidence suggests that children in overcrowded classes and poorly-equipped schools were less likely to pay attention after consuming breakfast, while children in well-equipped, crowded classrooms paid more attention after eating breakfast [20].

The teachers appreciated the importance of school lunch programs as a tool to improve the nutrition status of the schoolchildren, but they doubted the nutrition value of the food, as well as the motives of the distributor. This feeling was endorsed by a rumor that the reason for the widespread sickness that one school experienced was due to poison in school biscuits. Despite this concern, the teachers supported the idea of school-feeding programs. Unfortunately, the present school-feeding program in Egypt is insufficient to cover all primary schoolchildren throughout the academic year, so the teachers recommended that the school biscuit program should focus its efforts on the smaller children. They indicated that this age group was the most in need of nutrients. Where resources are limited, school meals should be targeted to the undernourished children rather than given to all children in insufficient or irregular amounts [10].

Regarding the schoolteacher's role in nutrition education programs in school, the teachers felt that they maintained much influence because they were often a role model for their students. However, they expressed worry that the introduction of a new program would burden the existing school curriculum. This is a valid concern that placing additional demands on the school curricula, without assessing the effect it has on existing programs and teachers, reduces the effectiveness and sustainability of health interventions [21]. In discussions about the ways in which to improve the nutrition status children, the schoolteachers thought they needed to be trained in the subject of nutrition so that they could identify malnourished children and teach them about ways to maintain good health status. They also felt that a means for parents to learn about caring for their children's health was necessary. Finally, they supported school-feeding programs as long as they were available, reliable and nutritionally suitable for the schoolchildren.

Conclusions and recommendations

Egypt faces a challenge in maintaining the health of the population as the number of children under the age of 18 is growing and current statistics indicate that malnutrition is prevalent among more than 30% of its schoolchildren [1]. The implications of nutrient deficiencies in children are of great magnitude because nutrition status has been shown to be strongly associated with the cognitive and intellectual development of children [3]. Schoolteachers are in a unique position to promote positive health and nutrition practices in their classrooms, yet little is known about teachers' awareness and perceptions of the interplay between nutrition and cognition. Our focus group discussions with Egyptian teachers suggest that they possess relatively limited education about nutrition and even less about the ways in which nutrient deficiencies affect children, both physically and mentally. Despite this limitation, the schoolteachers demonstrated that they were very aware of the other factors affecting their students' scholastic performance, such as classroom overcrowding. Encouragingly, the majority of the schoolteachers expressed interest and support for the introduction of programs to better educate schoolteachers, students and parents about proper nutrition. They also saw school-feeding programs as playing a central part in the success of this potential intervention.

To improve the nutrition status of Egyptian schoolchildren the authors suggest that an integrated nutrition education program be developed and instituted in schools across the country. Emphasis should be placed on the creation of a training program for schoolteachers to increase their knowledge about nutrition, malnutrition disorders, and the relationship between nutrition and the learning process of schoolchildren. In addition, nutrition education of the schoolchildren and the participation of parents are essential. Finally, school-feeding programs play an important role in the improvement of children's nutrition well-being, and while they are already being utilized in many parts of Egypt, consistency, reliability, and the provision of nutritionally valuable food should be enforced.

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Micronutrient status and intervention programs in Malaysia

Geok Lin Khor

Abstract

Approximately 70% of the world's malnourished children live in Asia, giving that region the highest concentration of childhood malnutrition worldwide. Prevalence of stunting and underweight are high especially in south Asia where one in every two preschool children is stunted. Iron-deficiency anemia affects 40%–50% of preschool and primary schoolchildren. Nearly half of all vitamin A deficiency and xerophthalmia in the world occurs in south and southeast Asia. Iodine deficiency disorders have resulted in high goiter rates in India, Pakistan, and parts of Indonesia. Compared with other developing countries in Asia, the nutrition situation in Malaysia is considerably better, owing to rapid economic and socioeconomic development that has occurred since Malaysia gained its independence in 1957. Prevalence of undernutrition and micronutrient deficiency is markedly lower in Malaysian children. Nonetheless, undernutrition in the form of underweight, stunting, and anemia can be found in poor communities throughout the country. A prevalence of 25% underweight and 35% stunting is reported among young children from poor rural households. Anemia and subclinical forms of vitamin A deficiency were reported in children under 5 years old. Typical of a country in nutrition transition, Malaysia faces the dual burden of malnutrition in children, with the persistence of undernutrition problems especially among the poor and the emerging overweight problem especially in urban areas. Since 1996, nutrition programs of the government sector are coordinated under the National Plan of Action for Nutrition. These activities and other nutrition intervention efforts by other agencies are discussed in this paper.

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Introduction

Globally, significant progress has been made over the last 30 years in improving the nutrition status of young children around the world. Between 1970 and 2000, the proportion of malnourished children was reduced by 20% in developing countries [1]. The prevalence of underweight among preschool children (< 5 years old) in developing countries declined from 34.3% in 1985 to 29.3% in 1995 [2]. In absolute numbers, however, the decline is not as impressive. In fact, the number of underweight children has changed little over this period, decreasing from 163.8 million in 1985 to 157.6 million in 1995. Asia, with several highly populated countries, bears a vast burden of malnutrition in children. The concentration of malnutrition among children is highest in Asia compared with other continents. Seventy percent of the world's malnourished children reside in the region [1]. About half of the preschool children in Asia are malnourished, ranging from 16% underweight in the China to 64% in Bangladesh. Some 120 million children in Asia are malnourished, constituting three-quarters of the global total. One in three preschool children are stunted, rising to one in every two children in the countries of south Asia such as India, Bangladesh, and Nepal. In terms of number of underweight children, India leads with an estimated 62 million, followed by 17 million in China [3].

A high proportion of young children in developing countries suffer from micronutrient deficiencies in addition to protein-energy malnutrition. In the Asian and Pacific region, commonly reported micronutrient problems involving children are iron-deficiency anemia, vitamin A deficiency, and iodine deficiency disorders. Micronutrient deficiency is described as "hidden hunger." Unlike the gnawing hunger that results from not having food, the hunger for micronutrients goes unnoticed, even by those affected [4].

Consequences of subclinical forms of micronutrient deficiency can be far reaching, affecting physical growth and immunologic and cognitive maturation, with ramifications that may be irreversible [5].

A multitude of strategies and intervention programs have been implemented to combat protein-energy malnutrition and micronutrient deficiencies. These approaches include breeding for micronutrient-dense staple food, food fortification, use of supplements, and nutrition education. The efficiency and efficacy of some of these activities have been reviewed [5–7].

Nutrition status of children in Malaysia

Malaysia has been undergoing rapid economic development in recent decades. The latest Human Development Report [8] showed Malaysia having better socioeconomic and health status than several countries in the southeast Asian region, in terms of life expectancy at birth (73 years), proportion of underweight children younger than 5 years (19%), and infant, toddler, and maternal mortality rates (8, 8, and 41 per 100,000 live births, respectively) (**table 1**).

Nonetheless, as a country that is in nutrition transition, Malaysia is burdened with both under- and overnutrition challenges. On the one hand, protein-energy malnutrition persists in the form of underweight and stunting among young children in rural areas, ranging from 20%–30% and 25%–35%, respectively [9]. The figures are higher among Orang Asli (aboriginal) children, and those from interior communities in the less-developed states of Sarawak and Sabah. By contrast, prevalence of overweight in children from urban areas is emerging and levels of 10%–15% have been reported [10]. The prevalence of overweight children in rural areas remains considerably lower at less than 2%.

The most important micronutrient malnutrition in children is iron deficiency from the point of persistence and prevalence. For decades, anemia has been identified in various age groups. Among preschool children, prevalence ranging from 18% to 33% in rural areas has been recorded [11–13]. The latter study that assessed more than 8,000 subjects in rural communities also identified a high prevalence of anemia in children of both sexes aged 7–12 years (22%) A survey in 1999–2000 by the Ministry of Health, and supported by UNICEF, showed the persistence of quite high prevalence of anemia in young children. Hemoglobin concentrations of < 11g/dL were found in 18.3% of boys 5 and younger and 20.8% of girls 5 and younger (**table 2**). The age group that appears to have the highest level of anemia is children between 12 and 24 months, an age group that coincides with decreasing consumption of breast milk and increasing reliance on complementary foods.

In poor households, complementary foods are usually based on rice or flour made from wheat or tapioca, with little protein and animal products. Besides poor dietary intake, helmintic infection is another important contributing factor in the higher anemia rates in young children from low-income households. In a study on poor villages, Chong et al. [12] reported that 71% of preschool children and 90% of primary schoolchildren had worm infection. High levels of worm infection are often reported among aboriginal children and children living in oil palm plantations , as a result of poor hygiene and sanitary practices, and inadequate clean

TABLE 1. Comparison of human development indices among southeast Asian countries [8]

	GDP per capita (US$) (2002)	Life expectancy at birth (2002)	Mortality rate (per 100,000 live births) (2002)		
			Infant	< 5 years old	Maternal
Singapore	24,040	78.0	3	4	30
Malaysia	9,120	73.0	8	8	41
Thailand	7,010	69.1	24	28	44
Philippines	4,170	69.8	29	38	200
Indonesia	3,230	66.6	33	45	230
Vietnam	2,300	69.0	30	39	130

TABLE 2. Anemia (hemoglobin < 11g/dL) in children 5 years old and younger in Malaysia [17]

Age (months)	Male % (*n*)	Female % (*n*)
Under 12	24.4 (41)	9.1 (33)
12 to < 24	28.1 (57)	38.5 (39)
24 to < 48	12.5 (104)	19.4 (103)
48 to < 60	13.3 (45)	15.6 (32)
All ages	18.3 (247)	20.8 (207)

TABLE 3. Vitamin A deficiency (retinol < 0.7 μmol/L) in children 5 years old and younger in Malaysia [17]

Age (months)	Male % (*n*)	Female % (*n*)
Under 12	5.6 (36)	9.1 (33)
12 to < 24	1.9 (54)	8.2 (37)
24 to < 48	2.9 (104)	2.0 (99)
48 to < 60	4.6 (44)	3.1 (32)
All ages	2.5 (238)	4.5 (201)

water supplies in these communities.

As for vitamin A deficiency, clinical forms of vitamin A deficiency, particularly among young undernourished children from poor rural communities [14, 15] were recorded until the 1960s, after which moderate to serious subclinical levels were found in poor rural areas [16]. Currently, Malaysia may be said to have a mild subclinical vitamin A deficiency status, based on a survey of more than 400 children aged 5 and younger by the Ministry of Health and UNICEF [17]. In this survey, 2.5% of boys and 4.5% of girls had blood retinol levels ≤ 0.7 μmol/L (**table 3**). Thus, unlike the situation with anemia that remains at a relatively high level, vitamin A deficiency in Malaysian children seems to have abated in severity over the past decades.

Iodine deficiency disorders were first found to be widespread in the 1970s and 1980s in Sarawak. Palpable goiter was detected in young children and adults [18, 19]. The gravity of the problem led to legislation being passed in 1982 making the import of iodized salt compulsory. Its availability in Sarawak increased from 28% in gazetted goitrous areas in 1988 to 65% in 1995. Another approach toward delivering iodine to the community was through the use of iodinators in conjunction with existing gravity-fed water supply in interior villages [20]. Since its implementation in 1993, the use of the iodinators has reached 300 villages and 40 boarding schools by 1997. Goiter is also prevalent among aboriginal women and to a lesser extent in children, especially from the interior communities [21]. Poor dietary intake of iodine-rich food and high intake of goitrogenic food, such as tapioca roots and leaves, are implicated in the etiology of goiter in Malaysia.

Nutrition intervention programs

Community-based public health intervention efforts in Malaysia have been put in place since the 1960s with the FAO-supported applied nutrition programs. Since 1996, with the establishment of a National Plan of Action for Nutrition (NPAN), multi-sectoral nutrition activities in the country—especially those carried out by the various government agencies—have come under the coordination of the National Coordinating Committee for Food and Nutrition (NCCFN). Also, the formation of the National Nutrition Policy in 2003 has provided further focus and impetus toward nutrition interventions aimed at enhancing the nutrition well-being of Malaysians.

Nutrition intervention programs and health promotion activities are undertaken principally by the Ministry of Health. Other government agencies including the Ministry of Education and Ministry of Rural Development are also involved in nutrition promotion activities. Professional associations also actively conduct nutrition education and health promotion activities for both the scientific community and the general public.

Below is a description of the main nutrition intervention programs and efforts of the government and non-government bodies:

» The Malaysian government supports several types of nutrition intervention programs aimed at improving the health status of vulnerable people, including pregnant mothers and young children from poor families. Pregnant mothers, for example, are given micronutrient supplements containing iron, folic acid, and B vitamins during their antenatal check-ups.
» A rehabilitation program for malnourished children from poor families has been implemented by the Prime Minister Department since 1989, as part of a poverty eradication program. Children 6 years and younger who are assessed to be severely and moderately malnourished and whose families' income is below the poverty income line (as determined by the Economic Planning Unit) are eligible to receive food aid. The family receives a food package or food basket each month that is worth about US $20–$25. Each food basket includes rice (6 kg), anchovies (1 kg), wheat flour (4 kg), full cream milk powder (1 kg), dry green bean (1 kg), cooking oil (2 kg), biscuits (2 kg), sugar (3 kg), and 30 tablets of multivitamins.
» Full cream milk powder is distributed through the Maternal and Child Health Clinics to underweight children aged 6 months to 7 years, pregnant women who have not gained adequate weight, and low-income lactating mothers with multiple births. One kg of milk powder for each underweight child is given per month for 3 consecutive months, after which each case is reviewed and supplementation is continued if necessary.
» Cooked meals are provided free of charge to all children in public preschools. According to the Education For All 2000 Report of the Ministry of Education, the gross enrollment in preschools is high, exceeding 95%. The government supports approximately 80% of the preschool demand, while the private sector provides the rest, mainly in urban areas.
» The School Supplementary Feeding Program of the Ministry of Education provides a free meal to primary schoolchildren from poor families. Each meal is estimated to provide one-quarter to one-third of the recommended daily allowances (RDA) for energy and protein.
» The Ministry of Education also provides milk in 250-mL packages to primary schoolchildren. Children from poor families do not have to pay for the milk, while other children pay a subsidized price.
» The IDD prevention and control programs of the government sector include the following strategies:

  – Mandatory universal salt iodization in Sabah.
  – Mandatory salt iodization in 16 endemic districts and 3 sub-districts in Sarawak.
  – Iodization of the water supply in remote schools and villages.
  – Distribution of iodized salt to pregnant women living in endemic areas.
  – Health education on food choices and preparation.
» Nutrition education is an important activity undertaken by various groups:
  – The Ministry of Education includes basic aspects of nutrition in the primary and secondary school curriculum.
  – The Family Health Clinics routinely disseminate nutrition education on balanced diet, food preparation techniques, and promotion of iron-rich foods.
  – As a follow-up activity of the National Plan of Nutrition, a Technical Working Group for Training was formed by the Ministry of Health to carry out training of trainers from various agencies using modules that include emphasis on balanced diet and healthful lifestyles.
  – The importance of breastfeeding has been advocated for many years by the Ministry of Health and non-government organizations.
  – Nutrition and food preparation demonstrations are part of home economics classes of the Ministry of Agriculture.
  – Professional bodies including the Nutrition Society of Malaysia and Malaysian Dietitians Association have been active in disseminating information to the public and updating the scientific community on food and nutrition.

Conclusion

The nutrition situation in Malaysia is, in general, markedly better than that in many developing countries. Nonetheless, it remains a matter of concern to note the persistence of problems of undernutrition in the midst of challenges from overnutrition. These “old” problems include underweight and stunting among young children in rural areas; anemia in young children, women of reproductive age, and the elderly; and endemic goiter, particularly in the states of Sarawak and Sabah, and among aboriginal women.

While school-based nutrition promotion programs have also been implemented for decades, data are lacking on their efficacy and cost-effectiveness. Since many resources are utilized in these programs, it is important that these programs be evaluated periodically.

Food consumption data of Malaysians on a national scale are lacking. The first country-wide food consumption survey was undertaken in 2003–2004 and it is recommended that the survey be implemented on a regular basis.

While the use of micronutrient supplements serves an important approach toward the alleviation of malnutrition in specific conditions and cases such as pregnancy, lactation, the malnourished, and the sick, the long-term solution of micronutrient deficiency lies in food-based intervention programs. There are many locally available foods including legumes, tubers, nuts, fruits, and vegetables that should be more widely utilized for their specific nutrients.

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The future of school feeding programs

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To forecast the future of school feeding programs, especially programs aimed at the underprivileged, we must closely examine the past and observe which processes have succeeded and which have failed. We have amassed a significant amount of information derived from well-controlled, brilliantly designed, experimental studies, almost all demonstrating the fact that poorly nourished children benefit cognitively from school feeding programs. Accumulating a large amount of replicable results in this difficult area of human behavior research, particularly with children, should constitute a source of great pride and accomplishment. However, many of us are left with a tremendous sense of frustration and maybe even despair. Why haven't governments used this information to initiate more school feeding programs for the poor? Instead, governments are either maintaining the status quo, or even worse, retrenching. The answer lies in the fact that our research agenda has been primarily aimed at our fellow researchers and not at political and government administrators.

The importance of re-orienting our research direction is plainly evident in the history of the re-authorization of the federal WIC (Women, Infants, and Children) program. This program provides food and nutrition counseling to low-income mothers and their children. The law was created as one of the Great Society programs of Lyndon Johnson, but was considered for renewal during the presidency of Ronald Reagan, no friend to programs designed to help the poor and the less fortunate. Although Reagan and other conservative politicians wanted the program destroyed, they were persuaded by some brilliant research of David Rush and other epidemiologic scientists [1–11].

What Dr. Rush was able to demonstrate was that it costs government less money to give poor mothers good food and nutrition counseling than it does to pay the cost of medical care for the low-birthweight babies that would result if they did nothing. The program was renewed and hasn't been seriously challenged since. The lesson to be learned is that it is not good enough for us, as educators and health care workers, to show that social programs have beneficial outcomes for individuals. Rather, we must demonstrate that the financial investment in social programs will save government money. An argument based on human rights or justice just doesn't sell. Only when translated into economic terms will a social program be adopted by conservative governments.

The papers presented at this conference provide important scientific information on the relationship between poor nutrition and school performance. Now we must begin to ask important economic and political questions such as "How much return does a government get for its investment in children's nutrition programs?"

To answer this question, we must begin to think about a wider range of dependent variables than we have heretofore. Again drawing on history as a model, I find the evaluation of the "Head Start" programs particularly useful. The intention of the Head Start programs was to bring preschool students from poorer backgrounds to the same level of readiness to begin school as their wealthier peers. Indeed, the program was very successful at raising children's IQ scores and their school performance during their first couple of years of school [12]. However, the IQ advantage of Head Start, as well as the boost in school achievement scores, quickly diminished as the children progressed through each successive year of schooling. What was most surprising, though, was the real advantage of the Head Start program, which was expressed much later and in unexpected ways. Children who experienced the Head Start program were less likely to be retained in later grades, were less likely to require special education, and were significantly more likely to graduate from high school [12]. Not only did these children stay in school longer, but they were less likely to engage in criminal behavior and get arrested than were children

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who did not attend the program [13].

How Head Start programs produced these long-term effects is still a mystery, but the ramifications of these results have clear economic and policy implications. There is little doubt that the earning power of high school graduates is greater than of non-graduates [14]. There is also little disagreement that reducing the number of children who are retained in the same grade, reducing special education classes, and reducing police and prison costs all add to significant cost savings. As a result, politicians and government administrators acknowledge that investing money into preschool programs is a worthwhile technique to cut the cost to the government.

How does nutrition fit into this equation? Although we have heard many brilliant attempts at quantifying the intellectual or cognitive benefits of school feeding programs, clearly the most robust finding that has emerged is that school feeding programs increase school attendance. Consequently, we have a unique hook, a proven mechanism to increase school attendance. We must now move beyond the idea of using the school feeding programs as a means of immediately improving performance of children in the classroom, toward making the link between the school feeding programs and the long-term financial and social benefits of feeding children in the schools.

Having offered the road to the future of school feeding programs, I hasten to add some words of caution. While no one among us would deny feeding hungry children, we must maintain awareness of the growing worldwide epidemic of obesity, particularly among the poor. Obesity not only may impose increasing medical costs upon the poor, but also carries terribly important political ramifications. Arguments have already been raised in the US Congress as to why governments should support food programs for the poor when they are already obese. This is a very serious argument and demands that we devote tremendous creative energy toward understanding and resolving this apparent paradox before the politicians use it to terminate nutrition programs aimed at the poor. Equally as important, however, is that our school feeding programs do not contribute to the problem of increasing obesity. In fact, we must begin to think about how school feeding may be used as part of the solution.

It is clear that we have progressed considerably from the time that we were arguing whether or not early malnutrition caused permanent reduction of brain cells to the formation of cogent economic and political arguments as to why it is economically beneficial to feed hungry children. Political reality has established the necessity of directing our research toward this end. Our success will depend upon the strength of our arguments and the tenacity of those engaged in the research.

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