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Invited Review Article

Early nutrition and adult health: Perspectives for international and community nutrition programs and policies

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Abstract

Recent economic changes throughout the world, either development or crises and recessions, have prompted a host of nutrition related problems, including a decreased prevalence of undernutrition, an increase in the prevalence of diet related diseases, widespread food insecurity as crop prices increase, and so on. In addition, evidence is mounting that suggests that exposure to poor nutrition early in life is a predisposing factor for chronic diseases in adulthood. Thus, the role of international or community nutrition professionals is vital to not only studying and understanding the interplay between economics, food policy, and health, but also to improving the ability to intervene and prevent many problems related to food insecurity in developed and developing countries. The purpose of this review is to outline and describe these issues as a means to open discussion on how to best alleviate major nutrition problems in the world.

Key Words: Undernutrition, developmental origins, double burden, economics, community nutrition

Status of nutrition and health in the world

Rapid changes in the global economy during the past two to three decades have been accompanied by several significant changes in the nutritional status and health of developing countries [1]. Some of these changes have been positive, such as a dramatic reduction in the prevalence of undernutrition. At the same time, some changes have been detrimental, most notably the increased prevalence of obesity and diet-related chronic diseases [2]. In addition, data suggesting that a biological link exists between exposure to poor nutrition early in life and chronic diseases in adulthood is growing [3,4]. Thus, the nutrition community is poised to evaluate current programs and design necessary new programs to alleviate undernutrition and diet-related chronic diseases in an effort to further improve the nutritional status of countries throughout the world. The purpose of this review is to describe the current understanding of factors influencing nutritional status and health, in global terms, review the literature related to the "fetal origins hypothesis", and describe potential changes in community nutrition programs that will enhance the improvement of nutrition for the global community.

Undernutrition

The global prevalence of undernutrition varies considerably by region and country, but global trends in wasting (i.e. weight for height less than the 10th percentile of health children in the United States) and stunting (i.e. height for age less than the 10th percentile of health children in the United States) has been decreasing, although in countries with civil strife or extremely unstable governments the prevalence is still higher than 20-30% [5]. In developed countries, undernutrition is mostly found among people living in rural areas, although poor nutrition, such as micronutrient deficiencies, are often associated with low income and poor access to nutritious foods, factors common in poor, urban areas [6,7]. For developing countries, the prevalence of undernutrition remains moderate to high, depending on the relative degree of economic development such that poor countries, including Paraguay, Vietnam, and many parts of Central Africa, still have approximately 30-40% of their children as wasted or stunted. One interesting anomaly is India, a country that has experienced rapid and consistent economic success, but where the prevalence of undernutrition remains high. A relatively recent trend, also associated with income and food insecurity, is the emergence of overnutrition in the same regions where undernutrition has been a dominant problem [8,9].

Obesity and the "double burden"

The prevalence of obesity is increasing worldwide with as many as 50% of some developed countries being classified as overweight or obese [10]. Yet, developing countries, generally

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known to have a high prevalence of undernutrition, are also experiencing a rapid increase in the number of people who are overweight or obese. In parts of Latin America and Asia, upwards of 10-15% of adults are considered to be overweight. Most often, problems occur within the same community (or even household), suggesting a common social or biological factor in the etiology of these conditions. At the same time, the coexistence of two seemingly opposing nutritional disorders is creating new challenges for health professionals and policy makers as low income countries now face what is termed a "double burden" of disease.

Recent data from the World Health Organization suggests that many developing countries will continue to see the prevalence of non-communicable diseases increase to the point that more than half of their disease burden will be due to chronic disease [4]. Most certainly, nutrition-related chronic disease (e.g. obesity or type 2 diabetes) are a growing concern in developing and transitional countries. Factors that promote the double burden of diseases include high levels of food insecurity (resulting in poor nutritional intake or consumption of nutritionally inadequate foods), urbanization (prompting a loss in traditional diets and a shift towards diets high in fat and sugar, but low in micronutrients), decreased physical activity, and continued economic challenges at the national and household level [2]. Furthermore, approximately 80% of living adults will reach the age of 80 in most countries, increasing the likelihood that they will eventually develop a chronic disease [11]. Attempting to address the double burden is challenging as it often occurs in resource-poor environments and the steps needed to address both extremes, concomitantly, are not always parallel or complementary. At the same time, the factors that promote each condition tend to cluster together, creating opportunities for solutions.

The issues underlying the double burden of diseases in developing countries form what is commonly referred to as a "vicious circle" in which common social, economic, and even biological factors are perpetuated generation after generation [5,6]. While there is no "beginning" to such a cycle, for arguments sake, imagine a poorly educated mother living in a low-income country where her family's level of food security is quite low. Most likely, this woman will give birth to a child who is small for gestational age and will develop in an environment in which their growth may be retarded due to insufficient energy or micronutrient intake [7]. It is well documented that a stunted child will remain short for his/her age into adulthood and also have lower cognitive abilities, poor school performance, and lower income compared to a normal height child [12]. This situation places the child at risk for remaining in the same low income and food insecure environment in which his/her parents lived, continuing the cycle of poverty and poor health.

Early growth and adult disease

The concept that the nutritional experience of a fetus or young child may have lasting effects into adulthood is termed the Developmental Origins of Health and Disease (DOHaD). Some of the more compelling evidence for this link come from historical research of adults who were exposed to famines either in utero or as children.

Studies of the Chinese famine of 1959 have provided extremely interesting and insightful pieces of data to support DOHaD. It was found that the risk of being overweight was 1.5 times greater for women who were toddlers during the famine compared to women born after the famine [13]. Li et al reported that adults who were exposed to the famine during gestation were nearly four times more likely to develop type 2 diabetes compared to adults born in non-famine areas of China [14]. Moreover, when this group analyzed the role of current diet on the risk for hyperglycemia, adults who were born in the famine areas and consumed a "Western" dietary pattern were almost eight times more likely to be hyperglycemic compared to those who consumed a traditional diet. These data provide not only interesting conclusions about the effect of gestational undernutrition on later health, but also model the exacerbating role of a high-fat, low-fiber diet on the potential metabolic abnormalities associated with previous undernutrition.

The study of the Chinese famine can be complemented with the study of the Dutch Famine of 1945 [15]. A cohort of men born before, during, and after the Nazi-imposed famine in Holland was studied to determine the relationship between adult body weight relative to famine exposure during gestation. Men who had been affected by the famine during early gestation were more likely to be overweight as adults compared to men who were exposed to the famine during the last part of gestation. Several other large epidemiological studies have reported an association between being born at-term with low birth weight (LBW) and chronic disease in adulthood [16-20]. Of particular interest has been the association between LBW and cardiovascular disease (CVD), hypertension, and T2D. In one cohort of men and women born in the Hertfordshire region of England [21], men and women with lower birth weight were more likely to suffer from CVD than men and women with normal birth weight. Barker et al reported that a correlation exists between birth weight and CVD mortality in a cohort of 1,586 men born between 1907 and 1924. These findings have been confirmed in other cohorts throughout the world, such as England [22], Croatia [23], Sweden [24], and the United States [25]. Potential mechanisms for DOAHD are lacking, but include abnormalities in the hypothalamic-pituitary axis that perturbs metabolism, a central fat distribution, impaired fat oxidation, and abnormal control of energy intake.

The association between growth retardation and central adiposity is of particular concern since central or visceral adipose tissue (VAT) mass is a major risk factor for cardiovascular disease and diabetes [26-30]. VAT mass increases the risk for

Syndrome X as a result of increased free fatty acid (FFA) mobilization by VAT and the direct entry of FFAs into the portal vein, both of which are associated with hepatic and systemic insulin resistance [31]. Low birth weight is associated with truncal fat mass, reflected by a high ratio of subscapular to tricep skinfolds [17]. Similar associations between low birth weight and truncal adiposity have been found in adolescents in the United States and the United Kingdom [32]. Exactly why persons who were growth retarded deposit more centrally is not known, but is the focus of several studies. One possible explanation is that growth retarded persons favor fat deposition under stable dietary conditions, a hypothesis that is supported by evidence from a clinical study of stunted children in Brazil.

Data from a cross-sectional study of stunted children in Brazil found that stunted children not only metabolize fat at a lower rate, a known risk factor for obesity [33]. The stunted group also demonstrated abnormal appetite control compared to normal height peers when presented with an abundant diet [34]. Results from a controlled feeding protocol found that the stunted children consumed more energy per unit body weight during a 3-day period. This would suggest that when these children are exposed to energy dense diets, often associated with fast-food restaurants or commercial, processed foods, they may be more likely to overeat and gain weight as adipose tissue. In fact, when this group of children was followed for 4 years, the stunted children actually deposited more fat compared to the healthy children [35]. These findings highlight the fact that undernutrition, often accompanied by poor nutrition, limited maternal education, and undeveloped health care systems is not an acute condition. Rather, undernutrition that results in growth retardation is a chronic condition with effects extending well beyond the recovery of body weight.

Recently, work was completed on assessing whether or not the metabolic abnormalities identified in stunted children may exist in other populations of adults who were undernourished at some point in their life. First, a cohort of adults from the Hertfordshire cohort in the United Kingdom were studied to determine the relationship between being born small for gestational age and fat metabolism [36]. Metabolic studies included the measurement of fasting and 24-hour fat metabolism using indirect calorimetry and ^{13}C palmitic acid. There were no significant differences in the rate of fat metabolism between the groups, although the 24-hour rate of fat metabolism did approach statistical significance ($P = 0.08$). The fact that the sample size was relatively small ($n = 15$ per group) may have limited the statistical power of the sample. Second, a cohort of women who were in recovery from anorexia nervosa were studied to better understand if severe energy restriction during adolescence had similar or different effects on metabolism compared to those associated with undernutrition in utero or during childhood [37]. The most salient result from this work was that the RAN women had a high rate of fat oxidation at rest compared to women with no history of anorexia nervosa. One factor that could explain this result is that women with anorexia nervosa generally exercise to an excess degree to maintain their low weights. This behavioral characteristic may carry over following recovery from anorexia nervosa and appear as a high degree of physical activity, often associated with increased fat oxidation. Unfortunately, physical activity was not assessed in this study and the effect of this potential explanatory variable could not be assessed relative to metabolism and RAN. Nonetheless, there is abundant evidence that experiencing degrees of energy restriction at various stages in the lifespan has effects on both energy metabolism and body composition, effects that are likely to promote chronic disease, under proper environmental circumstances.

In summary, what has been presented is a continuum of studies that clearly demonstrate that the DOHaD is more than an epidemiologic exercise, but rather a physiological condition that has health implications for millions of children and adults. The fact that moderate undernutrition in utero or during childhood is enough to prompt metabolic or anthropometric changes that promote hypertension, type 2 diabetes, and obesity should not be taken lightly as the medical fallout of DOHaD is not mortality, but morbidity that will need to be treated for many years. Economically, the cost of treating chronic disease is real in both direct (i.e. pharmaceutical or medical expenses) and indirect (i.e. loss of productivity or absenteeism) terms, factors that may threaten continued economic development in lower income countries.

Programs in international nutrition

Placing the concept of DOHaD into the realm of international or global community nutrition forces a discussion on the role of aid programs in alleviating nutrition-related problems and diseases in developing countries. It is well known that many of the current problems are products of corrupt or dictatorial governments, human rights abuses, inequality among genders and economic classes, and uneven trade policies. While these macro issues are difficult or impossible to correct in the short-term, they are clearly responsible for the most severe and acute nutrition problems, such as famine or undernutrition. The international response to these situations, as well as their response to natural disasters and humanitarian crises, has been to provide food aid in various forms, either through emergency aid (as is the case with the World Food Program, WFP), longer term food aid (such as CARE or the United States Agency for International Development, USAID), or development aid designed to promote food security (generally through USAID or the World Bank or other financing programs). To evaluate the effectiveness of such programs, a study on food aid and stunting in North Korea was conducted using data from UNICEF [38].

Briefly, North Korea has suffered social, economic, and political upheavals for over 50 years. The current situation in North Korea is extremely precarious and often exacerbated by

international sanctions, embargoes and a host of natural disasters. The end result of the situation in North Korea is that a great majority of adults and children continue to live with a high degree of food insecurity. In 1997, UNICEF conducted a random survey of households throughout North Korea and determined that approximately 40% of children under age 5 were stunted. This survey was repeated in 2002 and it was found that this prevalence had not changed, but that the prevalence of wasting had decreased from 16.5% to 8.2%. The analyses conducted with these data determined that household receiving food aid from the WFP were less likely to have a child who was stunted. Thus, when a chronic condition, such as stunting, results from complicated geo-political problems, international aid in the form of seemingly simple "biscuits" are apparently effective in preventing the linear growth retardation associated with undernutrition.

While this study may illustrate one potential success of international aid, it needs to be tempered with a discussion of the challenges that such programs face. Designing programmatic and thematic policies to improve maternal and child nutrition in any setting needs to be focused and supported at all levels, from national leadership to ministry level to community. Moreover, the need to draw on the education and experience of nutrition professionals, at all levels, is essential to potential success. As noted in The Lancet's Series on Maternal and Child Undernutrition [5], among the eight key challenges that countries face addressing and successfully preventing or managing undernutrition, placing nutrition problems on the national agenda and improving national capacity are among the most important. Briefly, the reason that having a national agenda that strives to improve nutrition is necessary is that without a national agenda, the issue can be lost among changes in leadership, shifts in focus, and decrease in media attention. Likewise, without the capacity to evaluate nutrition problems and interventions, understanding how to implement programs, leverage international aid, and ultimately sustain successful programs, whatever efforts and funding have been directed to an initiative or program will eventually dwindle and expire. For these reasons, and several others, it is obvious that nutrition problems will persist without a clear, comprehensive, and coordinated effort from all levels of government, academia, and non-governmental organizations.

The use of a "case study" will be helpful to clearly demonstrate the depth and degree to which simple plans and objectives can be limited by equally simple miscommunications and lack of transparent and unified cooperation. Honduras, a small impoverished country in Central America, has been working with several international organizations to improve key nutrition programs, such as breastfeeding promotion and food security, in an effort to reduce the alarmingly high prevalence of undernutrition (ranging from 25% in urban areas to as high as 50% in extremely rural areas). The range of agencies or organizations that are working in this small country include the WFP, CARE, USAID, the US Peace Corps, the International Atomic Energy Agency, as well as many others.

In 2007, a nutrition professional was asked to visit Honduras with a very specific objective: to assist and advise the Ministry of Health on designing a program to assess childhood nutritional status, nationally. One of the first visits made during this trip was to the Honduran office of the WFP. During this meeting it was discovered that the WFP had already been conducting very detailed and extensive surveys throughout the country. The fact that the Office of Maternal Health and Nutrition was completely unaware of data obtained by a UN program the government of Honduras was hosting exemplifies a lack of cooperation and integration of large international programs with the host governments. This brief case study is a rather simple lesson that expertise and resources can be squandered due to a lack of focus and efficiency that occurs when governments or ministries do not have a long-term objectives or missions. More important, what objective or missions are define may often change according to the whims of senior officials who may lack knowledge of or be involved with any real aspect of the actual workings of the office or ministry. Without considering the challenges presented in The Lancet's series, the risk of perpetuating and never solving nutrition problems that plague less developed nations is great.

Summary

What has been discussed in this review is a host of issues, concepts, and examples that ultimately place nutrition professionals with expertise in community and international nutrition at the forefront of battling undernutrition and obesity in the world. Integrating the expertise of community nutritionists with the efforts of governmental and non-governmental organizations to address food insecurity in the developing world is essential. The integration of programs and interventions to alleviate or moderate food insecurity is but one step in the course to correct or prevent these problems. Ultimately, these efforts will only succeed through coordinated efforts that begin with national policies and initiatives that make nutrition a priority. The role of community nutritionists is to continue to communicate with government officials and members of the international community to keep nutrition and diet-related diseases in dialogues related to broader agendas of public health and economic development. While it is obvious that food insecurity is intimately related to public health, it may not always be clear how it is linked to economic development. Thus, understanding the interrelated cycle of poverty, poor education, undernutrition, and poor adult health as they related to economic productivity, at the household, as well as national level, is an important first step in addressing this cycle. Through a deeper understanding of these issues and consistent interactions with policymakers, positive change can begin and problems related to diet may be solved.

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