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Earlier this century a number of eminent nutrition scientists recognized that nutrition deficiency, particularly with respect to vitamin A, was likely to be responsible for a large number of infectious conditions, but the biological mechanisms were entirely unknown. Thirty-one years ago, WHO published a historic monograph by Scrimshaw, Taylor, and Gorden that comprehensively reviewed the slowly mounting evidence of the interaction of nutrition and infection. This review marked a decisive turning point in research, epidemiologic investigation, and the management of malnutrition and infectious disease.

An important implication of this work is that, by working together-in science, in policy formulation and implementation, in nutrition and in infectious diseases, and in health and economic development-we are likely to raise the quality of life more than we do by working independently. In partnership, we can achieve more than we can separately.

In repeating this message today, I would like to give you a number of concrete examples, and look to a future where these partnerships must be routinely created because there is still much work to be done.

The combination of malnutrition and infectious disease is deadly. Separately, the effect of each is huge. Together, their impact is far greater than the sum of their parts. Both are conditions of poverty. They arise from poverty and they keep people in poverty, not just for one generation, but for many generations.

In a well-nourished child, a common infectious disease is usually a passing illness. In a malnourished child, the same disease can precipitate life-long disabilities such as blindness. A rapid sequence of common infection and malnutrition too often leads to death.

A slow sequence of disease followed by malnutrition leads to stunting and wasting, and affects mental development, decisively handicapping the affected millions that do not die. The survivors have special difficulties in terms of their cognitive and physical development. Their handicap, though invisible, is lasting. And when they reach adulthood, they are less productive and they earn less.

The malnutrition-infection complex is a drain on human resources. One condition aggravates the other. Infections lead to malnutrition, and malnutrition exacerbates infections, increasing their duration and severity. A look at the figures for each condition helps us to understand the true magnitude of this interaction.

Worldwide, infectious diseases kill approximately 10 million children each year before they reach the age of 5. Fifty percent of these deaths are associated with malnutrition. Seven in 10 of these deaths are due to diarrheal diseases, pneumonia, malaria, and measles, in combination with malnutrition. This is not counting tuberculosis, intestinal parasitic infestations, and HIV-which also comprise huge numbers in terms of ill-health and death-and are also associated with malnutrition.

Globally, children who are poorly nourished have up to 160 days of illness each year, with 3-4 episodes of diarrhea and 4-5 illnesses owing to severe respiratory
infections. They often come from large poor families whose mothers are not well educated, who have, or will have, many dependent children, who themselves are not well nourished, and who produce low-birth-weight infants. Such women are themselves likely to have been born with low birth weight; their time and energy are stretched to the limit.

A large proportion of the world's population is affected by at least one of the several major forms of malnutrition. I am referring to low-birth-weight infants, wasted and stunted children, people who are brain-damaged from iodine deficiency,
pre-schoolers who die or become blind from vitamin A deficiency and who are intellectually impaired as a result of iron deficiency, mothers who die in childbirth because of anemia, and the large numbers of malnourished elderly who are largely overlooked. This is how malnutrition kills, maims, cripples, blinds, and retards, thereby impairing human and national development on a massive scale.

Now, let us examine the interaction of malnutrition and infectious disease. Malnutrition magnifies the effect of disease. A malnourished person has more severe disease episodes, more complications, and spends more time ill for each episode.

Because they aggravate one another, we cannot partition deaths into those owing to malnutrition and those owing to infection. In any population, the impact of malnutrition depends on the prevalence of infection, and the impact on infection-in terms of severity and duration-depends upon the nutrition base. Both need to be vigorously tackled.

Historically, despite its magnitude and obvious importance for mortality, the prevention and management of malnutrition took a back seat, both clinically and programmatically, to the prevention and management of infectious diseases. Clinicians in developing countries still find it much easier to deal with diarrhea, pneumonia, measles, or tuberculosis than to manage severe protein-energy
malnutrition. In many health-care centers there is still a 30% mortality rate in children with severe malnutrition, compared with only 5% in those receiving proper management. Similarly, in developing countries, most national health services pour resources into combating communicable diseases, whereas relatively meager resources are fed into national nutrition programs. Yet, where malnutrition
prevails, the incidence of infectious disease, and its associated mortality, remains high.

Death rates increase exponentially with the degree of malnutrition. We have consistently found this to be so in all countries for which data are available.

Any deterioration in nutrition status carries with it an increased risk of death. Thus, a severely malnourished child is 11 times more likely to die than a well-nourished child, a moderately malnourished child is 3 times more at risk of death, and a mildly malnourished child is twice as likely to die than a well-nourished child.

This reality has serious policy implications. The volume of malnutrition globally is in the mild and moderate category. And as long as half or greater (45-83%) of all malnutrition-related deaths occur to children in the mild to moderate category, we need to focus on this group. We shall not be making a dent in mortality if our policies and programs focus only on the severely malnourished.

It is true that there are many children who are severely malnourished but we need to think on a still broader front. For every child that is severely malnourished, there are many more who are moderately or mildly malnourished. Indeed, this is precisely how all severely malnourished children started out! Severe malnutrition is but the tip of an exceedingly great iceberg. We need to pay attention to the base. And we can expect to achieve the greatest impact by tackling the base.

Poor nutrition, however, is not the whole story. The more infectious disease there is in a population, the higher the death rate at any level of malnutrition;
the bigger the burden of disease, the bigger the iceberg. This has profound policy implications. It means that we can reduce deaths by improving nutrition and we can reduce deaths by reducing infection but the greatest impact is likely to be achieved by addressing both at the same time.

Malnutrition, however, should be regarded as not just a single disease, but a range of conditions, many life-threatening or irreversibly disabling, resulting from an imbalance in availability or use of nutrients. Poverty and lack of education, which are so often the effects of under-development, are usually the primary causes of hunger and malnutrition. There are poor people in most societies who do not have adequate access to food, care, safe water and sanitation, health services, and education. All of these are basic requirements for proper nutrition, and they require both short-term and long-term sustainable solutions and strategies.

There are several critical strategic approaches of proven effectiveness for preventing, reducing, and eliminating malnutrition. Whereas not all approaches are the primary mandate, the health sector has the overall leadership role in combating malnutrition This is most likely because of its unique diagnostic contribution in assessing, measuring, and monitoring the different forms of malnutrition and alerting other sectors to its magnitude, trends, consequences, and the population groups affected.

These strategies include incorporating nutrition objectives into national development policies and programs; ensuring household food security, including food and nutrition as a human right; preventing and managing infectious diseases; promoting breastfeeding; caring for the socioeconomically deprived and nutritionally vulnerable; preventing and eliminating micronutrient malnutrition; promoting healthful diets and lifestyles; and assessing, analyzing, and monitoring nutrition status. Not all of these are completely or primarily within the domain of the health sector. However, they all affect health and nutrition well being. This means that we must look outside of our sector and into other sectors that affect our goals in order to make the difference.

There are three major areas on which I would focus. The first is pregnancy and early nutrition. The sequence that begins with fetal malnutrition and results in a low-birth-weight baby is well known. One-third of low-birth-weight babies are moderately and severely malnourished by 6 months of age, and half are malnourished
by 1 year. The poorer the start babies have in life, the more likely they are to become sick and malnourished and to die.

The antecedent of the sick malnourished child is low birth weight. Low birth weight results from pregnancies that are too short, too close together, too many, or too long. Pregnancies that are too close together do the most damage, especially among teenage or young mothers. Births that are spaced too closely do not give time for mothers to recover. Those who have not recovered cannot provide adequate nutrition for their fetus and fetal growth is retarded.

To improve the nutrition status of children, we must give them a healthy start. We must increase birth spacing and the rate of exclusive early breastfeeding of infants. We must ensure that mothers are adequately nourished before and during pregnancy.

A special issue in pregnancy is anemia. The prevalence of anemia in pregnant women is high: 63% in Africa, 80% in South Asia, and 30% in Latin America. It is increased when the mother lives in a malaria-endemic area, and is pregnant for the first time. Severe anemia in pregnancy is a major obstetric problem in malaria-endemic areas and a primary cause of maternal morbidity and mortality. The risk for underweight babies is twice as high in a malaria-endemic area as for an area without malaria. Five hundred million people live in malaria-endemic areas. Stillbirths are more common there as is the risk for miscarriage. Half of the pregnant women who develop cerebral malaria die.

One of the most important factors in reducing child deaths and the vicious cycle between nutrition, infection, and poverty, is female education and literacy. Female education determines infant (and child) health and is statistically more significant than rural-urban differentials, income differentials, or ethnic origin.

Malnutrition and infection in children is the outcome of poverty, ignorance, and among other factors, high-risk pregnancies. The responsibility for improving them lies with those dealing with economic development, education, social affairs, and agriculture, as well as with health. We need to be able to convince those dealing with education and economic development that their efforts affect health outcomes. To do this we must be backed by evidence.

The evidence can only come from interventions that are undertaken on a large enough scale to measure impact and that are done well enough to be generally applicable. Armed with such convincing evidence, we need to ensure that food and nutrition objectives are adequately incorporated into national development policies and programs. We need to ensure that sustainable improvement of nutrition and health, particularly of the most deprived and vulnerable population groups, goes hand in hand with permanent reduction of poverty and sustainable national development.

The role of health in development has been underestimated. The role of economic development in health is also underestimated. Poverty, poor female education, and rapid birth spacing give babies a poor start in life. A healthy start makes good economic sense.

The second point is related to repairing immune function. One of the most important interventions in interrupting the link between malnutrition and infection is the use of vitamin A supplementation. Since the 1920s we knew that an important function of vitamin A is its ability to repair immune function, and that the body is unable to properly resist infection without this micronutrient. Vitamin A supplementation is therefore a crucial immediate intervention that can break the malnutrition-infection complex in areas where vitamin A deficiency is prevalent. By increasing resistance to infection, it reduces case fatality rates when the infection does occur, as in diarrheal disease and measles.

Large supplementation trials show that routine vitamin A supplements given between 6-72 months of age can reduce overall mortality by at least 23% where vitamin A deficiency exists in a population. The impact of this single supplementation on childhood mortality is therefore as great as, or greater than, that of any single vaccine and it only costs a couple of cents per dose. Given to breastfeeding mothers postpartum, it protects infants from vitamin A deficiency.

The combined approach to nutrition and infection has achieved more. In the last 3 years we established that a combination of the two most cost-effective tools, vitamin A supplementation and vaccines, achieves more than the sum of their benefits. An example of the power of this combined approach is the case of the measles vaccine and vitamin A.

The measles vaccine, developed in the 1960s, is safe and effective, and provides long lasting immunity to measles infection. The priority target group for protection against vitamin A deficiency and measles is the same: infants and young children of poor families living in overcrowded housing who are already at risk of malnutrition.

Measles infection claimed 7-8 million of these lives per year before the vaccine became available. Measles causes loss of vitamin A, frequently precipitating acute vitamin A deficiency and blindness. Of children who become blind, half die within one year. Measles also leads to long-term complications including deafness, chronic lung disease, poor growth, and recurrent infections. Giving the measles vaccine at approximately 9 months of age with vitamin A enables infants to receive both interventions for the addition of only a few cents per child.

Today, approximately 900,000 infants die from measles each year. These deaths are preventable. When vitamin A is introduced as part of measles management, the case fatality rate can be reduced by greater than 50%.

Last year, of those countries classified by WHO as having clinical signs or severe, moderate, or mild subclinical symptoms of vitamin A deficiency, over 40 countries administered vitamin A with their National Immunization Day vaccines. Now, many other countries include vitamin A in their routine immunization services.

We must also be clear that the ultimate battle to reduce and eliminate vitamin A deficiency and effectively combat malnutrition will not and cannot be won simply through short-term interventions such as providing vitamin A supplements, nor through clinic and hospital-based improved management systems, even though these are important and effective for saving lives.

These short-term interventions must be backed up by long-term enduring

sustainable solutions to vitamin A deficiency and malnutrition in general. These include food-based dietary approaches, breastfeeding, appropriate complementary feeding, and fortification of appropriate foods with vitamin A.

The third area in which we can make a difference is iron supplementation. The nutrition science community is no doubt aware of the importance placed upon Rolling Back Malaria. The effect of this disease upon iron status was, until recently, unquantified. Iron deficiency is, of course, the most common nutrition disorder in the world, affecting more than 1 billion people, particularly reproductive women and preschool children in tropical areas. Uncorrected, it leads to severe anemia, reduced work capacity, diminished learning ability, increased susceptibility to infection, and increased risk of death associated with pregnancy and childbirth.

Because the adverse effects of iron deficiency are preventable, iron supplementation
has been WHO's policy in all areas where there is iron deficiency, except in malaria-endemic areas. In areas where there is malaria, efforts were hampered by conflicting evidence on the effects of iron deficiency (some studies show that iron supplementation triggers latent malaria or increases severe malaria episodes). As a result of this controversy, which has prevented the 500 million people in malaria-endemic areas with iron deficiency anemia from obtaining iron supplementation, WHO funded a study to establish whether or not iron supplementation
increased risk of malaria or protected against severe iron deficiency anemia.

These results are now well known. Iron supplementation protects a child who is at high risk of dying from severe anemia in the first 2 years of life. However, antimalarial prophylaxis protects against severe anemia much more. The work, published recently, has provided us with evidence that malaria is the single largest contributor to the etiology of severe iron deficiency anemia in malaria-endemic areas.

In short, in areas of intense malaria transmission, reducing malaria makes more of a difference than iron supplementation in preventing severe anemia. By rolling back malaria, a major cause of iron deficiency anemia will be removed.

There is so much more that could be said in examining the nutrition-infection relationship and exploring its implications for public health policy. The World Health Organization is committed to reducing the mortality caused by malnutrition
and infectious diseases. The impact we are likely to achieve to give children a healthy nutrition start in life is not likely to be made through the health sector alone. Solid evidence of strategies that are as good for health as for development is needed, as are the price tag and the impact.

We have a greater chance of making a difference, of getting programs implemented,
when the benefits and costs are apparent to all the stakeholders. We depend upon evidence not only on the nutrition and health cost/benefit relationship of a program, but projections of these calculations into broader benefits for the economy. Making every child a wanted child, a healthier child, a more productive child and adult, through female education and better birth spacing, has implications for human development as well as for economic growth.

I count on the scientific community to join forces with the World Health Organization in this task, so that together we can make a difference.