E-learning: A nutritionally ripe environment

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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, word-searches, 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 Inter-
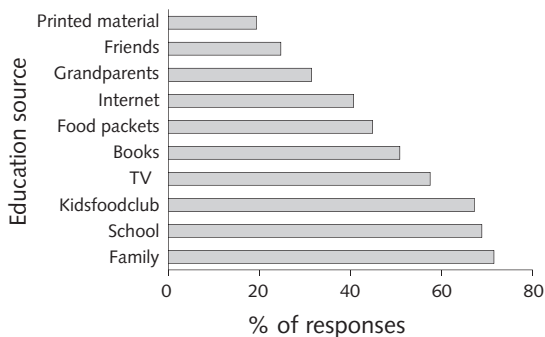
net (41%), grandparents (31%), friends (25%), and printed materials such as newspapers and magazines (10%). Children were also asked if they had a computer at home and access to the Internet. Nine out of 10 children indicated they had a home computer and approximately 60% reported having access to the Internet at home (data not shown).

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-

FIG. 1. Food education sources of survey participants

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-
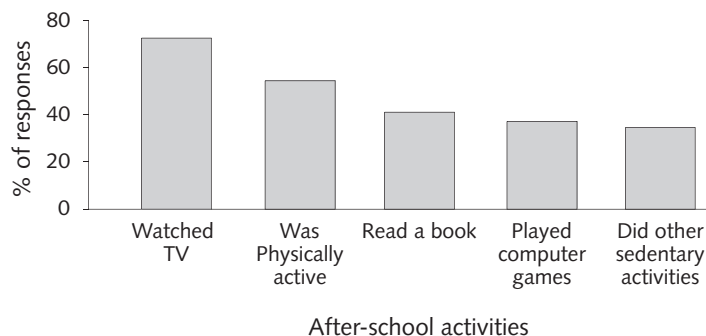

FIG. 2. After-school activity patterns of survey participants

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.

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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

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:

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

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:

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

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

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

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

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

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:

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

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 interac-

tion 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:

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

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

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

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:

$$\text{PHI}_1 = \text{ph}_1(Y, ME, FE, P_{H,1}, HE_1, \tau, \eta; \\ P_S, SC, \sigma, \alpha) \tag{10}$$

$$\text{PHI}_2 = \text{ph}_2(H_1, Y, ME, FE, P_{H,2}, HE_2, \tau, \eta; \\ P_S, SC, \sigma, \alpha) \tag{11}$$

$$\text{PHI}_3 = \text{ph}_3(H_1, H_2, Y, ME, FE, P_{H,3}, HE_3, \tau, \eta; \\ P_S, SC, \sigma, \alpha) \tag{12}$$

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):

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

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 deter-minants 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:

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

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.

Acknowledgment

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Height, weight, and education achievement in rural Peru

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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

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expected to be out of school and start working (in fact, this was the primary reason given by children for dropping out of school).

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
$z \geq 0$	44	8	112	22
$0 > z \geq -1$	7	1	22	4
$-1 > z \geq -2$	154	30	285	55
$-2 > z \geq -3$	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

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* 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].
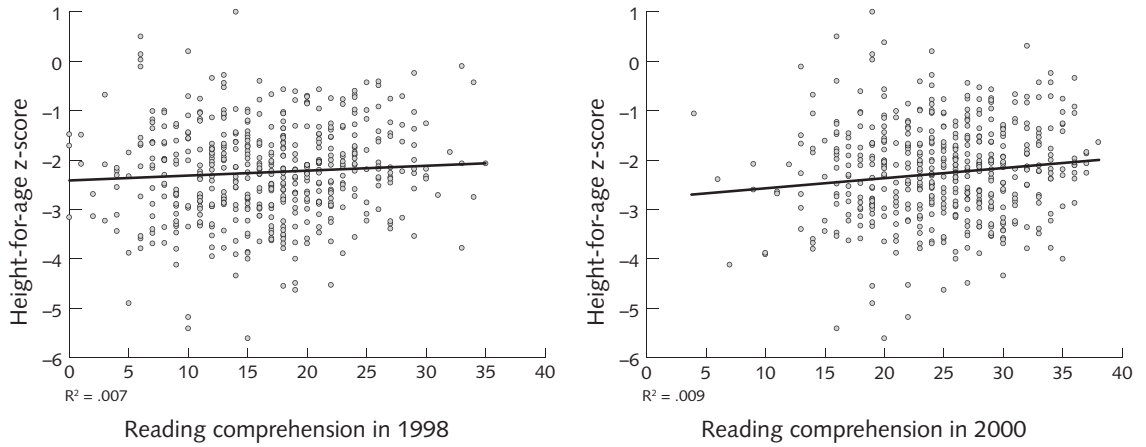
FIG. 1. Scatter between height-for-age z-score (1998) and reading comprehension in 1998 and 2000.
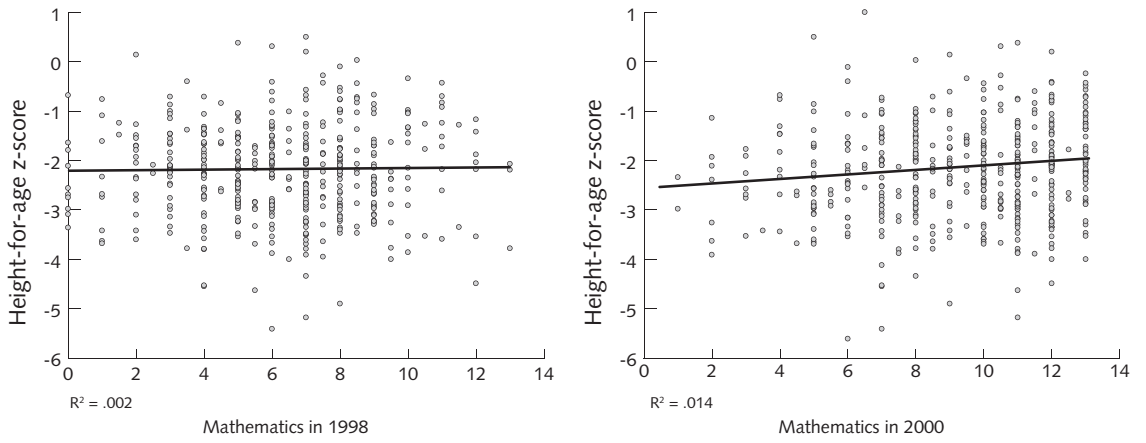
FIG. 2. Scatter between height-for-age z-score (1998) and mathematics in 1998 and 2000
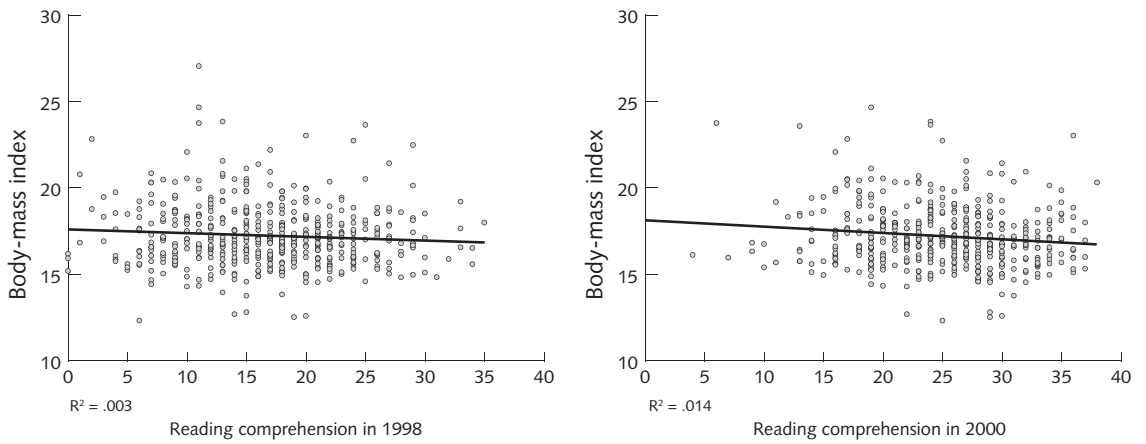
FIG. 3. Scatter between body-mass index (BMI; 1998) and reading comprehension in 1998 and 2000
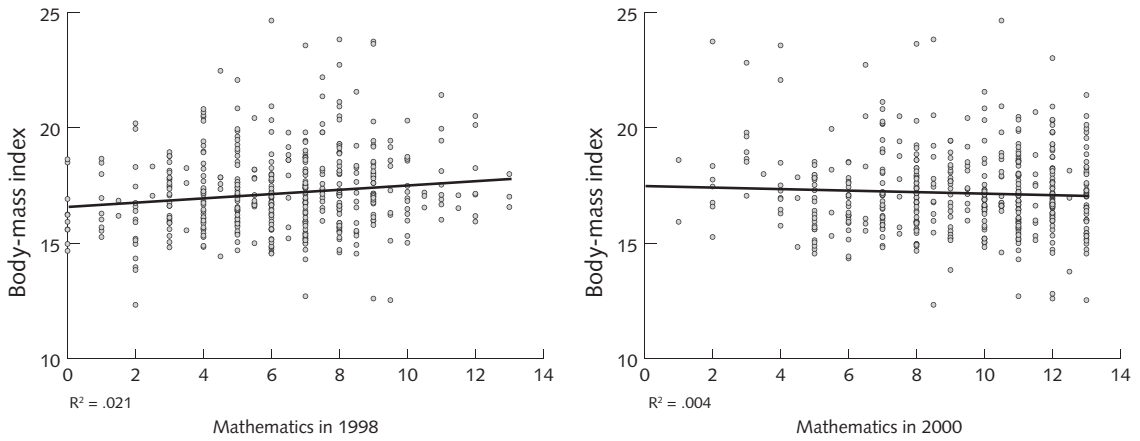
FIG. 4. Scatter between body-mass index (BMI; 1998) and mathematics in 1998 and 2000
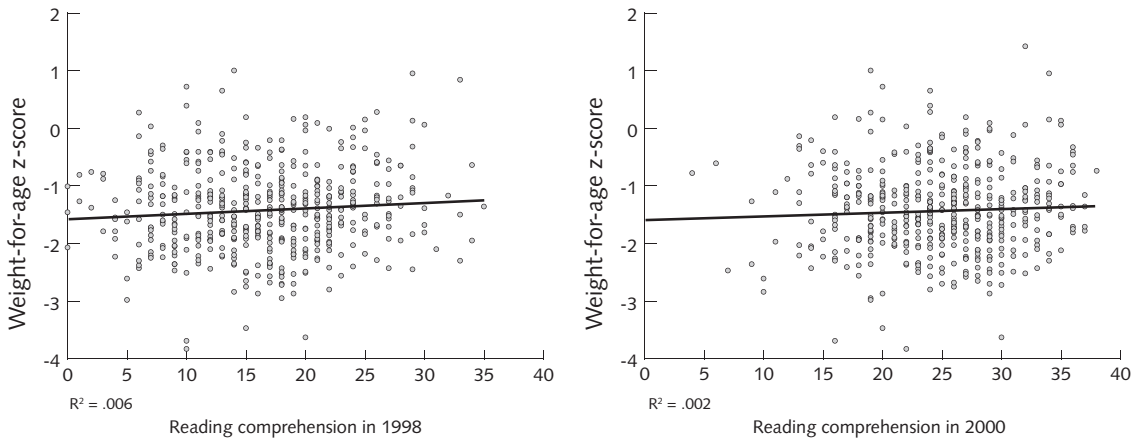

FIG. 5. Scatter between weight-for-age z score and reading comprehension in 1998 and 2000
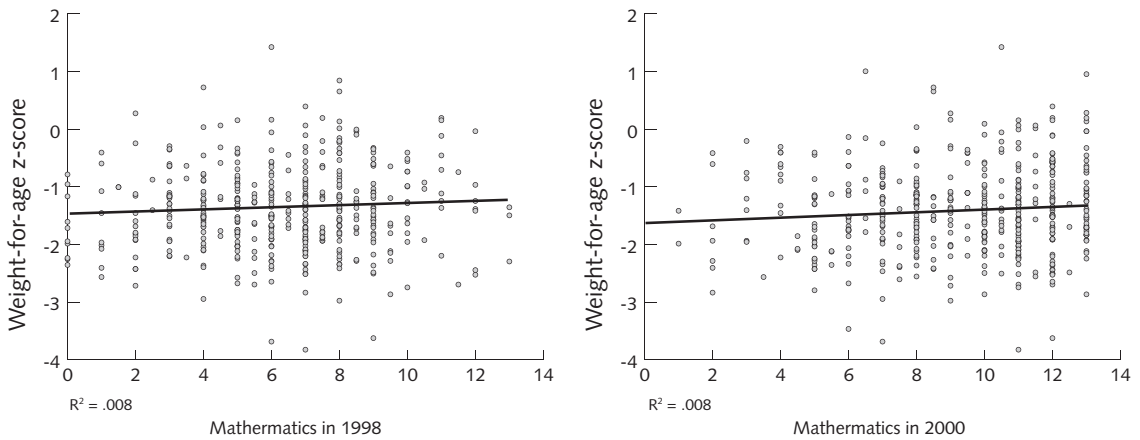

FIG. 6. Scatter between weight-for-age z-score (1998) and mathematics in 1998 and 2000

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.

Acknowledgments

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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

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

Morocco
0–5 years
1987–1992
2.7–6.8% (**2.5**)
Weight-for-height
>2 SD from median

England
4–11 years
Boys: 0.6–1.7% (**2.8**)
Girls: 1.3–2.6% (**2.0**)

Age-adjusted BMI cutoff linked to the adult value of 30 kg/m²

Scotland
4–11 years
1984 to 1994
Boys: 0.9–2.1% (**2.3**)
Girls: 1.8–3.2% (**1.8**)

Egypt
0–5 years
1978 to 1995–96
2.2–8.6% (**3.9**)
Weight-for-height
>2 SD from median

China
6–9 years
1991 to 1997
10.5–11.3% (**1.1**)
10–18 years
1991–1997
4.5–6.2% (**1.4**)
Age-adjusted BMI cutoff linked to the adult value of 25 kg/m²

USA
6–11 years
1971–74 to 1999
4–13% (**3.3**)
12–19 years
1971–74 to 1999
6-14% (**2.3**)
BMI >95th percentile

Japan
10 years
1970 to 1996
Boys: <4% to about 10% (**2.5**)
Girls: about 4% to about 9% (**2.3**)
>120% of standard weight

Haiti
0–5 years
1978 to 1994–95
0.8–2.8% (**3.5**)
Weight-for-height
>2 SD from median

Costa Rica
0-6 years (1982)
1–7 years (1996)
1982 to 1996
2.3–6.2% (**2.7**)
Weight-for-height
>2 SD from median

Chile
0–6 years
1985 to 1995
4.6–7.2% (**1.6**)
Weight-for-height
>2 SD from median

Brazil
6–9 years
1974 to 1997
4.9–17.4% (**3.6**)
10–18 years
1974 to 1997
3.7–12.6% (**3.4**)
Age-adjusted BMI cutoff linked to the adult value of 25 kg/m²

Ghana
0–3 years
1988 to 1993–94
0.5–1.9% (**3.8**)
Weight-for-height
>2 SD from median

Australia
7–15 years
1985 to 1995
Boys: 1.4–4.7 (**3.4**)
Girls: 1.2–5.5% (**4.6**)
Age-adjusted BMI cutoff linked to the adult value of 30 kg/m²
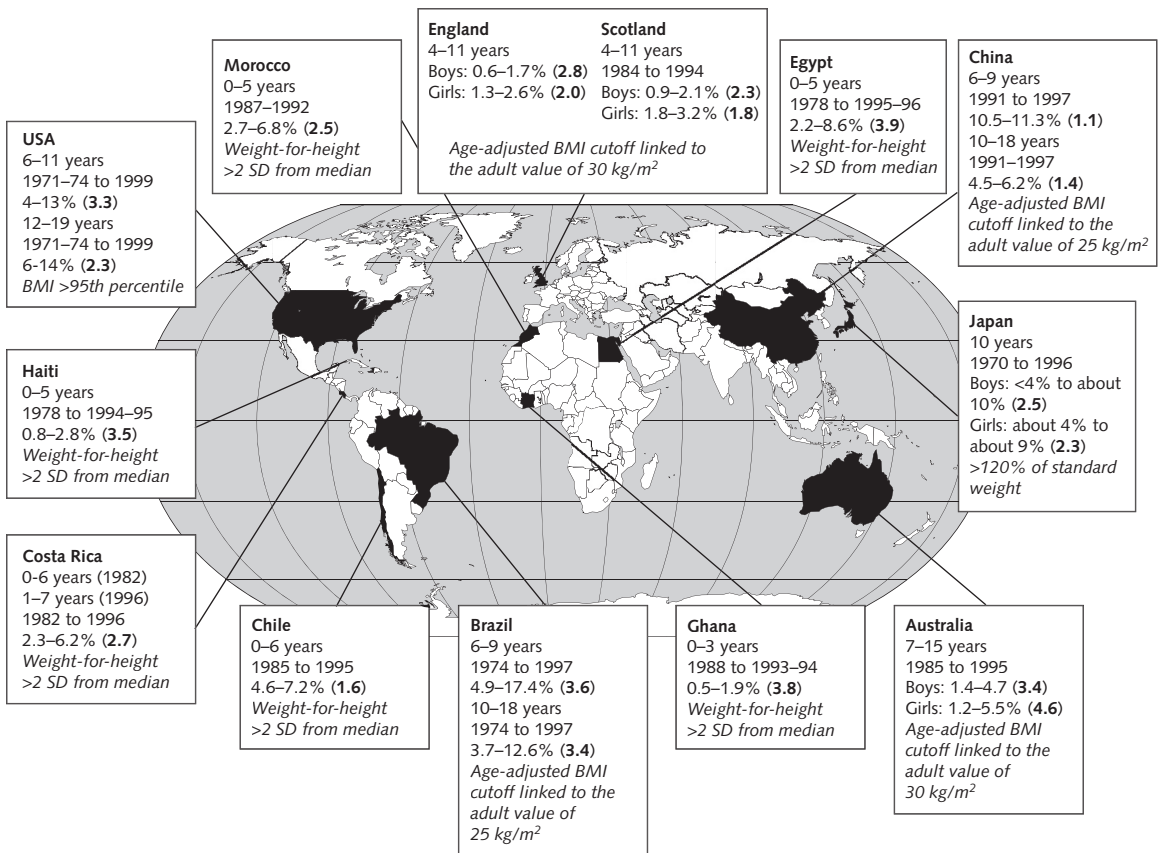
FIG. 1. Global increases in prevalence of childhood obesity. (Change factors are listed in bold for increases in prevalence over specified time intervals. Definitions of overweight and obesity are in italics.)
Source: Reprinted with permission from Elsevier. The Lancet 2002; 360(9331):473–82.

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 popula-

tion 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 endo-

crine [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.

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].

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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
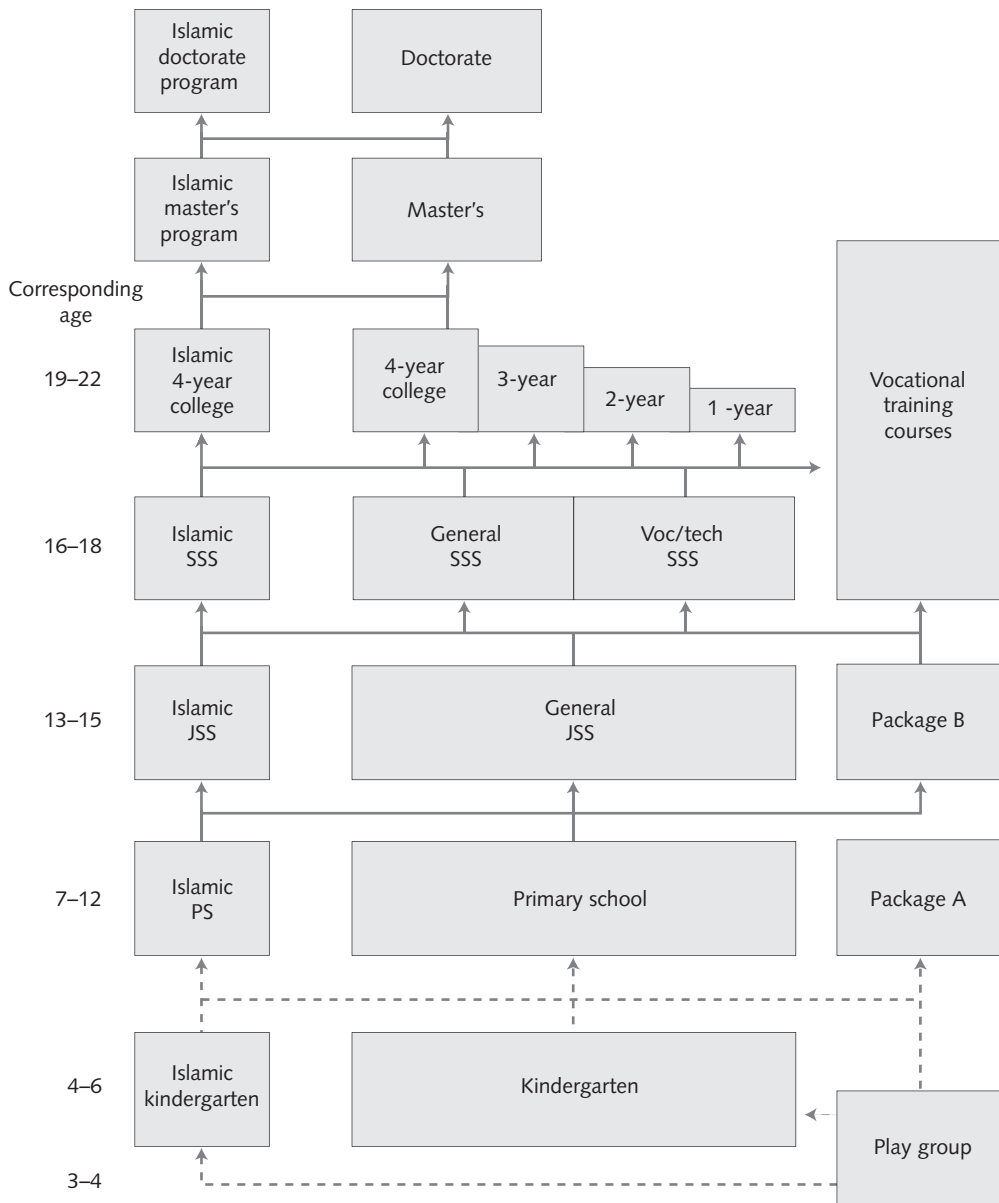
FIG. 1. The system of formal education in Indonesia. Paths indicated by --▶ are not prerequisites for access to a higher level of education. PS, primary school; JSS, junior secondary school; SSS, senior secondary school.

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 $\leq$ WAZ < –2 SD)	Normal (–2 SD $\leq$ WAZ < +2 SD)	Overweight (WAZ $\geq$ + 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]

Source	< –2 SD				< –3 SD			
	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]

Sex	< –2 SD		< –3 SD	
	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
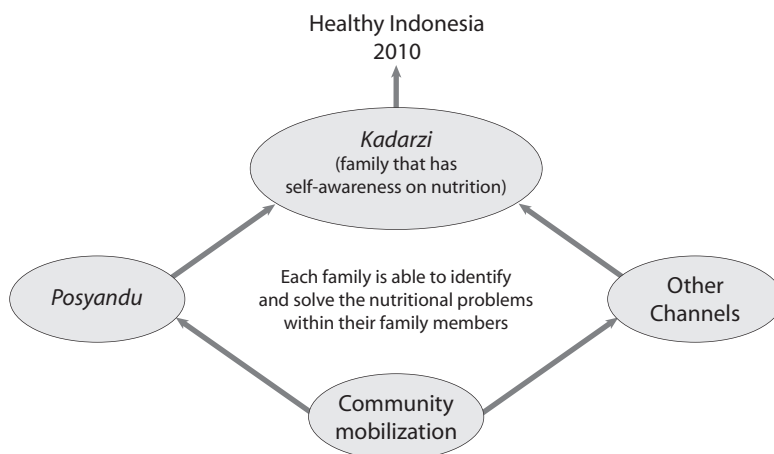

FIG. 2. Nutritional improvement program for Healthy Indonesia 2010. *Kadarzi, Keluarga Mandiri Sadar Gizi* (household that cares for the nutritional status of its family members); *Posyandu, Pos Pelayanan Terpadu* (integrated health post available at sub village level).

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 school-children 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 perform-ance of their students. The teachers advocate developing integrated programs between the Ministry of Educa-tion, the Ministry of Health and Population, teachers, children, and parents that provide nutrition education. A lack of awareness among teachers about the relation-ship 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 nutri-tion 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 school-children (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 vita-min 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 deficien-cies 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 cogni-tive function of primary schoolchildren. In doing so, education programs for teachers may be designed and implemented to enable them to detect the first signs

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 lessdeveloped 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.

Acknowledgment

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The future of school feeding programs

David A. Levitsky

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

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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