Chapter 8

Evidence of Impact of Interventions on Health and Development during Middle Childhood and School Age

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INTRODUCTION

A large literature has highlighted the multifaceted and negative long-term consequences of poor health in early life. The large body of evidence linking adversity in the first 1,000 days of life to later life outcomes has created a major policy shift toward the early years, and it has promoted the idea that the consequences of early insults are irreversible. A longitudinal supplementation study in Guatemala of children ages 0–7 years is frequently cited in support of this argument (Martorell, Khan, and Schroeder 1994). The authors concluded that stunting is a condition that results from events in early childhood and that, once present, remains for life. This view was echoed in *The Lancet* series on maternal and child undernutrition: "Poor fetal growth or stunting in the first two years of life leads to irreversible damage, including shorter adult height, lower attained schooling, reduced adult income, and decreased offspring birthweight" (Victora and others 2008, 340).

The available evidence does indeed support the contention that children with a poor start in life are likely to remain on that low trajectory if nothing else changes: indeed, early investment clearly is important. However, this does not mean that children's experiences in later childhood are not important. From a biological perspective, early programming is plausible, but the same obviously also holds for later life gene-environment interactions. Is it possible for children with positive later childhood experiences to catch up with their peers? If yes, to what extent?

This chapter explores evidence regarding whether interventions in school-age children can affect their later development. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017). The main objective of this chapter is to review the evidence for and against irreversibility: Can interventions after the early years of life help children regain or approach their innate capacity for development? Given that the evidence base for older children is more limited, we do not pursue a systematic review strategy in this chapter, but rather look for specific empirical examples supporting or refuting the idea of lifelong irreversibility; a search for black swans.

CHANGES IN ENVIRONMENT

Changes in environment provide an ideal setting for investigating the irreversibility hypothesis: many children who grow up in poor early life environments move to better environments as a result of migration, adoption, or transfer to different institutional settings. These transitions provide a natural starting point for assessing the potential for catch-up.

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Immigration Studies

One study on immigration found that school-age children who were born in Turkey and then migrated to Sweden were short at first measurement upon immigration but then caught up to achieve heights similar to those of ethnically Turkish children born in Sweden (Mjönes 1987). Similarly, a semilongitudinal study assessed children ages 5–12 years of Chinese, Filipino, Hispanic, and Southeast Asian origins who had migrated to San Francisco (Schumacher, Pawson, and Kretchmer 1987). Upon their arrival, most of the children from the four ethnic groups had mean height and weight between the 5th and 25th percentiles of those of the U.S. population. At follow-up one year later, the median growth rate of most cohorts exceeded that of the U.S. reference, with no differences noted between younger and older children.

Adoption Studies

As Golden (1994) highlighted, immigration studies examine the effect of far-reaching changes to the physical environment of a child, whereas adoption studies examine the effect of a change in the quality of the local or home environment on growth later in life. In general, most adoption studies report anthropometric gains for school-age children—for example, Korean orphans adopted by American families (Lien, Meyer, and Winick 1977; Winick, Meyer, and Harris 1975), Indian girls adopted by Swedish families (Proos, Hofvander, and Tuvemo 1991a, 1991b), and previously abused children taken into foster care or adopted in England (King and Taitz 1985).

Adoption studies offer some of the clearest evidence that improving conditions can reverse the consequences of early childhood deprivation. They also offer evidence that, even if early intervention has been successful, intervention later in life may be necessary to sustain the gains of early intervention. A study in Peru found that children who were treated for severe malnutrition early in life and later adopted were significantly taller at age nine years than were similar children who remained in their original home environments (Graham and Adrianzen 1972). Also in Peru, a unique study (Graham and Adrianzen 1971) admitted children from very poor families to a convalescent unit after birth and maintained them on an optimal diet until an average age of 17.6 months. These children showed initial gains relative to their siblings who did not receive this treatment, but within one year of returning home and through the last measurements at age eight years, there was no significant difference in the heights of the two groups (Adrianzen, Baertl, and Graham 1973; Baertl, Adrianzen, and Graham 1976). These findings suggest that environments promoting growth later in life may be needed to consolidate early gains.

Historical Migration Evidence

Steckel (1987) examined historical data on children brought to the United States as slaves and found that they were initially stunted but grew rapidly through the centiles during adolescence. Similarly, Komlos (1986) examined historical data on students at Hapsburg military schools following the Napoleonic Wars and found that boys who were the sons of poor families and stunted at admission showed sizable catch-up growth, presumably attributable to improved diet and living conditions, once they were admitted to military schools.

SECONDARY STUNTING AND UNDERWEIGHT

Clinical and physiological conditions, such as frequent exposure to diarrhea or worm infections, can be associated with stunting and underweight that are secondary to disease. If the initial effects were irreversible, removing the primary risk factors later in life should not have an impact on growth. However, successful treatment of several conditions has been shown to result in partial or complete catch-up growth for school-age children: celiac disease (Barr, Schmerling, and Prader 1972; Bodé and others 1991; Cacciari and others 1991; Damen and others 1994), growth hormone deficiency (Burns and others 1981; Kemp and others 2005), hypothyroidism (Boersma and others 1996; Pantsiotou and others 1991; Rivkees, Bode, and Crawford 1988), and corticosteroid excess (Davies and others 2005; Prader, Tanner, and von Harnack 1963).

FOOD SUPPLEMENTATION

Studies of food supplementation in school-age children have reported small but significant gains in growth. Kristjansson and others (2007), in a meta-analysis of three randomized controlled trials (RCTs) in low-income countries and lower-middle-income countries (Du and others 2004; Grillenberger and others 2003; Powell and others 1998), reported a small, significant effect of school meals on weight gain (0.39 kilogram), approximately 0.25 kilogram per year factoring in study duration. The review also found a small, nonsignificant effect on height gain (0.38 centimeter).

More recently, the World Food Programme and the World Bank assessed the impact of school feeding programs on anthropometric outcomes in three independent studies in Burkina Faso, the Lao People's Democratic Republic, and Uganda. In Uganda, no significant effects were found on body-mass-index-for-age z-scores or height-for-age z-scores (HAZ) in children ages 6–13 years (Adelman and others 2008). In Burkina Faso, significant gains were reported in weight-for-age (0.21 standard deviation) for children ages 6–10 years, especially boys (Kazianga, de Walque, and Alderman 2014). In Lao PDR, significant improvements were reported in both height-for-age (0.29 standard deviation) and weight-for-age (0.22 standard deviation) among children ages 3–10 years, although the authors suggested that the nutritional findings were inconclusive because of the complications that arise in stratified analyses (Buttenheim, Alderman, and Friedman 2011).

Kristjansson and others (2007) conducted a meta-analysis of three controlled before-and-after studies of school meals in low-income countries and lower-middle-income countries (Agarwal, Agarwal, and Upadhyay 1989; Bailey 1962; Devadas and others 1979). They found greater weight gains of approximately 0.75 kilogram per year, slightly larger than the impacts found in RCTs (0.71 kilogram). In contrast to the RCT evidence, meta-analysis of the three controlled before-and-after studies found a significant effect on height gain (1.43 centimeters), approximately one-third more than in control groups.

MICRONUTRIENT SUPPLEMENTATION

Micronutrient supplementation and fortification have been found to increase growth at school age. A meta-analysis of 33 zinc supplementation studies in prepubertal children conducted by Brown and others (2002) found significant effects for both weight (0.31 kilogram) and height (0.35 centimeter). In seven of the studies, the mean initial age of the children was greater than five years. Ramakrishnan and others (2004), in a meta-analysis of the effects of vitamin A, iron, and multiple-micronutrient interventions on the growth of children younger than age 18 years, found significant improvements in height and weight with multiple-micronutrient interventions, but not with vitamin A or iron alone. Five multiple-micronutrient interventions were included, two of which were in school-age children and reported significant effects on height and weight (Abrams and others 2003; Ash and others 2003). A systematic review focusing on multiple-micronutrient fortification in school-age children reported mixed effects for height and weight gain (Best and others 2011).

DEWORMING

The ability to detect improved growth as a result of anthelmintic treatment of children is controversial. Much of this controversy is about the interpretation of studies of interventions that treat all children in a community irrespective of their infection status, as discussed in chapters 13 and 29 in this volume (Bundy, Appleby, and others 2017; Ahuja and others 2017, respectively). Here we focus on the observation that effects are generally seen in studies of children who are known to be infected, especially when infection rates are high. For example, deworming of children with intense trichuriasis—which is associated with *Trichuris* dysentery syndrome and severe stunting—results in dramatic catch-up growth (Cooper and others 1995). Similarly, a Cochrane review of the effect of soil-transmitted helminths on growth in children younger than age 16 years found that the three studies that followed up with only those children who had been screened and found to be infected showed a significant mean increase in weight (0.58 kilogram), with no significant difference in height following treatment (Taylor-Robinson and others 2012).

A meta-analysis of 19 RCTs by Hall and others (2008) found that children ages 1–19 years who are treated for intestinal worm infections experience significant improvements in height (9 studies, 0.11 centimeter), weight (11 studies, 0.21 kilogram), HAZ (6 studies, 0.09 standard deviation), weight-for-age z-score (5 studies, 0.06 standard deviation), and weight-for-height z-score (4 studies, 0.38 standard deviation). According to Taylor-Robinson and others (2012), differences in the findings of the two reviews could be due to differences in their protocols.

IMPACT OF INTERVENTIONS AND CATCH-UP GROWTH ON COGNITIVE ACHIEVEMENT AMONG SCHOOL-AGE CHILDREN

Growth- and nutrition-promoting interventions in school-age children have been found to improve learning and cognitive functioning. Although not true for all studies (Gertler and others 2014), several studies on the impact of food supplementation (Cueto, Jacoby, and Pollitt 1998; Muthayya and others 2007), micronutrient supplementation (Soewondo, Husaini, and Pollitt 1989; Zimmermann and others 2006), deworming (Nokes and others 1992), and treatment of growth-hormone deficiencies (Van Pareren and others 2004) on school-age children found that these interventions led to significant improvements in learning and cognitive outcomes.

Evidence from studies using observational data indicates that reversing stunting or achieving catch-up growth among school-age children leads to gains in learning and cognition. Some of these studies used data from the Young Lives child cohort study in Ethiopia, India, Peru, and Vietnam, which follows children from infancy through childhood and adolescence. In particular, the studies by Crookston and others (2013), Crookston and others (2014), Fink and Rockers (2014), and Georgiadis and others (2016) found evidence that children who experienced higher growth, as measured by the change in HAZ, in early primary school years and in adolescence performed better in reading comprehension, vocabulary, and mathematics tests and were less likely to be over-age for their grade than were children with slower growth across the four countries.

Although this evidence is suggestive, it is not conclusive regarding whether catch-up growth among school-age children leads to improvements in learning and cognitive outcomes.

Two studies used observational data to address this issue and to identify the causal effect on cognitive development of growth during school-age years. The first study is by Glewwe and King (2001), who investigated the impact of growth at different periods (from conception to age two years and from ages two to eight years) on the intelligence quotient (IQ) test score of children from the Philippines. The key finding of this study was that only growth in the second year after birth had a significant and positive effect on IQ test scores. The second study is by Georgiadis (2016), who investigated the impact of higher growth during early primary school years, compared with the period from conception to infancy and from infancy through just before starting primary school, on children's achievement in mathematics and vocabulary tests using data from the Young Lives study. In particular, Georgiadis (2016) compared the test scores of children who experienced different growth in these periods as a result of local weather conditions that, in turn, led to differential exposure to pathogens related to parasitic infection. The methodological approach of this study is based on instrumental variables that produce valid results as long as local weather conditions affect cognitive achievement only by influencing child growth. Georgiadis (2016) presents a range of tests that support this key assumption and thereby the validity of his conclusions. His findings suggest that growth in utero and in infancy and its impact on cognitive development can be reversed through parental promotion of nutrition and cognitive development in school-age years.

CONCLUSIONS

The evidence reviewed in this chapter suggests that the effects of early deprivation do not necessarily persist throughout life, especially if environmental circumstances change. Consistent with Golden's (1994) claim that substantial catch-up growth is possible at school age, we find that trajectories of child growth and cognitive development respond rather strongly to growth-promoting interventions after age two years, as summarized by the evidence in table 8.1. Of course, this does not mean that catch-up growth and improvements in cognitive functioning in school-age children always happen; it just means that there is very little evidence to support the notion that early deficits are irreversible, as concluded in the original work by Golden (1994).

Table 8.1 Findings of Studies on the Possibility of Catch-Up Growth

Study	Source of changed conditions	Description	Quantitative findings
Schumacher, Pawson, and Kretchmer 1987	Immigration	Immigrant children ages 5–12 years with low HAZ were studied upon their arrival in the United States and after one year.	On average, 0.1 standard deviation improvement in HAZ occurred after about one year.
Mjönes 1987	Immigration	The growth of school-age children who were born in Turkey and immigrated to Sweden was compared with the growth of Turkish children born in Sweden.	Immigrant children were short on arrival but caught up to heights of ethnically similar children born in Sweden.
Steckel 1987	Improved diet and lower exposure to infection (inference)	Anthropometric data were analyzed from logs of tens of thousands of American slaves between 1820 and 1860.	As children, slaves were about the first or second centile for height; as late adolescents, they exceeded the 25th centile.
Komlos 1986	Move to boarding school	Anthropometric data were analyzed from students who were born between 1775 and 1815 and who attended Hapsburg military schools.	The boys, who were stunted at admission, exhibited sizable catch-up, potentially attributable to improved diet and living conditions.
King and Taitz 1985	Foster care and adoption	Growth of previously abused children was tracked following (1) long-term placement in foster care or adoption or (2) short-term placement in foster care.	The children experienced significant improvements in both HAZ and WAZ, with the long-term foster care group showing the greatest improvement.

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Table 8.1 Findings of Studies on the Possibility of Catch-Up Growth (continued)

Study	Source of changed conditions	Description	Quantitative findings
Abrams and others 2003	Micronutrient supplementation	Children ages 6–11 years were administered a beverage fortified with 12 micronutrients for eight weeks.	The treatment group on average gained 0.17 standard deviation in WAZ, significantly different from the 0.08 standard deviation gain in the control group.
Ash and others 2003	Micronutrient supplementation	Children ages 6–11 years were administered a beverage fortified with 10 micronutrients for six months.	The treatment group on average gained 3.2 centimeters in height, significantly different from the 2.6 centimeter gain in the control group.
Cooper and others 1995	Deworming	Children with intense trichuriasis associated with *Trichuris* dysentery syndrome and severe stunting were dewormed.	Six months after deworming, the children exhibited growth in mean height and weight that was two standard deviations greater than the growth of British children their age.
Stephenson and others 1993	Deworming	Primary school boys in a high-prevalence area were given a single dose of deworming treatment and followed up with four months later.	The treatment group exhibited rapid gain in weight, 1.0 kilogram more than the control group, across the four months of the study.

Note: HAZ = height-for-age z-score; WAZ = weight-for-age z-score.

The significant remaining task is to develop and evaluate a range of interventions, including intensive interventions that can be introduced over time into a policy broader than now exists for reaching disadvantaged children throughout their lifecycle. That many of the studies most relevant to understanding catch-up growth and its implication for cognitive development are now decades old points to the need for revitalizing the research and development agenda.

NOTE

World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  a) lower-middle-income = US$1,046 to US$4,125
  b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

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