GLOBAL HEALTH

**AUTHOR:** Ruth A. Etzel, MD, PhD
*Joseph J. Zilber School of Public Health, Milwaukee, Wisconsin*
*Address correspondence to Ruth A. Etzel, MD, PhD, Joseph J. Zilber School of Public Health, University of Wisconsin, 1240 N. 10th St, Milwaukee, WI 53201. E-mail: ETZEL@UWM.EDU*

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# Reducing Malnutrition: Time to Consider Potential Links Between Stunting and Mycotoxin Exposure?

*Yes, moldy food is one more important factor to consider in our global effort to abate the extraordinary high prevalence of malnutrition. Over recent years, the incidence of stunted growth in much of the African continent has actually increased. Now, Dr Etzel brings the issue of food fed to children that contains high levels of mycotoxins as a likely part of the cause. Clearly, we must consider both the quality and quantity of the food children are fed during the early years of life. The environmental conditions that prevail causing an adulterated food supply deserve much closer scrutiny as we address potential remedies to the detrimental effects of poverty and hunger.*

—Jay E. Berkelhamer, Section Editor

Malnutrition is a major threat to global child health.[1–3] Linear growth retardation, or stunting, is one indicator of malnutrition. Stunting, defined as height for age below −2 SDs from the median height for age of the standard reference population, has decreased globally among children <5 years of age from 40% in 1990 to 25% in 2012, the most recent year for which data are available[4] (see Fig 1). Globally, 162 million children <5 years old were stunted in 2012; 56% of all stunted children lived in Africa and 36% in Asia. In Asia, the number of stunted children is estimated to have more than halved between 1990 (192 million) and 2012 (91 million). In Africa, however, the number of stunted children increased from 46 million in 1990 to 59 million in 2012.[3]

Stunting is important because of its major short- and long-term effects on children. A significantly low height for age is a strong predictor of mortality in the first 5 years of life.[5] Stunting also has effects on long-term outcomes, such as educational attainment, increased formal employment, and physiologic functioning.[6]

Current efforts have had variable results in eradicating stunting.[7,8] Recently there has been interest in considering environmental factors that may be important contributors to this condition. Research suggests that exposures to environmental contaminants in the food supply, especially naturally produced mycotoxins, may be linked to stunting.[9,10]

Children in many parts of the world are routinely exposed to many mycotoxins in the food chain; the 3 most common are aflatoxins, fumonisins, and deoxynivalenol. These are prevalent in foods such as maize and groundnuts that are staples in many low-income countries in parts of Africa and Asia. Exposures to mycotoxins are often higher among infants than among other age groups. This is especially true in low-income countries, but even in industrialized countries such as Japan, aflatoxin intake is estimated to be greater in the young age groups (1–14 years old) than in the senior age groups.[11] In the United States, exposure to aflatoxin is estimated at 2.7 ng/kg body weight per day.[12] In a study of fumonisins in Spain, the most highly exposed group was infants.[13] Assessments in Japan showed that children aged 1 to 6 years have the highest deoxynivalenol intake.[14]

Exposure to mycotoxins in the food supply may cause acute diseases such as aflatoxicosis, resulting in vomiting, abdominal distress, hepatitis, and death.[15,16] More often, however, the effects of exposures to mycotoxins are more insidious. The International Agency for Research on Cancer has determined that aflatoxins are carcinogenic to humans.[17] In addition, they may be linked to stunted growth. For example, a cross-sectional study demonstrated that aflatoxin-albumin adducts were associated with stunting among children in Benin and Togo, West Africa,[18] and a longitudinal study found that the highest quartile of aflatoxin-albumin adducts was associated with a 1.7 cm mean height reduction compared with the lowest quintile.[19] A study in Cameroon detected aflatoxin $B_1$ in 35.5% of children with kwashiorkor, 45.5% of children with marasmic kwashiorkor, and 11.1%

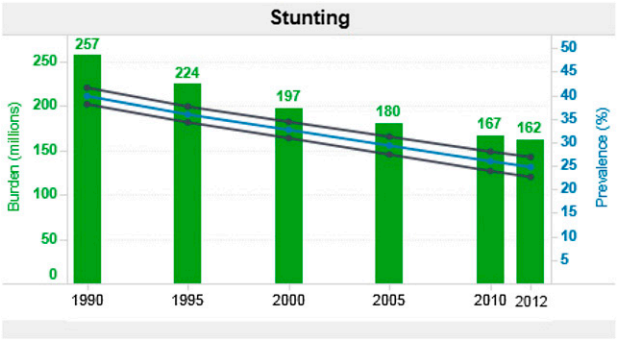


**FIGURE 1**

Trends in stunting (1990 – 2012). The bar chart shows estimates of burden (in millions of children aged < 5 years.) The lines graph prevalence estimates with upper and lower confidence limits. Available at: http://www.who.int/nutgrowthdb/jme_2012_summary_note_v2.pdf?ua=1.

of control children within the same age range and from the same area of residence ($P < .05$).[20]

Fumonisin exposure also has been associated with stunting. In rural Tanzania, fumonisin exposure through corn (maize) in complementary foods was negatively associated with linear growth in infants.[21] Infants exposed to fumonisin intakes above the provisional maximum tolerable daily intake of 2 $\mu$g/kg body weight were significantly shorter by 1.3 cm.[21] Deoxynivalenol (vomitoxin) exposure has been extensively studied in pigs but far less is understood about its effects on human children. In pigs, feeding on grain contaminated with deoxynivalenol causes lower feed intake and lower weight gain.[22] Acute outbreaks of vomiting in humans after ingesting foods contaminated with deoxynivalenol have been reported in China,[23] India,[24] and the United States,[25–27] but no studies of the effects of chronic ingestion of deoxynivalenol among children are available.

Exposure to these 3 toxins and other contaminants may induce environmental enteropathy, a mild malabsorption syndrome that manifests with villus atrophy, crypt hyperplasia, T-cell infiltration, and general inflammation of the jejunum. This condition is prevalent among children in low-income countries[28] and is plausibly an underlying mechanism for stunted growth.

The main window of opportunity to prevent stunting is during the intrauterine and postnatal periods, from conception until 24 months. Reductions in stunting can be achieved through a set of nutrition-specific interventions.[8] Efforts to reduce mycotoxins are not currently among them. The major national and international food safety agencies have published standards for some mycotoxins in milk and other foods consumed by children. The joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives has not established a provisional maximum tolerable daily intake for aflatoxins (because they are carcinogenic), but it has established a provisional maximum tolerable daily intake of 2 $\mu$g/kg body weight per day of fumonisins[29] and a provisional maximum tolerable daily intake of 1 $\mu$g/kg body weight per day of deoxynivalenol.[30] Although these standards exist, they are rarely enforced.[31]

The United Nations Millennium Declaration, signed in 2000, committed world leaders to combat hunger, poverty, and disease, among other factors; the Millennium Development Goals, derived from this Declaration, are 8 goals that United Nations Member States have agreed to try to achieve by 2015. Millennium Development Goal 1 is to eradicate extreme poverty and hunger. A target is to halve, between 1990 and 2015, the proportion of people who suffer from hunger. Global progress in reaching this target has been mixed. One of the indicators of progress toward this goal is the prevalence of stunting. There is now only about a year left until the date on which the Millennium Development Goals were to be achieved, and much work remains to be done. Efforts to deliver nutrition-specific interventions to children need to be scaled up globally.[8] Recent findings underscore that it may be time to also consider interventions to reduce the environmental risks from toxins in the food supply, including planting disease-resistant crops; bio-control agents; cultural planting practices; and harvesting, storing, and preparation practices.[32] Pediatricians can play a key role in expanding understanding of the role of exposure to mycotoxins in stunting.

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