Addressing Malnutrition to Improve Global Health
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Malnutrition is a complex topic that affects different communities and different populations in a variety of ways. Given its many faces, adequate data to address this serious condition is essential if solutions are to be found. Defining exactly what malnutrition is (or isn’t) has also been a challenge. However, there is agreement that malnutrition is an issue of critical importance around the globe.

All too often, the words malnourished and starving are considered synonymous. To be sure, the sight of the swollen bellies and skeleton thin arms of undernourished children is heart-wrenching. But this does not tell the full story. Malnutrition is not exclusively a problem of extreme poverty, nor only of the young, but affects all communities around the world and people of all ages.

Four particular facets of malnutrition are often overlooked. The first is that of inadequate nutrition seen in the elderly, an important issue that has become particularly problematic in Asia and many developing countries around the world. The latest evidence shows an awareness gap in health care workers and the broader community when it comes to the extent and implications of malnutrition in the elderly. Too often, aged hospital in-patients are not properly assessed for nutritional insufficiency either at admission or during their stay, seriously complicating and prolonging their treatment.

Disease-associated malnutrition (DAM) is also an increasingly urgent issue, not in the least because it places significant economic burden on countries. DAM can often be due to chronic conditions or conditions prevalent in aging populations. Its impact, however, is not limited to historically wealthy nations. China faces an increasing challenge from DAM as its population rapidly ages, with estimates in the billions of dollars annually.

Thirdly, overnutrition, or obesity, is another underrecognized malnutrition condition, one that is of particular concern in developed nations. Since proper nutrition is a balance of macro- and micronutrient intake and adsorption, overnutrition can cause nutritional insufficiencies in essential nutrients, leading to a range of negative health consequences including diabetes, cancer, and cardiovascular disease.

Finally, maternal malnutrition has been associated with lifelong nutritional issues, a process known as fetal programming. These issues, and more, are discussed in some depth in this publication, which brings together important research articles previously published in Science with original articles, all from top researchers and thought leaders in the field. This booklet is intended to be a call to action for the scientific, academic, governmental, and medical communities to assess and address the economic and clinical burden that malnutrition (in all of its forms) exerts on the global economy and to find a means to provide both short- and long-term solutions for those suffering from malnutrition and its consequences.

Sean Sanders, Ph.D.
Editor, Custom Publishing, Science/AAAS

“A thought for food... and food for thought
“Malnutrition is not exclusively a problem of extreme poverty, nor only of the young, but affects all communities around the world and people of all ages.”
Nutrition is vital for health at all ages. Inadequate nutrition intake and poor diets can result in malnutrition, an underrecognized and undertreated condition with significant consequences on global health. Malnutrition is multifaceted and far reaching, existing in both developed and developing countries, in health care situations, and out in the community. The challenge is great and the need for solutions is immediate.

Malnutrition is an often hidden problem for our health care systems. The numbers are staggering: Even in the most well-developed health care systems in the world, up to 50% of patients are malnourished or at risk. Those who enter the hospital malnourished heal more slowly and are much more likely to be readmitted. Nutrition, while critical to healing and recovery, is often overlooked. Research shows that simply providing an oral nutrition supplement can reduce readmissions, complications, length of hospital stay, and mortality.

The challenge of malnutrition exists across the lifespan. Even before we are born, nutrition intake impacts our development. As children, nutrition enables our physical and mental development, and growth. As adults, nutrition supports a healthy and active lifestyle. And as we age, nutrition supports a healthy and active lifestyle. As adults, nutrition supports a healthy and active lifestyle. And as we age, nutrition extends physical and mental health resulting in longer and higher quality independent living. Malnutrition—at any stage—can take away these fundamental elements.

Malnutrition can have a ripple effect across countries, their economies, and their health care systems. For example, China has both the world’s largest population, and also one undergoing dramatic change. By the year 2040, the Chinese population will grow by an additional 300 million people. China’s rapid growth and overall aging of the population is creating health care and healthy living challenges that never before existed, but now require near-term solutions. Malnutrition is one of these challenges. Fortunately it can be fully preventable and treatable whether occurring in a hospital setting or in the community.

At Abbott, we are committed to being part of the solution to improve health outcomes for patients with malnutrition. Our work centers on two streams. First, we are actively engaged in the emerging field of health economics and outcomes research (HEOR) to quantify the health economic benefits of nutrition. Secondly, we are acting on these findings by developing and clinically validating new solutions to address the greatest needs.

For example, we have quantified the economic impact of malnutrition for the U.S., Europe, and China in key populations, setting the groundwork for additional research to understand the cost-effectiveness of different nutritional interventions of the most prevalent diseases.

The cycle of hospital admission from the community and back to the hospital can be prevented when health care providers address a patient’s nutrition status, beginning at their admission. Simply stated, early nutrition intervention can help lower costs and improve patients’ health and quality of life. Solving this complex issue of malnutrition and health outcomes requires collaboration between many stakeholders, including health care, academic, industry, and government leaders. This collaboration will lead to solutions which extend and expand the quality of life for the people around the world.

We at Abbott Nutrition ask you to learn more about the issue and partner with us in making strides against malnutrition. We look forward to being an active part of this complex solution and thank you for your interest in our research. Together, we can solve this problem.

Robert H. Miller, Ph.D.
Abbott Nutrition
Divisional Vice President, Research & Development and Scientific & Medical Affairs

Section 1: The burden and impact of malnutrition on public health

Malnutrition, a complex condition resulting from inadequate nutrition intake, is significantly impacting both developed and developing countries. Scarcity and security of food plays a critical role in the development of malnutrition. This condition has created a quantifiable, significant health care and economic burden on society, driven by growth and aging of the global population. The impact is greatest in key countries, such as China, where these rapidly changing demographics are reshaping the population and with it, the scope and burden of malnutrition. The following articles deal specifically with the significant challenges the world faces.
What is malnutrition? Different definitions exist, many of which are vague and of limited use for either clinical practitioners or researchers. The World Health Organization International Classification of Diseases 10 (ICD-10) defines it as a “body mass index (BMI) ≤ 18.5 kg/m² or unintentional weight loss of 5%, with evidence of suboptimal intake resulting in subcutaneous fat loss and/or muscle wasting.” The National Library of Medicine MESH definition states that malnutrition is “an imbalanced nutritional status resulting from insufficient intake of nutrients to meet normal physiological requirements.” The American Society for Parenteral and Enteral Nutrition and the Academy of Nutrition and Dietetics define malnutrition based on an imbalanced nutritional status and its relation to starvation, and acute and chronic disease conditions (1), while the European Society for Parenteral and Enteral Nutrition integrates both undernutrition and overnutrition into its definition.

Malnutrition encompasses a group of diseases that involve compromised patho-physiological mechanisms, making it a challenge for public health, especially in a developing country with a large population such as China. Malnutrition can become a burden for society and families, especially as the population ages. In China, 178 million people are over 60, constituting over 13% of the total population. The proportion of those who are 65 and older increased from 7.0% to 8.9% between 2000 and 2010, and is expected to exceed 10% by 2020 (2, 3), doubling to 20% by 2050 (4). To add to this burden, the number of hospitalized elderly patients is increasing (24–44)/16 of 96% and malnutrition in the elderly is associated with poor outcomes, including mortality, postoperative morbidity, and extended hospitalizations.

Recent demographic and clinical surveys indicate that between 10% and 60% of all hospitalized Chinese patients suffer from malnutrition (4–6). The imprecise data suggests a lack of systematic screening and diagnosis for malnutrition. Some studies estimate that at least 17 million hospitalized elderly patients (~50%) suffer from malnutrition each year (Table 1) (5, 6). Malnutrition is therefore an important public health concern that requires appropriate responses from physicians, scientists, and health providers.

### Diagnosis challenges

Early, accurate diagnosis is critical for malnutrition monitoring and intervention in the elderly. Although many screening tools are available, with more than a dozen in clinical use, none provide a comprehensive diagnosis that fully reflects the complex nature of malnutrition and its related metabolic components. Additionally, these tools have not been rigorously assessed for efficacy of diagnosis.

Many subsections fall under the general diagnostic term “malnutrition.” Nutritionists and dietitians have attempted to provide some classifications, including protein-energy malnutrition, disease-related malnutrition, protein-energy wasting syndrome, and malnutrition with certain micro-nutrients deficiencies. However, there is currently no systematic framework or “body of knowledge” that comprehensively integrates the various indicators such as nutrient intake, disease, body composition, metabolic disturbances, and pathophysiological processes (including inflammatory response and oxidative stress). In the past decade, Chinese physicians have become aware of the importance of malnutrition and attempts have been made to improve malnutrition diagnoses, including the introduction of the nutritional risk screening (NRS-2002) tool. However, success has been limited. A robust diagnostic system is needed to integrate these variables and recognize different patterns of malnutrition.

A good malnutrition diagnosis should provide an objective, quantifiable measure based on clinical indicators; only then is effective and individualized intervention possible. None of the available nutritional screening or evaluation tools currently meet these criteria in terms of mathematically accurate. Ideally, the diagnostic framework that would incorporate physical symptoms, biochemical tests, and physiological evaluations to generate a single malnutrition score that accurately delineates and describes various types of malnutrition.

### A new diagnostic framework

We suggest redefining the classification system for malnutrition to create “malnutrition-ontology.” Ontological systems have been successfully applied in bioinformatics and computer science (10) and provide a powerful methodology for organizing and defining complex sets of heterogeneous data, a challenge when dealing with patient variability. In ontological terms, malnutrition could be deconstructed into individuals (instances), classes (concepts), attributes, and relations. Here, class defines the different types of malnutrition, while the attributes are used to quantify each class. The relation describes the relationships between the different categories of malnutrition.

Utilizing the enormous set of existing nutrition survey data together with computerized pattern-recognition techniques, an artificial intelligence system could be developed capable of detecting the heterogeneous incidence of malnutrition in different responses. This would additionally provide information on malnutrition patterns and the efficacy of nutritional interventions. This process would enable more accurate malnutrition diagnosis as well as establish a monitoring system that could identify those most at risk of malnutrition and provide a rational basis for appropriate individualized intervention.

In addition to introducing multiple iomics techniques (such as metabolomics and transcriptomics), technologies such as cloud computing, social networks, and wearable health monitoring devices could enable solutions that promote patient adherence (11–13). This is especially critical for elderly patients. Information generated by social networks and collected using wireless technologies can provide big data sets, the analysis of which can help to optimize new diagnoses and monitoring systems. The low cost and prevalence of various sensors, as well as the growing popularity of smartphones, means that those solutions will be increasingly affordable for middle to low income countries.

In summary, we believe that the proposed malnutrition ontology will lead to better diagnosis and individualized intervention, and improved population monitoring of malnutrition in the coming decades, equipping doctors with new tools for the managing of aged health care in the 21st century.

### Acknowledgments

The authors thank Dr. Charles Damien Lu, Dr. Hao Yang, and Dr. Jin Peng of Metabolomics and Multidisciplinary Laboratory of Sichuan Provincial People’s Hospital and Sichuan Academy of Medical Sciences for their generous help in preparing and writing this manuscript.

### References

Nutrition insecurity and malnutrition in developed countries

Susan Finn

We are familiar with the face of malnutrition in developing countries where men, women, and children suffer from bloating and body ulcers caused by protein deficiency (kwashiorkor) and the wasting that results from inadequate energy intake (marasmus). These two markers for malnutrition don’t tell the whole story. This paper briefly examines the nature, drivers, and impact of malnutrition in the Western world and suggests some foundational steps to combat it.

The big picture

Nutritional health depends on an intricate balance of macro- and micronutrients. Thirst is no one food: a clinical test for malnutrition, and we don’t always recognize it when we see it. According to the Academy of Nutrition and Dietetics, malnutrition can be defined as any nutritional imbalance, whether it be a lack of calories needed to meet the body’s energy demands or a lack of vital nutrients (1). A recent United Nations Food and Agriculture Organization publication, The State of Food Insecurity in the World 2014, reported that more than 790 million people (15% of the population in developing countries) have an insufficient amount of food available to meet basic energy needs. In developed countries, that number drops dramatically to just short of 15 million (<5% of the population) (2). Malnutrition, however, is not a one-dimensional issue. It is as much about hunger—getting enough calories (quantity)—as it is about the macro- and micronutrient density of those calories (quality). Thus, a malnourished person may be extraordinarily thin and gaunt, as in the pictures we see of starving third-world children, or may be overweight/obese. In the Western world and in rapidly developing emerging countries, we are seeing more and more of the latter.

Nutrition insecurity

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Nutrition insecurity

Codifying the definition of malnutrition to reflect not only the impact of too few calories in the diet, but also the ramifications of too few nutrients, demands that we take a closer look at root causes. Food insecurity is not the only roadblock to eliminating malnutrition; nutrition insecurity is equally as challenging. While extreme hunger leading to malnutrition does occur in developed countries, it is not equivalent to the same issue in developing nations; however, nutrition insecurity—lack of nutrient density in calories consumed—is a worldwide problem. For example, the 2010 Dietary Guidelines for Americans (for the population as a whole) identifies four shortfall nutrients in the U.S. diet: fiber, calcium, potassium, and vitamin D. Canada and the European Union have similar guidelines (3). The inability to access, purchase, and prepare nutritious food can have serious short- and long-range consequences for the health care system as well as the economy and society as a whole. Infants (including newborns in utero) and children who experience nutrition insecurity may face developmental delays, poor health outcomes, and educational challenges. These children enter the workforce ill prepared to be fully productive and to earn a living wage. Adults who experience nutrition insecurity face the risk of increased acute illness and chronic disease. The resulting dip in productivity and rise in sick days malnourished employees less likely to succeed in the competitive marketplace. Seniors experiencing nutrition insecurity may face an accelerated decline in cognitive function as well as an increase in chronic disease, both of which stress the health care system.

Challenges

In the United States, key drivers behind food and nutrition insecurity include poverty, nutrition illiteracy, and resistance to agricultural biotechnology.

Poverty

A 2013 Pew Research Global Attitudes Center survey revealed that, despite their country being the wealthiest in the world, almost a quarter of Americans said they had trouble putting food on the table during the prior 12 months. This rate is up from 16% in 2007, the year the Great Recession began (4). Researchers Walter Willett, Frank Hu, and colleagues, reported in the September 2014 issue of JAMA Internal Medicine that the quality of the American diet had improved from 1999 to 2010. They also observed that people with higher socioeconomic status had healthier diets than those with lower socioeconomic status, most likely due to the price of and access to healthier foods. In addition, they noted that dietary quality was lowest and improved more slowly among people who had had 12 years or less of school (5).

Nutrition illiteracy and confusion

Academy of Nutrition and Dietetics surveys show that while almost 90% of consumers say that nutrition is very important to them, less than 50% believe they are doing all they can eat a balanced, nutritious diet and only 40% say they know and understand the guidelines for healthy eating (6). In International Food and Information Council polls, 75% of consumers say that over-changing nutrition information makes it difficult to know what to believe (7).

Resistance to agricultural biotechnology

Advances in science have created new opportunities for the agricultural community to meet global food and nutrition security demands and environmental/sustainability challenges. Agricultural biotechnology—including genetically modified organisms and livestock vaccines—helps increase productivity by reducing crop and animal damage. These advances, however, are not without controversy. As agricultural biotechnology continues to evolve, the application of sound science and civil discourse are necessary to ensure biotech crops and livestock produce safe, nutrient-rich foods.

Responding to nutrition insecurity

Government, professional, and grassroots innovation is needed to promote nutrition security. These examples from the United States represent the kind of infrastructure found in developed countries.

Safety net

The U.S. government provides a food and nutrition safety net focused on protecting society’s most vulnerable people—infants, children, and seniors. This extensive support network includes free and reduced-price school nutrition programs for children of all ages and economic means; senior feeding programs; food distribution programs; food stamps (Supplemental Nutrition Assistance Program, a.k.a., SNAP); and the Special Supplemental Nutrition Program for Women, Infants and Children (WIC).

Nutrition literacy

Initiatives such as the Academy of Nutrition and Dietetics literacy programs, its Future of Food campaign and its Alliance to Advance Patient Nutrition, address the need to improve not only the public’s working knowledge of nutrition in the food system, but also health care professionals’ understanding of the role of nutrition security in preventing and treating disease.

Innovation

From continuous and transparent multidisciplinary partnerships to research, test, evaluate, and report on innovations in food and nutrition security, agriculture, biotechnology, health promotion, and disease prevention up and down the food system spectrum are necessary to leverage knowledge and resources, promote expert dialogue, and enhance sustainability. The 10-member bipartisan National Hunger Commission, convened in 2014, is currently exploring ways to encourage public-private partnerships and greater involvement from community and faith-based groups in providing a food and nutrition safety net for the poor. For example, in Indianapolis, Indiana, the Indy Hunger Network is a model grassroots coalition of local businesses; advocacy groups; food banks; WIC, SNAP, and child nutrition programs; senior groups; and faith communities that aims to reduce hunger and promote nutrition security. Food and nutrition insecurities that escalate into malnutrition in developing nations as well as in developed countries such as the U.S. present a multifaceted challenge. Economic, social, and cultural variables render one-size-fits-all solutions futile. This is not to say, however, that we cannot learn from each other. In fact, we must learn from each other through hands-on multidisciplinary, multinational joint ventures, partnerships, coalitions, and alliances from the grassroots to the highest level of policymaking.

References

Food security: The challenge of feeding 9 billion people

H. Charles Godfray1, John R. Beddington, Ian B.Crute, Lawrence Haddad, David Lawrence, James F. Meuli, Julius Pretty, Sherman Robinson, Sandy M. Thomas, Camilla Toulmin

Continuing population and consumption growth will mean that the global demand for food will increase by 70% between now and 2050 (1). Whether or not the world’s people are hungry, despite a doubling of the total population over the next 40 years (2), an additional 700 million people today still do not have access to sufficient food and energy, in addition to the overexploitation of fisheries, will affect our ability to produce food, as will the urgent requirement to reduce the impact of the food system on the environment. Both challenges are a further threat. But the world can produce more food and can ensure that it is used more efficiently and equitably. A multifaceted and linked global strategy is needed to ensure sustainable and equitable food security, different components of which are explored here.

T he past half-century has seen marked growth in food production, allowing for a dramatic decrease in the proportion of the world’s people who are hungry, despite a doubling of the total population over the next 40 years (2). However, there are some 9 billion people by roughly the middle of this century. A major correlate of this de- celeration in population growth is per capita income and wealth, and with higher purchasing power comes greater demand for processed food, meat, dairy, and fish, all of which add to the food supply. At the same time, food producers are experiencing greater competition for land, water, and energy, and the need to curb the many negative environmental impacts of agricultural activity. In the near future, the threats of climate change and concerns about how mitigation and adaptation measures may affect food production and the environment will increase, while the pressure to increase food production is expected to grow further. The yield gap is not static. Maintaining, increasing, or closing the yield gap is a major challenge now faces the world (3). The rapid changing demand for food from a larger and more affluent population to its supply, so do that and the crop and livestock yields that maximize the amount of food harvested or supplied for a given amount of (or even less) land. Moreover, there are no major new fishing grounds. Virtually all capture markets have been captured, and most are overexploited. Taken together, this means that the world will need to 100% more food by 2050 (1, 18). In this article, major strategies for addressing the challenges of the growing population, including the most disadvantaged, and the emphasis is given to sustain-ability, as well as to the combi- nation of both national and social sciences in analyzing and addressing the challenge.

The closing yield gap

There is widespread recognition that the yield gap—between what crops and livestock are able to achieve and the best that can be achieved using current genetic material and available technologies and management—is termed the “yield gap.” The best yields that can be obtained locally depend on access to land, water, and other inputs, and much higher yields are generally possible, particularly on relatively small farms where on-farm resources are not shared with other uses.

In recent years, decisions to produce food have involved many factors, including the need for food security, economic gains, and environmental considerations. But the yield gap is an important factor to consider, as it is the difference between what farmers can produce and what they are actually producing. This gap can be closed by increasing the skills and knowledge of farmers, improving their access to inputs, and using new technologies and practices.

The yield gap is not static. Maintaining, increasing, or closing the yield gap is a major challenge now faces the world (3). The rapid changing demand for food from a larger and more affluent population to its supply, so do that and the extreme cases of failed states and nonfunctioning economies. The yield gap of those who have the least influence on how global food systems are organized and managed, and those who benefit most from improved food production, may be the best choice. When investment flows are made to the countries with the least access to food, they may not be able to store the produce or have access to the infrastructure to transport the produce to markets. Farmers, often the poorest and most are overexploited. Reductions in some greenhouse gas emissions can potentially be achieved by changing agronomic practices, the adoption of integrated pest management, the use of biopesticides, and the adoption of management practices that enhance soil organic matter and conserve agro-biodiversity. However, the effects of different agronomic practices on greenhouse gas emissions can vary widely. The use of biopesticides can help avoid pesticide resistance, which is still one of the most important and effective ways to control pests and diseases.

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The Green Revolution succeeded by using only recently identified domestic breeding, achieving rapid increases in rice and wheat yields through selection for drought tolerance. By mid-century, new technologies focused on boosting crop yields in areas so remote that they are effectively displaced by many of the world’s poorest communities. These new technologies include crops such as sorghum, millet, cassava, and banana, staple crops that are staple foods for many of the world’s poorest communities.

SECTION ONE | ARTICLES: REVIEW

### Table 1. Examples of current and potential future applications of GM technology for crop genetic improvement

<table>
<thead>
<tr>
<th>Time scale</th>
<th>Target crop trait</th>
<th>Target crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term</td>
<td>Tolerance to broad-spectrum herbicide</td>
<td>Maize, soybean, oilseed rape, canola</td>
</tr>
<tr>
<td></td>
<td>Resistance to chewing insect pests</td>
<td>Nutritional biofortification</td>
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<tr>
<td></td>
<td>Resistance to fungus and virus pathogens</td>
<td>Potato, wheat, rice, banana, fruits, vegetables</td>
</tr>
<tr>
<td></td>
<td>Resistance to root pests</td>
<td>Wheat, potatoes, fruits, vegetables</td>
</tr>
<tr>
<td></td>
<td>Improved processing and storage</td>
<td>Staple cereals and tubers</td>
</tr>
<tr>
<td>Medium-term</td>
<td>Drought tolerance</td>
<td>Staple cereals and tubers</td>
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<tr>
<td></td>
<td>Salt tolerance</td>
<td>Staple cereals and tubers</td>
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<td></td>
<td>Increased nitrogen efficiency</td>
<td>Staple cereals and tubers</td>
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<td></td>
<td>High-temperature tolerance</td>
<td>Staple cereals and tubers</td>
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<td></td>
<td>Nitrogen fixation</td>
<td>Increased photosynthetic efficiency</td>
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<td>Long-term</td>
<td>Defensification inhibitor production</td>
<td>Conversions to perennial habit</td>
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<tr>
<td></td>
<td>Conversion to perennial habit</td>
<td>Increased photosynthetic efficiency</td>
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</tbody>
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**Fig. 2. An example of a major successful sustainable agriculture project.** Niger was strongly affected by a series of drought years in the 1970s and 1980s and by environmental degradation. From the early 1980s, donors invested substantially in soil and water conservation. The total area treated is on the order of 300,000 ha, most of which went into the rehabilitation of degraded land. The project in the Filai district of Niger promoted simple water harvesting technologies. Contour stone bunds, hill farming, stone building, and improved traditional planting practices (gard) were used but hill farming and terracing alone, on steep, crusted land. More than 300,000 ha have been rehabilitated, and crop yields have increased and become more stable from year to year. True cover rains increased, as shown in the photographs. Development of the land marked and continued incremental expansion of the treated area without further project assistance indicate that the outcomes are sustainable (52, 53).

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*on what can be measured relatively simply (carbon, for example) may lead to dimensions of sustainability that are harder to quantify (such as biodiversity) being ignored. These are areas at the interface of science, engineering, and economics that usually need more attention (see Box 3). The introduction of measures to promote sustainability does not necessarily reduce yields or profits. One study of 286 agricultural sustainability projects in developing countries, involving over 2.5 million smallholder farmers on 37 million hectares, found an average yield increase of 7% across a very wide variety of systems and crops types (27). One-quarter of the projects reported a doubling of yield. Research on the ability of these and related projects to be scaled up to country and regional levels should be a priority (28). Strategies designed to close the yield gap in poor countries face some particular challenges (29). Much production is dominated by smallholder agriculture with very limited access to inputs and extension services. Where viable, investment in on farm research and extension to assist the farmers to exploit the potential of agricultural systems, the magnitude of this effect on sustainability, a major cause of the malnutrition that will be the ability to grow crops in places that are currently unproductive, particularly the northern tier of countries, such as crop productivity due to overextraction of resources that are currently unproductive, such as crop productivity. The lack of secure land rights can be a particular problem for many farmers, especially those who farm on common lands. The lack of secure land rights can be a particular problem for many farmers, especially those who farm on common lands. The lack of secure land rights can be a particular problem for many farmers, especially those who farm on common lands. The lack of secure land rights can be a particular problem for many farmers, especially those who farm on common lands. The lack of secure land rights can be a particular problem for many farmers, especially those who farm on common lands.

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The issue of trust and public acceptance of genetically modified (GM) crops is a major issue, particularly in developed countries, as there is a growing mistrust of scientists and technology. GM crops have been fanned by a substantial increase in the number of consumers who are concerned about the environmental impact of GM foods.

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There are particular issues involving new SCIENCE
Fig. 3. Makeup of total food waste in developed and developing countries. Retail, food service and home and municipal categories are lumped together for developing countries.

Table 2. Comparison of the impact of grazing and intensive (confined/industrialized) grain-fed livestock systems on water use, grain requirement, and methane production. Service water is that required for cleaning and washing livestock housing and other facilities. Dashes indicate combinations for which data are not available. Such a combination cannot be measured or because it does not exist. This table does not include other impacts of differing livestock management systems such as (i) nutrient runoff and pollution to surface and groundwater, (ii) antibiotic and bacterial contamination of water and air, (iii) emission of NOx from fuel in soils and water, (iv) odor nuisance from wastes, (v) inputs used for feed production and lost to erosion, (vi) livestock-related land-use change (Source: (7, 250)).

<table>
<thead>
<tr>
<th>Water</th>
<th>Measure of water use</th>
<th>Grazing</th>
<th>Intensive</th>
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<tr>
<td></td>
<td></td>
<td>liters day⁻¹ per animal at 15°C</td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>Drinking water: all</td>
<td>123</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Service water: beef</td>
<td>103</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Service water: dairy</td>
<td>13</td>
<td>52</td>
</tr>
<tr>
<td>Pigs</td>
<td>(fasting adult)</td>
<td>17</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Drinking water</td>
<td>29</td>
<td>125</td>
</tr>
<tr>
<td>Sheep</td>
<td>(fattening adult)</td>
<td>96</td>
<td>29</td>
</tr>
<tr>
<td>Chicken</td>
<td>(broiler and layer)</td>
<td>1.3–1.8</td>
<td>1.3–1.8</td>
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<tr>
<td></td>
<td>Drinking water</td>
<td>0.95–1.05</td>
<td>0.95–1.05</td>
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<tr>
<td></td>
<td>Service water</td>
<td>0.95–1.05</td>
<td>0.95–1.05</td>
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Table of mean weight of meat produced per kg of feed.

- Beef: 1.3–1.8 kg
- Chicken: 0.95–1.05 kg
- Pigs: 0.95–1.05 kg

Reducing waste

Robustly 30 to 40% of food in both the developed and developing worlds is lost to waste, though the waste patterns and contributing factors are different. (Fig. 3) (67, 37–39). In the developed world, food safety primarily attributable to the absence of food-chain infrastructure and the lack of knowledge or investment in storage technologies. In the developing world, food safety primarily relates to the quality of food on the shelf, which is often lower than in the developed world. This is because of the way food is produced, transported, and stored. Food safety is a major concern for retailers and consumers. (Fig. 3) (67, 37–39). In the developed world, food safety primarily relates to the quality of food on the shelf, which is often lower than in the developed world. This is because of the way food is produced, transported, and stored. Food safety is a major concern for retailers and consumers.

Reducing the conversion efficiency of plant into animal biomass requires a decrease in the volume that there would be a decrease in the volume of lost trust if their potential benefits are extended to domestic strategies for reducing pre-retail losses. In developing countries, unwanted food goes to a landfill instead of being used as animal feed because of the assumption that it contains pathogenic bacteria. New technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is directed at the needs of those communities, which are often different from those of more developed country farmers. To increase the likelihood that new technology works for, and is dire
17. J. Fargione, J. Hill, D. Tilman, S. Polasky, P. Hawthorne, Science 319, 1238 (2008); published online 7 February 2008 (10.1126/science.1152747).
38. Waste and Resources Action Programme (WRAP), The Food We Waste (WRAP, Banbury, UK, 2008).
53. The authors are members of the U.K. Government Office for Science’s Foresight Project on Global Food and Farming Futures. J.R.B. is also affiliated with Imperial College London. D.L. is a Board Member of Plastid AG (Geneva) and owns shares in AstraZeneca Public Limited Company and Syngenta AG. We are grateful to J.O.K. Krebs and J. Ingram (Oxford); N. Nilsson and D. Flynn (Foresight); and colleagues in Defra and DfID for their helpful comments on earlier drafts of this manuscript. If not for his sad death in July 2009, Mike Gals (Institute of Economic Affairs, London, UK) would also have been an author of this paper.
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The global economic burden of malnutrition

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round the world, malnutrition imposes an immense burden on society through its effects on health as well as its economic impacts. Whether malnutrition arises due to poverty or is associated with disease, cost-effective interventions are available to reduce this burden. Existing evidence suggests that the benefits of such efforts are likely to exceed the costs. In this article, we review and summarize the burden on society from malnutrition and discuss cost-effective solutions.

Introduction

According to 2009 data from the Food and Agriculture Organization of the United Nations, 1.02 billion people globally, or approximately one in six individuals, are undernourished.1 Malnutrition has serious health consequences at both the individual and societal level. Functionally, malnutrition2 negatively affects almost every system in the body, and is associated with stunted growth (2, 3, reduced muscle strength and endurance (4); diminished gut function (5); impaired cognition across the lifespan (6, 7); and compromised immune function (5, 8). In developing regions, malnutrition has stemmed primarily from poverty leading to inadequate food intake (2). In developed countries, the prevalence of malnutrition associated with noncommunicable or chronic disease (for example cancer or heart disease) has risen considerably (9, 10). At the societal level, malnutrition imposes a substantial burden in morbidity, mortality, and economic costs (see Figure 11, 11). In this article, we summarize the burden of malnutrition in developing and developed countries, comment on how malnutrition differs in the two settings, and discuss cost-effective solutions. We find that the burden of malnutrition is large in both settings, though for different reasons. Yet a multitude of interventions, such as malnutrition screening, micronutrient supplements, and provision of oral nutritional supplements, can be used to reduce the burden of malnutrition in a cost-effective manner.

Malnutrition in developing countries

While the effects of poverty on health and nutrition impact people in every country, poverty-related undernutrition is particularly prevalent in low-income countries. Populations in extreme poverty are vulnerable to economic or environmental shocks, such as prolonged drought or conflict, leaving them at risk of starvation. While such crises of acute and widespread hunger may be more visible, chronic malnutrition also imposes a substantial burden on these countries and society in general (11, 12). The effects of poverty-related malnutrition are most widespread and serious among children and maternal-age women (3, 11-12). A recent study estimates that 3.1 million child deaths per year are caused, at least in part, by undernutrition (12).

In addition to the considerable burden from increased morbidity, chronic childhood undernutrition leads to stunting, delayed intellectual development, and other problems that have lifelong impacts. Approximately one in three children in developing nations is undernourished, stunted, and micronutrient deficiencies affect approximately 30% of people in these countries (11). Moreover, childhood undernutrition is linked to lower educational attainment and lower economic productivity as an adult (2, 13). Over lifetime, undernutrition reduces lifetime earnings by more than 10% (11).

Given the far-reaching health and economic effects of poverty-related undernutrition, it is perhaps not surprising that programs to reduce undernutrition in the developing world have been found to be among the most cost-effective development programs (14, 15). Micronutrient supplementation, for example, is a well-documented approach to battling the effects of undernutrition. Considerable research has been devoted to determining the efficacy and cost-effectiveness of supplementation/fortification programs addressing iodine and vitamin A deficiency, with ongoing work under way to identify the best delivery system for these interventions. While most effectively, these programs are ideally incorporated alongside screening approaches and nutrition education provided either at the community or primary care level, with a particular emphasis on the needs of gestating and lactating women, and early childhood (16, 17).

Poverty-related undernutrition is particularly prevalent in regions of Sub-Saharan Africa and South Asia, where the burden of low-income countries are concentrated. As economies develop, the prevalence of poverty-related undernutrition tends to diminish. For example, the prevalence of undernutrition in developing countries, defined as the prevalence of underweight children in China fell by nearly 82% between 1987 and 2010 (18), which coincided with a period of rapid economic growth. However, the prevalence of chronic noncommunicable

1 It should be noted that, although the focus of this paper is on undernutrition due to poverty or disease, undernutrition also has significant negative health consequences (e.g., diabetes and cardiovascular disease), and the overweight and obese may also be malnourished.
Health and economic burden of malnutrition is a global concern

DAM, malnutrition associated with 10 diseases, causes annual economic burden of US$948 billion (in 2013 dollars), which exceeds the burden in the U.S. and Europe combined (30). As in the U.S., the elderly bear a disproportionate share of the burden of DAM: 13.4% of the Chinese population is ≥60 years old, but this group bears 38.0% of the burden.

Interventions aimed at reducing malnutrition

The substantial economic burden from DAM makes it an important policy priority. Fortunately, effective and relatively inexpensive interventions are available to reduce this condition and improve patient outcomes (16, 21–34). In order to treat DAM, providers must first know which patients are malnourished. Although screening for nutritional status has been found to be a cost-effective strategy (23), and is recommended by the Joint Commission for the Accreditation of Health Care Organizations, research indicates that many patients may never be screened (35) and up to 50% of malnourished individuals are never identified (22).

Once DAM has been identified, low-cost options exist to improve nutritional status and energy balance. For example, in-hospital dieters and physicians may counsel patients with specific micronutrient deficiencies on a healthier diet plan or provide supplementation of their existing diet. Oral nutritional supplements (ONS) are food and fluids modified to deliver protein, carbohydrate, lipid, and/or micronutrient fortification and are typically used when normal dietary intake is insufficient to meet daily nutritional requirements (36–37). ONS are most commonly provided to patients when they interact with the health care sector, with their use potentially continuing in the community setting (38).

A substantial amount of research has been conducted in the U.S. and Europe over the past decade to evaluate the impact of nutrition screening and ONS provision in adult and elderly DAM patients in various settings. Specifically, both during and after hospitalization for a range of medical, pre-surgical, and post-surgical conditions, patients who received oral nutrition screening and ONS showed consistent improvements in quality of life and physiologic markers, alongside decreased readmissions and reduced complication rates (33, 34, 39–41).

The available literature on the effectiveness of ONS in addressing DAM in clinical settings is largely confined to industrialized nations in the U.S. and Europe, indicating a need for more research in developing countries. However, available data indicate a consistent and positive impact of ONS, both clinically and financially, across a range of study types including randomized controlled trials, meta-analyses, and observational and economic analyses (33, 34, 39–42).

Research across developing and developed regions shows that the implementation of nutrition screening and support protocols in clinical or institutional settings provides a low-cost way to identify and treat individuals who will benefit from nutrition intervention (17, 22, 23, 33, 34, 39–44). The recent move by the U.S. Centers for Medicare and Medicaid Services to increase the freedom of registered dieticians to manage patients’ diets and order nutrition-related laboratory tests reflects the strength of the evidence that the potential benefits of nutrition interventions are likely to far exceed their costs (45).

Conclusions

Malnutrition imposes a significant health and economic burden through increased morbidity and mortality, impaired physical and intellectual development of children, decreased economic productivity, and increased costs of health care. In developing countries, the primary trigger of malnutrition continues to be poverty, with children and maternal-age women most at-risk of long-term detriment (11–13). In the developed world, the bulk of the societal burden from malnutrition is due to DAM and is borne disproportionately by the elderly. In reality, both resource-related malnutrition and DAM exist in all countries. This is particularly true in a large number of middle-income countries, such as China, India, and Brazil. In these cases, both disease and poverty are likely to be major drivers of malnutrition, and strategies to reduce malnutrition must consider both. As the elderly are expected to live longer, population susceptibility to chronic diseases is increased and the impact of DAM on society is likely to increase. As such, it is important for policymakers and medical professionals in developed and middle income countries to understand the size of the burden from DAM as well as strategies to reduce the burden.

Current evidence suggests that cost-effective strategies exist to reduce the burden from both poverty- and disease-associated malnutrition. Addressing poverty-related malnutrition through micronutrient supplements and micronutrient fortification is an example of one of the best ways to advance global welfare (14, 15). In the realm of DAM, a powerful case can be made for the importance of identifying patients at high risk and targeting additional resources to improve malnutrition management in clinical settings. Compared with many interventions commonly used to address complex conditions, nutrition interventions are often cost-saving or at minimum highly cost-effective, and may lead to improvements in underlying disease states. In addition, the societal value of potential longevity gains, morbidity and mortality reductions, and increased economic productivity accompanying effective nutrition management are high. This makes reducing malnutrition not only an important clinical and public health issue, but also an effective economic tool that can be leveraged against the burden imposed by malnutrition, and the availability of cost-effective solutions, this problem deserves to be a global policy priority.

References

China's demographic history and future challenges

Xihua Peng

On 28 April 2013, China’s state statistics bureau released its first report on the country’s 2010 population census. The report states that the total population of mainland China reached 1.3397 billion in 2010, with an annual average population growth rate of 0.57% during recent rapid population growth, with an average annual population growth rate of 0.14 decreased from 2.22% in 2000 to 16.6% in 2010, whereas the proportion increased from 58.5% in 2001 to 16.6% during the same period. This indicates that China’s population is aging. The current population aging is not only China’s, but also a worldwide phenomenon. The rapid increase in life expectancy and the shift in the population structure are the main reasons for population aging. The rapid increase in life expectancy has increased the proportion of elderly people in the total population, while the rapid decrease in birth rate has reduced the proportion of young people in the population, leading to a rapid increase in the proportion of elderly people. This phenomenon is expected to continue in the future, and it is expected to accelerate in the next few decades. The aging population will have a significant impact on China’s economic development, social stability, and government fiscal policy.

The aging population will have a significant impact on China’s economic development, social stability, and government fiscal policy. The aging population will put pressure on the government’s social security system, especially the pension system. The aging population will also have a significant impact on the labor market. The aging population will reduce the labor force, which will affect the economic growth. The aging population will also have a significant impact on the government’s fiscal policy. The aging population will increase the demand for public services, such as healthcare, education, and social security, which will put pressure on the government’s fiscal policy.

China’s economic growth has slowed in recent years, and the government has taken measures to address these challenges. The government has implemented a number of policies to improve the economic growth, such as promoting innovation, increasing investment in infrastructure, and improving the business environment. However, the aging population will continue to have a significant impact on China’s economic development, social stability, and government fiscal policy, and it will be necessary to address these challenges in the future.
modernization—and its implementation relied heavily on government administrative controls and disincentive measures. In fact, China has never implemented a pure one-child policy. In general, all “one-child policy” has only been carried out among urban residents. The majority of the rural families are allowed to have two children, whereas regulations on minority ethnic populations are more flexible. (9-11) Furthermore, there is also a lack of scientific understanding of the one-child policy and its implementation, which is an oversimplification. It is also evident that other social and economic factors, such as advancements in education, improvements in women’s status, and the position of women, and reductions in mortality, also contributed to the general fertility decline.

China has always been marked regional variation in all demographic indicators in China. Thus, TFRs today range from above 1.7 in the northeastern region, down to below 1.2 in some of the inland provinces to well below 1 in the major cities of Shanghai and Beijing (Table 2). Similar varia-
tion exists with respect to life expectancy: The highest, 79 years, is recorded in Shanghai, the lowest, 61 years, in some very poor and remote areas of Shaanxi and Qinghai provinces and Xizang (Tibet) autonomous region. Urbanization and population aging show similar regional patterns. Thus, the more socioeconomically advanced regions of the country tend to be much more urban and have older populations. In contrast, those areas with a low level of development, such as those in Shaanxi and Gansu provinces during the 1980s was quite low, and it increased very slowly over time. Indeed, the country’s fertility rate has only been widely viewed as an example of “underurbanization”—that is, a case of industrial growth without parallel urbanization. Only about 20% of the population lived in urban areas in the early 1970s (Table 1). However, the urban population has increased rapidly since the beginning of China’s economic reforms in the early 1980s. Today about half of the population lives in cities. The urban population in China increased from less than 20,000 towns. Between 2000 and 2010, the urban areas absorbed more than 15 mil-


Table 2. China’s provincial population statistics around two census years in 1980s and 2010s. Grouping of provincial units into three main areas is based on an official government statement in 1984. Data for Hainan were unavailable in 1982 because these two provincial units were set up in later years. The overall demographic dependency is calculated as (number of people aged 0 to 14 and those aged 65 and over)/(number of people aged 15 to 64) × 100. Data were unavailable for empty cells. (View map of China’s provinces at www.scim.ag/sciencemag.org)
of the elderly population is expected to reach about 100 million by 2020 and 200 million by 2040. In addition, note that the proportion of the population aged 65+ under the “current policy unchanged” scenario will be higher than in other scenarios by an appreciable degree. This is because lower fertility will inevitably mean more rapid aging (28).

Although the increase of the elderly population will be both in China. One common concern is that the working-age population (aged 15 to 64) in China will remain enormous, both in terms of absolute size and as a share of the total population. The influence of potential adjustments in population policy on the size of the working-age population will only emerge after the period 2025–2030. All projections show that China’s working-age population will continue to grow in the next decade, that it will peak around 980 to 1000 million around 2020–2025 and then be maintained for a while. The shrinking of the working-age population is more or less inevitable to ensure the time that the population stops growing. The size of the working-age population will largely be determined by changes in population policy and the prevailing fertility level. The working-age population would gradually decline and remain under the “current policy unchanged” scenario and would be a little less than 900 million under the “two children for one-only-child couples” scenario. Varied policy adjustment and TFR options can result in growth of the working-age population in China ranging between 780 million and 1060 million in 2050. Moreover, the huge migration involved in the process of urbanization has always been regarded as one of the motive forces of China’s economic growth and development. The scale and pace of urbanization promise to continue at an unprecedented rate. If current trends hold, the urban population will expand from about 665 million in 2000 to 915 million in 2050 and will hit the 1 billion mark by 2030 (24). This means that China’s cities will add 355 million people in the next 20 years—more than the entire population of the United States today. Most of these 335 million new urban resident (240 to 260 million) will be rural-urban migrants. This growth will undoubtedly impinge mounting pressures for many cities. After all, there will be 259 cities with more than 1 million inhabitants by 2025, compared with just 35 in Europe today. Moreover, 24 of these cities will have more than 5 million people (24).

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lational system in China to cope with future population-related socioeconomic changes. China's population issues should be dealt with in an integrated and balanced way.

REFERENCES
15. Y. Mao, “There is no food crisis in China at al” (working paper; Unina Institute, Economics of 2007, www.unirieda.org.cn/).
people born in the 1950s, when China’s first population boom took place, are now reaching 60 years of age. This suggests that China will soon face an aging society, creating a growing challenge to the healthcare system. According to a report entitled “The Blue Book of Aging - China Report of the Development on Aging Cause (2013)” released by the Chinese Academy of Social Sciences, the portion of the population aged 60 years or over in China was approximately 194 million in 2012 and is expected to reach 202 million in 2013 (1). In the next 30 years, from 2010 to 2040, China will see an increase of 15.7 percentage points in the proportion of those aged 60 years or over (from 12.4% to 28.1%), the fastest rate of growth in the world (1, 2). Further exacerbating the challenge of an aging society is the shifting demographics of the elderly population. According to the 2010 census, of those over 60, 56% are aged 60 to 69, 32% are between 70 and 79, and almost 12% are over 80. Compared with census data from 2000, the proportion of over-60’s in the 60-69 age group has decreased by 2.6%, while the proportion in 80+ increased 2.5% (in raw numbers, up from 12 million in 2000 to 20 million in 2010) (3). Twenty-three million persons aged 80 years or over were living in China in 2013, making it the country with the largest population of persons in that age group. This fact is expected to hold true to 2050, when the estimated number will be 90 million (2).

Population health by the numbers
The most recent estimates of the average life expectancy in China is 74.83 years (males 72.38 years and females 77.37 years) (3). To analyze the healthfulness of this aging population, Du et al. reported health data from China’s 6th National Population Census in 2010 to conduct a comprehensive analysis of the health status of those over 60 years of age, the health status of this age group was found to be good, with 43.9% self-identifying as having good health and 39.3% saying their health status was moderate (5). By contrast approximately 30%, or 16.85% of the total, indicated that they had an unhealthy status. Disabilities were reported by approximately 3% of respondents, equating to an estimated 5.24 million aged people who require long-term care. Reported health status declines with advancing age: those reporting good health status declined from 60.8% in 60-64 year-olds to 48.4% in 65-69 year-olds, 26.3% in 70-74 year olds, and 28.0% in 75-79 year olds. The percentage of those with a disability increased dramatically from 12.7% in the 85-89 age group to 26.1% in the 95-99 group (5).

The data also indicated that the urban elderly are healthier than those living in a rural environment, with 49.9% of urban residents self-reporting good health compared to 40.4% of rural residents. Additionally, the percentage of aged people with a disability in rural areas (3.3%) is higher than that in urban contexts (2.5%) (6). Demand for health services is high in both rural and urban settings (7, 8), and the two-week prevalence of chronic disease and hospitalization rates have increased dramatically from 2003 to 2010 (9). The percent of patients in urban contexts who had physician contact within the two-week duration of the study was higher than that in rural areas in 1993, 1998, and 2003, but these differences disappeared by 2008 (9).

An epidemiological shift
As China is moving towards a demographic transition, the aging and lifestyle experience increases, health in old age has become an important goal, including avoidance or effective management of chronic age-related diseases, prevention or retardation of the progressive decline in physical and cognitive function, and maintenance of psychological health. China is at a point of rapid epidemiological transition in the past few decades as the predominant cause of mortality has shifted from infectious diseases and perinatal conditions to chronic diseases. Of particular interest is the population structure is resulting in higher ratios of chronic diseases commonly seen in older age groups. According to the 2013 China Health Statistical Yearbook, the prevalence of chronic disease can be found in 65.8% of those over 65 (85.1% in urban areas and 52.3% in rural). Cancer was the leading cause of death in the 60–80 age group, while cerebrovascular and heart disease had almost stagnant growth trends in over the age of 80 (9). Using data from the Global Burden of Disease Study 2010, Yang et al. found that in China, stroke took the largest health and well-being impact on individuals. Stroke and ischemic heart disease accounted for 15.2% of all Disability Adjusted Life Years (DALYs); a measure of years of healthy life lost in 2010, stroke was found to be almost as high as ischemic heart disease (11).

Cognitive dysfunction and mental disorders have also been critical diseases which affect the health and quality of life of the elderly. The prevalence of dementia in China is between 3% and 5% of the total population over 60 years of age (13), while the prevalence of Alzheimer’s disease (AD) in China, a marker of pre-dementia syndrome is 12.7% (CI: 9.7%-16.5%) (14), and the prevalence of depressive symptoms among the population aged over 60 years is 22.8% (CI: 19.4%-26.4%) (15). Dietary risk factors, high blood pressure, and tobacco use are the risk factors that constituted the largest number of attributable DALYs in China (11). Public health programs to reduce sodium intake, and change other dietary risks are clearly important strategies for improving health of the elderly in China.

In conclusion, to achieve the goal of a healthy aging population in China, the following considerations should be addressed. First, basic medical security needs to include equitable access to multilevel medical health care for all patients, whether they live in urban or rural situations. Second, medical health care capabilities at the grass roots level should be upgraded, especially the prevention and treatment of drug and non-drug interventions. Third, regulations, policy measures, and law reform are needed to be drafted to ensure that health care systems can support the aged people after their retirement in the future. In the next 20 years, the Chinese government expects that the number of aged people in the country will surpass 400 million. And fourth, prevention remains the most viable avenue for lessening the disease burden and generating substantial health benefits in the future, including nutrition education and good dietary practices such as reducing the amount of oil and salt used in traditional cooking. It is worth reiterating the importance of creating a culture that supports good dietary nutrition and treatment to ensure that elderly people can enjoy a healthy and active life in their home and hospital (10).

References
**Why a macroeconomic perspective is critical to the prevention of noncommunicable disease**

Richard Smith

Effective prevention of noncommunicable diseases will require changes in how we live, and thereby implement more effective communication policies, sectors, and communities. What we do not know is which populations, sectors, or countries will be positively or negatively affected by such changes, nor how much. Without this information we cannot know which policies will produce effects that are beneficial both for economies and for health.

**Why is this important for NCD prevention?**

NCDs, such as diabetes, cancer, and heart disease, are becoming more widespread due to changes in infectious diseases, as they are not transmitted from person to person (although there is increasing concern about the emergence of social “contagion,” where social networks appear to influence the probability of obesity, for instance). However, they also differ in that they are intrinsically lifestyle diseases, and hence the cause and impact are linked in a multiplicity of ways to everyday economic activity (Fig. 1). The effects of NCD-related health (Fig. 1, box 1) is determined directly by risk factors (Fig. 1, box 2), which are shaped by genetic predisposition to disease, such as diabetes and heart disease, but also by a range of other social determinants of health, which refer to the general condition in which people live and work, including levels and types of employment, environmental conditions, and education (Fig. 1). These social determinants, contribute to the risk of different diseases, such as pollution and heart disease, and they are also intimately linked with lifestyle, household and individual choices (Fig. 3), which represent how people behave and, crucially, invest (or disinvest) in their health. This results in a situation where what they consume and are in the environment they undertake (Fig. 3). For example, cancer and heart disease risk will be affected by decisions concerning smoking, alcohol consumption, and exercise. But risk will also influence how much individuals can save and spend. For example, an individual is known that they have a higher genetic risk of heart disease but who also choose to engage in unhealthy eating and exercise. As a result, they will be in a less favorable position to get better health.

**Economic impacts of NCDs**

Although the NCD epidemic is a global issue with local consequences for NCD risk factors. Problems with subprime lending in the United States, for example, have given a global impulse to various forms of health care and excess consumption, and inflation, and in the case of the United States (60). This has to do with the macromodel perspective, it is difficult to say what all about at all how other sectors will adjust and thus we cannot know what the overall net impact on the wider economy, or even health, will actually be. Consider an example where such a tax increases the price of beef. How might consumers react? Any change in price will cause a decrease in demand and supply of beef (2). The demand for beef will be affected by the price of other goods and services that the consumer could not just beef. At the extremes, consumers may either reduce spending on beef, to keep spending on everything else the same, or speed up spending on some other thing to keep beef consumption the same. What are the implications of these two scenarios?

If consumers reduce their demand for beef, then beef farmers will experience reduced revenues, and thereby suffering, which may generate yet further health effects, such as malnutrition and hunger. What we do not know is which populations, sectors, or countries will be positively or negatively affected by such changes, nor how much. Without this information we cannot know which policies will produce effects that are beneficial both for economies and for health.
general, effect of changes in disease upon the economy, or of changes in the economy upon disease (22), or focus upon a specific sector (e.g., studies concerning “fat taxes” tend to consider the impact of a price increase only on the food of interest) (23). Very few studies quantify these effects, as it is often the economic and health effects (24). Yet without this information, we cannot know which policies will produce net beneficial effects, for the economy or health, or what counterbalancing policies may be required to minimize negative spillovers. Because NCDs affect the economy so profoundly and pervasively, we also need to quantify those effects, as it is often the economic case that swings the agenda and mobilizes resources. The history of communicable disease, in this respect, provides valuable lessons. The economic impact of HIV/AIDS, tuberculosis, and malaria in particular was important in mobilizing initiatives such as the President’s Emergency Plan for AIDS Relief and The Global Fund to Fight AIDS, Tuberculosis and Malaria. This was due in part to the WHO Commission on Macroeconomics and Health in 2000, which established firmly that investments to reduce such diseases would be a primary driver of macroeconomic development (25). Having HIV/AIDS as the first health-focused UN high-level meeting in 2001 was also prompted by the devastating effect the virus was having on African economies (26). The second health-focused UN high-level meeting on the NCD challenge, in 2013, also stressed the economic impact of chronic disease (27). With the resolution of the 65th World Health Assembly in 2012 to reduce premature deaths from NCDs by 25% by 2025, the imperative now is to formulate strategies to achieve this target, which requires us to recognize that NCD prevention is “not just a matter of life and death, it’s more important than that.”

REFERENCES AND NOTES
2. For a lay report, see www.youtube.com/watch?v=VGrzyY2mG6u&feature=related.
17. For a lively debate, see www.youtube.com/watch?v=ftn4wn50HzE.

ACKNOWLEDGMENTS
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Table 1. Projected foregone national income due to heart disease, stroke, and diabetes, 2006 to 2015 (20).

<table>
<thead>
<tr>
<th>Country</th>
<th>2006 (US$ billions)</th>
<th>2015 (US$ billions)</th>
<th>Cumulative GDP loss (US$ billions) as a percentage of 2006 GDP</th>
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<td>18.1</td>
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<td>Total</td>
<td>0.68</td>
<td>0.95</td>
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Despite gains, malnutrition among China’s rural poor ranks concern

Richard Stone

Healthier future. Children like these in rural Sichuan may benefit from China’s nutrition initiative.

BELING—From SARS to bird flu to a flat- teled new bovine, China is a crucible for deadly pathogens. Wang, a veteran of the Chinese Center for Disease Control and Prevention, knows no microbial scourge now in circulation poses as stark a threat to society as malnutrition.

One of the most visible manifestations of malnutrition is stunting, defined as being two or more standard deviations below the WHO’s standard for median height by age. Stunting rates in Chi-

na have declined dramatically, from 33.8% in 1990 to 9.9% in 2010. However, recent trends indicate the country’s ability to provide adequate nutrition is eroding, threatening recent gains in China’s impoverished countryside, where “many people have very small bodies,” Wang says. “Children who are very short look to be around 5 or 6 years old,” he says. “Body development is lagging, and most children never catch up.”

Wang is not alone in hoping to steer the nation onto a more robust trajectory. Last week, the Chinese Academy of Medical Sciences announced a $2.5 billion, 5-year program to improve school meals for 26 million kindergarten through 12th grade students in 680 poor counties in China. That program will help, Wang says, to keep children in school, because “it’s too late” to head off stunting related deficits.

To eke out further gains, China may look to Brazil, which slashed stunting rates in its widespread sarheit from 34% in 1986 to 6% in 2006. “The Brazilian experience shows that better nutrition during infancy can be rapidly reduced if income among the poor rises and simultaneously there is increased access to schools, clean water, sanitation and basic health care,” de Onis and colleagues report in the January issue of the British Medical Journal.

5-year-old children in 2010. China has targeted a child nutrition issue is on the political agenda. The agency also in-

Elsewhere in the world, the idea that undernutrition in utero might influence future risk of noncommunicable diseases (NCDs) in the baby (1). There is increasing understanding that these influences may span more than a single generation, and that non-Mendelian, modifiable epigenetic mechanisms contribute to the heritability. Against this background, we are investigating the influence of maternal nutrition on fetal growth and its risk for future NCDs, including diabetes, hypertension, and cardiovascular disease (CVD).

Addressing malnutrition to improve global health

The nutritional double burden

In many parts of the world, concerns about maternal undernutrition have now been replaced with concerns about overweight and obesity. For example, in the developing world (United States and Europe), as many as three-quarters of mothers are overweight or obese (BMI ≥25 kg/m²). Excess maternal weight also affects outcomes during pregnancy (increased incidence of diabetes and hypertensive disorders), delivery (hemorrhage, caesarean delivery, macrosomia, birth trauma, and infections), and postpartum (higher weight retention and failure of lactation). In the low and middle income countries (LMICs) undergoing nutritional transition, the proportion of overweight and obese pregnant mothers is increasing (2), due to urbanization, increasing age at the time of conception, and other lifestyle factors (3). Both undernutrition and overnutrition in the mother are transmitted to the child, setting up a cycle of intergenerational malnutrition, which disproportionately affects female children.

A rapidly changing epidemiology due to demographic and nutritional transitions produces a double burden of under- and overnutrition in early life with lifelong consequences for health and NCD in later life. This creates additional challenges for health care providers and policymakers trying to manage the health of the population. It is notable that those parts of the world contributing the largest proportion to the burden of undernutrition in early life (LMICs), also suffer from NCD epidemics such as type 2 diabetes, hypertension, and CVD (Figure 1)(5).

Nutrition and disease

The idea that undernutrition in utero might influence future risk of NCDs was first documented in studies of Dutch men and women who were fetuses during the so-called hunger winter of World War 2 (6). Rationing during this time reduced food intake to about 600 calories per day per person. Follow up studies showed that male offspring who experienced hunger during the first two trimesters of pregnancy were at increased risk of obesity later in life, compared to those born outside of the hunger winter. On the other hand, those undernourished in the third trimester were less likely to be obese. It was postulated that the increased obesity in the former group was due to resetting of the hypothalamic appetite centers, while in the latter group, reduced number of adipose cells decreased obesity. Subsequent studies have provided further evidence of the increased risk of diabetes, hypertension, and other NCDs in those who faced the hunger winter in utero (7). A recent study in China demonstrated an increased risk of diabetes in those who faced a famine in early life (8), suggesting to speculate how famine and other natural calamities in different parts of the world in the last few hundred years could have sown the seeds of the modern day epidemics.

David Barker and colleagues considered fetal growth and birth size as surrogates of fetal and maternal nutrition. They demonstrated an association between smaller size at birth (9) and increased risk of diabetes, hypertension, and other NCDs in those who faced the hunger winter in utero (10). It is interesting to speculate how famines and other natural calamities in different parts of the world in the last few hundred years could have sown the seeds of the modern day epidemics.
important, and early embryonic nutrition is known to
However, gestational length is now also considered
were considered exclusive determinants of future health.
the cord blood (112), fetal body composition, placental size and
9, 10). In the past, fetal growth disturbances
predicts fetal growth restriction, suggesting a causal role of
homocysteine (23). Studies in The Gambia demonstrated a seasonal pattern in methyl donor availability in the maternal bloodstream, which was reflected in different levels of DNA methylation in the cord blood (24). Similarly, folate supplementation trials in pregnancy also influenced cord blood methylation (25). These human findings suggest a possible role for methyl donors in epigenetic fetal programming and later occurrence of NCDs. Animal models support such a role (26), but there is an urgent need for more human studies. Other micronutrients of interest in fetal programming include vitamin D, vitamin A, calcium, zinc, and omega-3 fatty acids.
We have proposed a “dual teratogenesis” construct to
explain the U-shaped association between birth weight and diabetes (Figure 2) (27). Maternal-fetal undernutrition produces thin (poor lean mass) children with high adipose percentage and insulin resistance (“nutrient-mediated teratogenesis”). If these children continue to live in a deprived situation, they propagate this phenotype without overt diabetes. However, if they face overnutrition in postnatal life (urban migration), they are likely to develop obesity and hyperglycemia at a young age, and gestational diabetes in girls that propagates the obesity and diabetes phenotype (“fuel-mediated teratogenesis”) (28). Rapidly transitioning countries like India seem to have both forms running simultaneously, feeding into an explosive epidemic of NCDs.
Child undernutrition is a major public health challenge, estimated to be responsible for 2.2 million annual deaths worldwide of children under the age of 5, although full implementation of available nutrition interventions could prevent more than one-third of these deaths (1). Interventions to improve breast-feeding and complementary feeding are estimated to be the first and most effective preventive interventions against child mortality—the second being the use of insecticide-treated bed nets to protect against malaria (2). Improved breast-feeding and other nutritional interventions aimed at children under 5 and pregnant women have substantial benefits beyond affording mortality, including improvements in intelligence quotient (IQ) and lower risks of some communicable diseases in mothers and children decades later. Nonetheless, breast-feeding and complementary feeding practices differ greatly from global recommendations. Although the World Health Organization recommends that infants receive solely breast milk for the first 6 months of life, only about one-third of infants in low-income countries meet this goal, just one third of children 6 to 24 months old in low-income countries meet the minimum criteria for dietary diversity, and only one in five who are breast-fed receive a minimum acceptable diet. Although the potential effects of improved breast-feeding and complementary feeding practices appear large, funding for research and greater use of existing effective interventions seems low compared with other life-saving child health interventions.

Child undernutrition is a broad and complex phenomenon, encompassing fetal undernutrition, insufficient breast-feeding, and complementary feeding of diets low in energy-dense foods, essential fatty acids, and micronutrients. The effects of undernutrition include low birth weight and deficits in height and weight, as well as physiological outcomes later in life. The importance of these factors prompted U.S. Secretary of State Hillary Clinton to describe the benefits of improved nutrition in utero and during the first 24 months of life as providing a "two-year window of opportunity" for lifelong health and development (6). At the risk of oversimplifying the topic, we review the recent and growing evidence of benefits of early nutrition, particularly breast-feeding, on child mortality and material and child health outcomes. We endeavor to distinguish between effects reported in low- and high-income countries, as those effects and the success of interventions may differ with diet and social conditions. Our review covers research in low- and high-income countries, including observational, case control, prospective cohort, and randomized studies. Our survey indicates there is credible evidence that improved population coverage of child nutrition interventions, particularly related to breast-feeding and complementary feeding, could provide large benefits in absolute terms and that these measures could do so at exceptionally low cost. However, public health funding for child nutrition research and programs is still relatively low compared with the potential of improving child health interventions (7).

We present evidence for benefits, an economic rationale for government intervention in breast-feeding, and a review of breast-feeding practices and policies. The rest of this paper addresses the early nutritional origins of disease, effective nutrition interventions in the first 1000 days, breast-feeding and NCD risk, the economic rationale for breast-feeding promotion, data on current breast-feeding and complementary feeding practices, and, finally, conclusions.

Early nutritional origins of disease

The past few decades have seen an explosion of research suggesting that nutrition insults during fetal life have surprising and long-lasting ramifications for health (4). Analysis of such effects is complicated by the lack of accepted measures of in utero exposure, benefits of early nutrition, particularly breast-feeding, on child mortality and material and child health outcomes. We endeavor to distinguish between effects reported in low- and high-income countries, as those effects and the success of interventions may differ with diet and social conditions. Our review covers research in low- and high-income countries, including observational, case control, prospective cohort, and randomized studies. Our survey indicates there is credible evidence that improved population coverage of child nutrition interventions, particularly related to breast-feeding and complementary feeding, could provide large benefits in absolute terms and that these measures could do so at exceptionally low cost. However, public health funding for child nutrition research and programs is still relatively low compared with the potential of improving child health interventions (7).

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The difficulty separating in utero exposure of children to poor nutrition, birth weight, and the possibility of effects sufficiently severe to increase perinatal mortality, thus masks later adverse effects (19). Researchers have addressed these complications by proposing "natural experiments" such as the Dutch Hunger Winter (resulting from severe wartime food shortages during the winter of 1944–1945) and religious fasts—episodes for which earlier or later cohorts provide suitable control groups (20).

Effects of prenatal exposure to the Dutch Hunger Winter include obesity among year-old children, high blood pressure, and elevated blood pressure (20). Prenatal exposure to daytine fasting during Ramadan has been reported to increase the likelihood of adult disability by more than 25% among women in Indonesia (21). Pregnancy with substantially larger effects for mental health and higher lifetime diet, physical activity, and genetic pre-disposition (22). A recent study employing nation-wide data from a hospital-based birth cohort with birth outcomes is considered effects of dietary supplementation with iodine during pregnancy in Tanzania—iodine deficiencies can cause low IQ score. Before the advent of iodized salt, maternal iodine deficiency is still a major public health concern in many parts of the world.

Interventions in the first 1000 days

In the first 1000 days of life, a variety of policy interventions affecting nutrition in low-income countries, include breastfeeding and complementary-feeding strategies, as well as food security (when necessary) in children 6 to 24 months of age (18). Providing vitamin A and zinc supplements, ensuring universal school attendance, and Unicef, and timely treatment of severe acute malnutrition are all interventions known to be effective in reducing child mortality (4).

Iron supplements are also recommended, but not where malaria is prevalent because of the risk that iron supplements may increase the duration of malaria parasitemia, thereby increasing the risk of malaria recrudescence (27).

An important attribute of breastfeeding is that it is less expensive and more effective in controlling diarrhea. However, there is a substantial body of evidence that suggests that different individuals may have different responses to even minor differences in quality products in instances such as breast milk, infant formula (23). After 6 months, breast-feeding still has substantial contraceptive effects, which are particularly important as the use of oral contraceptives is difficult to obtain in many parts of the world.

Breastfeeding and NCD risk

Emerging data show that breastfeeding plays a role in reducing NCDs, which in 2010 were estimated to cost $863 billion globally in medical expenses and lost productivity (24). Childhood breast-feeding is associated with a lower prevalence of overweight and obesity, lower blood pressure, lower risk of type 2 diabetes, and a lower risk of cardiovascular disease (25). The World Health Organization (WHO) has recommended breastfeeding exclusively for the first 6 months and complementary feeding for infants over 6 months, in line with the evidence that breastfeeding can contribute to the prevention of NCDs and chronic diseases later in life (26). The right to be breastfed is a fundamental human right, and the right to act on this right is of particular concern in contexts of conflict and poverty, where mothers and children are vulnerable to influence from medical staff or family and ill-placed guidance (27).

Fig. 1. Selected trends in exclusive breast-feeding, shown as percentage of infants aged 6 to 11 months who were exclusively breast-fed in different regions and countries, and rates of less than satisfactory breast-feeding behaviors.

Breastfeeding promotion: The economic rationale

Among the causes of the global disease burden, communicable diseases have long been the target of choice. The rationale for inter-ventions affecting diet, physical activity, and genetic pre-disposition (22). As a non-technological intervention, breastfeeding is one of the most cost-effective interventions for child survival, equal to other high-impact interven- tions such as immunizations. However, this advantage does not necessarily translate into cost-effects substantially more attractive.

The revolution in information technology could provide an unprecedented opportunity for breastfeeding promotion. Timely delivery of information that is culturally sensitive, spe-cific, and relevant to the needs and circumstances of the community, can be used to promote breastfeeding or complementary feeding during pregnancy and early childhood. In this context, media campaigns could greatly improve the cost-effectiveness of child nutrition programs.

Breastfeeding promotion has declined (46). U.S. Agency for

Fig. 2. (A and B) Percentage of infants and children meeting recommended breast-feeding and complementary feeding practices. Data are from a national representative 2002 and 2008 household sample surveys conducted in 46 low- and middle-income countries between 2002 and 2008 and represent 8.2, 58, and 22% of the population of children younger than 5 years of age in Asia, Africa, and Latin America/the Caribbean, respectively.
International Development (USAID) global spending on child nutrition, of which breastfeeding promotion was an important component, declined from $3.6 million in 1999 to $3.3 million in 2005. Between 1999 and 2005, investment in breastfeeding in USAID’s flagship maternal and child nutrition project declined from $4.9 million to $2.3 million, while project expenditures for prevention of low birth weight and the impact of HIV increased, reflecting the seismic shift in global funding priorities related to the HIV/AIDS epidemic. Donors other than USAID also cut funding (46).

Data from African, Asian, and Latin American/Caribbean countries suggest that supportive policies and programs can markedly affect exclusive breastfeeding-percentaget (Fig. 1). In Ghana and nearby Mali had reasonably high rates of exclusive breastfeeding by 2005, but the rates differed by 15 percentage points, despite improvements in both countries. Cambodia achieved a phenomenal gain in exclusive breastfeeding, with nearly 50 percent of children in the first 6 months and 35 percent in the first 24 months of age meeting the recommended standard of daily dietary diversity. In contrast, 9 percent of children 6 to 24 months of age met the minimum standard acceptable daily diet. Moreover, there are poor breast-feeding rates. However, a large gap between current and best practices exists. Research on how best to cost-effectively improve the coverage of existing nutrition interventions is needed to accelerate their health impacts. Research is also needed to better understand the biological mechanisms through which the effects of improved breast-feeding occur, because randomization in breast-feeding studies is nearly impossible to achieve. Most evidence does derive from observational studies whose interpretations are complicated by self-selection, measurement of exposure, and residual confounding (5). Knowledge of the underlying metabolic pathways, through which breast-feeding or breast milk affects specific health outcomes, such as the role of human milk serum adiponectin exposure (3) and early childhood weight gain (52) and how human milk and complementary foods affect the gut microbiome, will improve interpretation of epidemiological studies. Acquiring a deeper understanding of the most common breast-feeding and complementary feeding difficulties and identifying the most effective strategies to overcome these difficulties is essential. Surveys, randomized interventions, and systems analyses are needed to explore the functioning of health care systems and the behavior of health professionals in relation to the persistence of impediments to better feeding practices. Both basic and applied research are required to develop an evidence-based set of policies and programs to improve complementary feeding. Finally, research is needed to measure the population risk attributable to suboptimal feeding practices and child nutrition, as well as the costs in medical treatment and lost productivity. The beneficial effects on child mortality and IQ and on maternal NCD risks of improved nutrition during the prenatal period and first 2 years of life appear large compared with other public health interventions. Studies of the most effective breast-feeding promotion programs have identified the greatest short-term benefit for children living in poor environments, investments in breast-feeding protection and promotion will also improve global health equity. Nonetheless, funding for research and research with the use of existing effective interventions is low compared with other life-saving child health interventions. None-
**Worldwide undernutrition in older adults: Too often unrecognized and untreated**

Jean-Pierre Michel

Undernutrition is a specific form of malnutrition in which energy intake falls short of energy expenditure, creating an energy deficit and is characterized by unintentional weight loss, low body mass index, and/or insufficient food intake. In patients identified as moderately to severely malnourished, proper diagnosis and treatment are vital. On-going medical conditions, disability, poor life habits, and altered social conditions can contribute to undernutrition, which may be relieved by appropriate treatment or counseling. Whatever the clinical situation, nutrition plays a crucial role, facilitating health recovery after an acute medical or surgical event, and it should be an integral component in the treatment of chronic diseases so as to reduce complications from them. When dietary advice is not sufficient to meet nutritional requirements, oral nutritional supplements should be used to supplement food intake. Training of health care professionals and routine dietary counseling in specific situations are essential to be improved since there are numerous clinical and economic benefits to adequate prevention and treatment of undernutrition.

The terms malnutrition and undernutrition are often used indiscriminately, but there are important differences to appreciate. Malnutrition covers four different nutritional problems: excessive nutritional intake (overweight and obesity), unbalanced diet (economic-, age-, disease-, or treatment-related changes in taste, smell, and cultural nutritional habits), specific nutritional deficit(s) (e.g., vitamin and mineral deficiencies), and insufficient nutritional intake regardless of etiologies (e.g., insufficient protein-energy intake, specifically called undernutrition)(1). Undernutrition, which corresponds mainly to protein-energy deficit, can be defined as a specific form of malnutrition in which energy intake is insufficient to meet body energy needs, with the BMI being the most used parameter for screening nutritional status. However, undernutrition is rarely adequately treated in hospitalized older adults. When dietary advice and counseling are not sufficient, oral nutritional supplements should be used to supplement food intake. Training of health care professionals and routine dietary counseling in specific situations are essential to be improved since there are numerous clinical and economic benefits to adequate prevention and treatment of undernutrition. The terms malnutrition and undernutrition are often used indiscriminately, but there are important differences to appreciate. Malnutrition covers four different nutritional problems: excessive nutritional intake (overweight and obesity), unbalanced diet (economic-, age-, disease-, or treatment-related changes in taste, smell, and cultural nutritional habits), specific nutritional deficit(s) (e.g., vitamin and mineral deficiencies), and insufficient nutritional intake regardless of etiologies (e.g., insufficient protein-energy intake, specifically called undernutrition)(1). Undernutrition, which corresponds mainly to protein-energy deficit, can be defined as a specific form of malnutrition in which energy intake is insufficient to meet body energy needs, with the BMI being the most used parameter for screening nutritional status. However, undernutrition is rarely adequately treated in hospitalized older adults. When dietary advice and counseling are not sufficient, oral nutritional supplements should be used to supplement food intake. Training of health care professionals and routine dietary counseling in specific situations are essential to be improved since there are numerous clinical and economic benefits to adequate prevention and treatment of undernutrition.

Undernutrition too often goes unrecognized

The diagnosis of undernutrition can be complex, a common factor being illness or injury, which can interfere with adequate food intake, absorption, and metabolism. Undernutrition has been linked to infection-related changes in metabolism, disease-specific cataloging (e.g., in cancer and diabetes), increased catabolism, appetite loss, swallowing problems, and immobility, risk of falling, and need for helping performing daily activities, as well as increased morbidity and mortality (21, 22). Nevertheless, in most cases, undernutrition is also overlooked. After three days of bed rest, elderly in-patients lose approximately one kilogram of muscle in their lower limbs (23), contributing to the weight loss often noted when they are discharged. In fact, a comparison of undernutrition rates at hospital admission and discharge has shown wide differences: 8.2% vs. 11% for surgical patients in China (24), 12% vs. 20% for frail elderly in-patients in Korea (25). A prospective matched case control study in Singapore demonstrated that malnutrition was a significant predictor of death in patients aged 18 to 74 years (odds ratio of 4.4, 95% confidence interval 2.6-7.3) (26). Finally, in-patient malnutrition is 35% to 36% as an in-patient mortality (27). Dietary supplementation with ONS, and more specifically β-hydroxy-β-methyl butyrate (HMB), significantly reduces the loss of lean body mass after 10 days of bed rest, while HMB coupled with physical exercise increases lean body mass under the same bed rest conditions (28). Finally, ONS treatment can significantly reduce the hospital stay and continued at home after discharge enhances independence and quality of daily life (39). A systematic review (which included a meta-analysis of individual patient data) concluded that ONS treatment can be considered as a cost-effective intervention. Many ONS can be considered as a safe intervention without any significant adverse effects. While there was some reference to minor gastrointestinal symptoms, the majority of trials do not assess gastrointestinal tolerance (40).

Conclusions

This paper presents strong evidence that among community-dwelling and hospitalized subjects, undernutrition is not sufficiently well recognized and that significant benefits in terms of quality of care and reduction in the overall cost of care can be obtained by providing supplemental nutrition that counteracts the protein-energy deficit of undernourished patients on bed rest. The importance of the clinical attitude found in many hospitals can be explained by a lack of robust nutritional protocols for screening, a deficit in knowledge about nutrition due to inadequate training of health care professionals, and poor documentation of nutrition-related information, all of which result in inadequate nutritional care planning and monitoring. It is essential to counteract the deficit of knowledge and clinical skills, and educate health authorities and institution managers about the clinical and economic benefits that result from better diagnosis and treatment of undernutrition.

References
Feeding them right to improve outcomes — it takes the whole team

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A reputation of the wrong leg. Treatment of the wrong patient. Feeding into the wrong tube. Medical errors are feared by patients, physicians, and administrators alike. However, not all medical errors are as shocking as those that make the nightly news. In fact, far more prevalent—estimated to account for 17% of preventable errors in hospitalized patients—are diagnostic errors that result in incorrect diagnoses.

Malnutrition is a commonly missed diagnosis with big implications. Conservative estimates indicate that 30%-50% of hospitalized patients are malnourished upon admission (2), yet 2010 data indicate that only 3.2% of patients discharged from U.S. hospitals had this diagnosis (3). Failure to identify and treat malnutrition is a significant problem because patients with malnutrition do less well—they are at increased risk for complications, longer length of stay, and readmission to hospital (2). Clearly, we need to do better.

Why is malnutrition so often overlooked by medical professionals specifically trained to identify and treat patients with a long and complicated list of health problems? The reasons are multifold; however, the lack of courses about nutrition in medical education must certainly play a role. In 2009, only 25% of medical schools surveyed required courses dedicated to nutrition (4). Overall, students received less than 20 contact hours of nutrition instruction during medical school.

Not only does this quantity of nutrition exposure fall short of the minimum requirement endorsed by the National Academy of Sciences, but many students lack the opportunity to commit to this field of study throughout medical school. (5) Thus, the need for nutrition expertise is a common theme related to malnutrition diagnosis. RDNs are professionals with extensive nutrition knowledge who are trained to identify patients with malnutrition and provide scientifically-based nutrition interventions. However, many institutions lack adequate RDN staffing to properly address all patients and RN D recommendations are poorly implemented. Recognizing these barriers, in May 2014 the U.S. Centers for Medicare and Medicaid Services (CMS) granted long-awaited privileges allowing hospital RDNs to independently order therapeutic diets and laboratory tests essential to the nutrition care and monitoring of patients under their care. This new ruling is expected to improve quality of care by increasing efficiency, and save CMS $459 million per year (6).

Streamlined nutrition care and intervention by providing RDN-ordering authority is only one step toward solving the problem of malnutrition. Barriers related to effective functioning of the care team must be broken down. Optimal nutrition care requires physicians, nurses, RDNs, and other health care practitioners to work together, each within their scope of practice, to evoke meaningful improvements in nutrition care. Taking an example of an elderly grandmother admitted to hospital with dementia and poor regulation of diabetes on a Wednesday morning last December. Though very weak and having trouble walking on her own, a cursory assessment indicated that she was a little overweight so a nutrition concern was ruled out. A nutrition screen following admission—specifically designed to identify patients at risk—was never done. Further procedures proceeded routinely. Psychology and endocrinology consults were ordered; diabetic meals were delivered to the room, and the family members sat with “mother” each and every day. Yet, waiting until the following Monday when the diabetes diagnosis spurred the attention of the RDN (who isn’t scheduled to work over the weekend). Nutrition assessment clearly revealed a moderately malnourished patient—“mother” had lost 20 pounds in the last three months, lost all interest in her meals, had peripheral muscle atrophy and diminished strength, had false teeth that were cracked and not fitting properly, and anemia due to a vitamin B12 deficiency that provided the basis for her dementia. The RDN documented the diagnosis and intervention recommendations in the electronic medical record (EMR) to alert the physician to the need for nutrition intervention. However, nutrition was clearly not being addressed by the team until the RDN physically tracked down the physician three days later because nutrition notes aren’t integrated in a prominent position within the EMR and the RDN is not included within the daily huddles discussing each patient. In this instance, over 30 meal trays were taken in and out of “mothers” room, relatively untouched, due to inadequate process to provide accessible and nutritious food to a patient with a nutrition-related diagnosis.

In “mothers” case, there are multiple points of failure. First, visual nutrition screening is not adequate. Our hospitals need to adopt policies and procedures where validated nutrition screens are applied to each and every patient upon admission. Many screening tools are available that can be administered easily by any staff member by asking two simple yes/no questions. Until nutrition screening is properly applied to all patients, many of those with undiagnosed malnutrition will go untreated. Had the patient in the example above been properly screened, the RDN would have been alerted shortly after admission, rather than stumbling upon a high nutrition risk diagnosis by being proactive the following week.

to observe a patient’s food intake, tolerance to meals, and to reinforce the importance of good nutrition. Empowered nurses who felt responsible for the nutrition care of “mother” may have expressed concern after two or three untouched meal trays, rather than three dozen.

Third, nutrition care must be integrated as an essential part of patient care. The role that nutrition has on patient outcomes must be recognized by physicians, administrators, and other health care providers so that it can be prioritized. Nutrition should be discussed at daily rounds, integrated into a prominent part of the EMR, and routinely emphasized with patients and their caregivers. The scenario above is unfortunately far too common. At least one-third of patients admitted to hospital are malnourished, and another third will become malnourished during their hospital stay (2). And our collective failure to nourish these patients stems from multiple problems that will require the entire health care team to rectify.

To address adult hospital malnutrition (Figure 1) (2). To facilitate adoption, these recommended principles are discussed within the disciplinary framework of the various health care professionals to demonstrate the necessity of all team members to the nutrition care process and provide relevant examples where specific actions are needed. Finally, the Alliance also launched a comprehensive website, www.malnutrition.com, as an authoritative resource on hospital malnutrition. The website makes available a practical toolkit with validated screening tools, feeding tips, fact sheets, case studies, patient discharge materials, and patient education handouts. The website further offers an evidence library of research on nutrition intervention in clinical settings, provides study overviews vetted by specialists in hospital-based malnutrition, and links to education material.

One does not need to be a nutrition expert to realize that nutrition is neither optional, nor an issue that can be put off for a couple of weeks until the patient is doing better. Indeed, one of the first things any mother will do in an effort to care for her sick child is whip up a batch of chicken noodle soup. Though it seems unacceptable, nutrition care plans are poorly implemented for many of the reasons outlined above. To solve this problem, strong expectations must be in place that individualized, evidence-based nutrition care be provided to patients as an essential element of the overall care they receive.

2. Hospital-acquired malnutrition defined as a never event.

In health care, a never event is that kind of mistake that should not ever happen. For example, performing surgery on the wrong body part is considered a never event. If inadequate nutrient provision resulting in malnutrition while a patient was in care at a health care facility were to achieve never event status, awareness and accountability for this issue would be increased. Until nutrition care is included on the list of issues by which hospitals are evaluated and reimbursed it will continue to be overlooked.

3. Presence of EMR template to support nutrition care.

Contemporary EMRs are not just the venue for documentation and communication, but serve as an important hub to advance patient safety and quality improvements, achieve operational efficiencies and cost saving, and improve both patient and staff satisfaction. As such, nutrition needs to be thoroughly integrated into EMR platforms to strategically leverage this reality of current practice. Standardized nutrition nomenclature, integrated templates, and clinical decision support are an essential portal for integrating nutrition into patient care, but will also open the door to further data collection that is necessary for both efficacy and quality.

As individuals, we have high expectations for our health care. We expect to be treated promptly. We expect to be safe. We expect the most advanced, science-based care. Why is it in 2014 that we need to explicitly state that we expect to be fed? Feeding patients is indeed an essential element of prompt, safe, and advanced, science-based care. Nutrition needs to be elevated; nutrition is a vital sign.

References

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