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

Matthew Jukes

Abstract

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

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

Introduction

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

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

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

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

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

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

Interpretation of cognitive test scores

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

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

Infectious disease

Malaria

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

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

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

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

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

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

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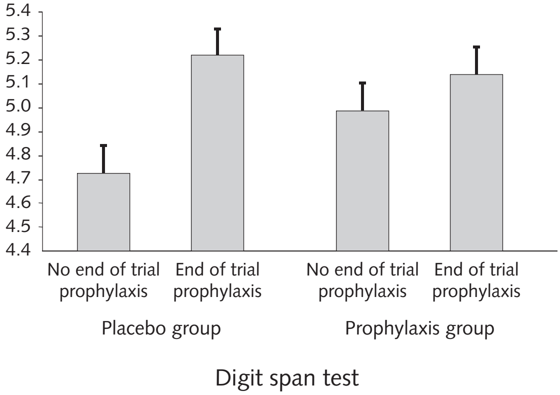

FIG. 1. Digit span of adolescents (mean age 17 years) according to malaria prophylaxis regimen offered to them as young children (aged 6 months – 5 years).

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

Giardia

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

Nutrition deficiencies in preschool and infancy

Protein energy malnutrition

Effects on early childhood development

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

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

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

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

Long-term impact

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

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

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

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

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

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

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

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

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

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

Timing

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

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

Low birthweight

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

Breastfeeding

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

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

Iron-deficiency anemia

Iron deficiency and mental development: children younger than 2 years

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

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

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

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

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

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

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

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

Long-term effects

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

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

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

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

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

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

Conclusion

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

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

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

* Effect is positive, size not reported in paper.

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

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