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Olivier Ecker “Economics of Micronutrient Malnutrition”, University of Hohenheim, 2009

Summary

Malnutrition remains a major public health problem throughout the developing world and particularly in sub-Saharan Africa. Mostly caused by a lack of sufficient quantities of calorie-rich foods, protein-energy malnutrition is still widespread in developing countries, but - though more obvious - much less prevalent than micronutrient malnutrition. About one-third of the world's population suffers from deficiencies in one or more micronutrients that are typically associated with a poor dietary quality, inadequate in terms of bioavailable vitamin and mineral amounts. Deficiencies in vitamin A, iron, iodine, and zinc are of most concern due to their health hazards and the fact that they are extensively widespread across the globe.

Beyond individual suffering, malnutrition afflicts people in the developing world by slowing economic growth and perpetuating poverty. The economic costs of nutritional deficiencies are substantial and considered to be many times over the costs for their treatments in most cases (Behrman et al. 2004). The World Bank (2006) estimates productivity losses to malnourished individuals at more than ten percent of lifetime earnings and GDP lost to malnutrition running as high as two to three percent overall. The enormity of the problem of malnutrition in general and of certain micronutrient deficiencies in particular calls for comprehensive response.

Contribution to Literature

The development and effective implementation of economic policies and large-scale interventions to tackle malnutrition directly or indirectly require good knowledge of the status quo of the nutrition situation in populations at risk of deficiencies and the possible nutritional outcomes of interventions. Analyzing household food consumption data can provide important information in this regard. Specifically, examining food and nutrient consumption patterns helps to understand the immediate dietary circumstances associated with nutritional deficiencies, and assessing people's nutritional status relative to norms of nutrient requirements gives evidence on individual nutrient adequacy and facilitates to estimating the possible prevalence of specific nutrient deficiencies, indicating the dimensions of the malnutrition problem in the population under consideration. Moreover, when suitable food composition tables and appropriate data on household income/expenditure, food prices, and sociodemographic factors are available, income and price elasticities and sociodemographic effects can be estimated with respect to the demand for (consumption of) nutrients. Such demand elasticities can give important evidence on the cause-effect relationships of socioeconomic conditions and the nutritional status of people and thus on the potential nutritional impacts of external shocks and intervention measures.

Yet, literature provides little empirical knowledge concerning the economics underlying micronutrient malnutrition. To narrow this gap has been the main motivation of this thesis. It

represents the first comprehensive work that incorporates micronutrient aspects in the framework of demand economics in a developing country context. Particularly, we have delved into the issue of how changes in household income, food prices, and socioeconomic factors affect the nutrition situation in sub-Saharan Africa with special emphasis on micronutrient aspects.

Methodologically, we have contributed to existing literature by establishing a procedure that is suited to evaluating the nutrition situation in populations by assessing people's adequacies in the consumption of calories and micronutrients and the possible prevalence of their deficiencies based on food consumption data from household surveys, as are available from various sources. In the field of nutrition economics, the methodological achievement is the elaborated documentation and extension of traditional models of food demand in order to estimate nutrient demand elasticities in a theoretically plausible and empirically feasible manner.

Two principle approaches and proper model specifications have been presented and exemplarily applied in two empirical studies. It holds in practice that the choice of the model is often driven by the specific properties of the survey data used. In the first approach, nutrient elasticities are directly derived from reduced-form demand functions in a pragmatic way, without full recourse to neoclassical consumer demand theory. The usefulness of such models emerges especially through the easy and wide applicability in empirical analyses, even under data limitations. In the second approach, nutrient elasticities are derived from food demand elasticities, estimated in a preceding step. To be consistent with neoclassical consumer demand theory, food demand elasticities must be derived from complete demand systems that must possess a high level of disaggregation to yield reliable elasticity estimates in terms of the consumption of nutrients. This involves a high computational challenge and necessitates a high depth and breadth of the underlying data, specifically referring to income/expenditure and price records. Compared to other ordinary demand systems, the almost ideal demand system (AIDS) possesses the most desirable properties but requires quadratic extension to allow for the obligatory flexibility in the curvature of demand functions, as found in empirics. Thus, the quadratic almost ideal demand system (QUAIDS) has been identified as the superior demand system for modeling food demands. To circumvent the extreme computational complexity in large-equation demand systems, we have suggested the adoption of a multistage allocation process in household expenditures but ware of over-disaggregating the system in consideration of the relatively strong separability assumptions implicitly imposed on consumers' preference structure.

The empirical contribution is achieved by means of two studies. Based on household survey data from sub-Saharan Africa and the methods presented, we have revealed typical food and nutrient consumption patterns and evaluated the problem of micronutrient malnutrition in the studied populations. Furthermore, we have provided detailed basic knowledge of the socioeconomic conditions governing micronutrient malnutrition as well as sets of elasticity estimates of the demand for calories and micronutrients in rural East Africa and Malawi that may serve as basic data for other researchers to model the nutritional outcomes of specific policy scenarios for instance.

Review of the Empirical Studies and Major Findings

The presented studies have differed in several aspects with reference to the research emphasis given, the population studied, the data used, and the methodology applied. The formation has

been chosen in each case in order overall to provide a comprehensive picture of the problem of micronutrient malnutrition, examined from various angles of a nutrition economics perspective.

The first study has adopted a rather focused look at the bioavailable intakes of three of the four most deficient micronutrients - namely vitamin A, iron, and zinc - in rural areas of East Africa, where extreme poverty, food insecurity, and malnutrition are typically more prevalent than in urban areas. The vast majority are farmers who consume large shares of their food produce, so that economic policies and direct interventions to combat micronutrient malnutrition may have to be of another nature than for consumers who largely rely on food purchases. The study has comparatively analyzed dietary patterns, calorie and micronutrient intake associations and adequacies, and socioeconomic determinants underlying calorie and bioavailable micronutrient intakes in rural areas in Rwanda, Uganda, and Tanzania, selected to cover a range of the regional variation in the composition of African diets. In most countries south of the Sahara, diets are based on starchy roots and tubers - mostly cassava and sweet potatoes - and/or plantains such as in the study areas in Rwanda and Uganda or on cereals - often maize - such as in the study areas in Tanzania.

The second study has been primarily concerned with the broader and multi-faceted nutritional effects of changing household income and food prices across the entire population in one of the least developed countries in sub-Saharan Africa and worldwide, namely Malawi.¹ Such income and price changes are typically associated with economic growth, food crisis, or economic intervention measures. Using representative household data and a sophisticated demand system model, a large set of income (expenditure) and price elasticities with respect to food demand and nutrient consumption has been estimated, and implied impacts have been examined. Expenditure and own- and cross-price elasticities have been presented for 23 food aggregates, calories, protein, and eleven vitamins and minerals essential for human nutrition. In addition, common food and nutrient consumption patterns and the prevalence of nutritional deficiencies in the country have been analyzed. Based on these data, the nutritional outcomes of changes in household income and the price of maize - the major staple crop also in Malawi - have finally been simulated within four scenarios and their results discussed.

Taken together, the findings from the two studies establish an overall consistent picture of the nutrition situation in populations at special risk of micronutrient malnutrition and allow for general conclusions to be drawn, specifically with regard to sub-Saharan African regions in particular need of action:

Food insecurity and unbalanced diets are the main causes of micronutrient malnutrition. Aligned to satisfy calorie requirements, diets are characterized by an imbalance in food consumption towards a strong dominance of starchy staples. This is associated with a poor dietary diversity, exposing consumers to a high risk of micronutrient malnutrition and multiple micronutrient deficiencies in particular. Especially in view of the lack of animal-source foods in most diets, the consumed amounts of vegetables and fruits are clearly too low for healthy nutrition. This has a twofold, negative effect on nutritional status: the intakes of nutrients from foods are inadequate per se that additionally limit the bioavailability of some key micronutrients from the whole diet. Moreover, the narrow food variety in the diets limits the provision of nutrients to few sources, making sufficient intakes of most essential

¹ According to the Human Development Index, Malawi is ranked at 164 of 177 countries considered (UNDP 2007).

micronutrients exceedingly difficult, especially in periods of food shortages. In fact, our prevalence estimates support common knowledge that deficiencies in vitamin A, iron, and zinc are most alarming; but also the widespread existence of the vitamin B deficiencies - specifically folate and vitamin B12 - is worrisome. Under circumstances of general food insecurity, the intakes of some micronutrients - primarily of iron, zinc, and some B-vitamins, but barely of vitamin A - is closely related to the intake of calories, implying that eradicating hunger is a necessary but not sufficient condition for the alleviation of micronutrient deficiencies. For a sustainable reduction in micronutrient malnutrition as a whole, increasing the consumption of vegetables, fruits, and animal-source foods and expanding the variety of consumed foods towards an adequately diversified and nutritionally well-balanced diet is indispensable.

The overall nutritional status is highly income-responsive. Expenditure (income) elasticity estimates show highly positive values (mostly below unity) of the demands for most nutrients. Our estimates exceed most estimates available from other publications, mainly due to the focus of this thesis on especially needy populations. It underlines that, among extremely income-poor and food-insecure people, additional household income is predominantly used up for food consumption. Rising real incomes lead to reductions in all nutritional deficiencies; albeit there are crucial peculiarities in the responsiveness of nutritional status with respect to single nutrients. They are most distinct for vitamins and for vitamin A in particular. Vitamin A status is relatively low income-responsive in populations who rely on carotenoid-free staple foods such as maize, rice, cassava, and white sweet potatoes - the most consumed staples in sub-Saharan Africa. Exceptions are diets containing a high share of plantains or carotenoid-fortified staples. The reason for that is straightforward: facing a high risk of undernourishment, additional household income is primarily spent on consuming calorie-rich staples (and pulses) and barely for vegetables and fruits - the dominant providers of vitamin A in diets poor in animal-source foods. This allocation, in combination with the high demand increase for animal products at rising real incomes, contributes to substantial improvements in the nutritional status with respect to iron, zinc, and vitamin B12. Higher shares of meat, poultry, and fish in the diet improve the zinc and iron status in a twofold manner, namely by higher intakes of zinc and the well-absorbable heme iron, as well as by a better bioavailability of zinc and non-heme iron in the whole diet.

Partial price changes of most foods have relatively small effects on nutritional status in general. In the light of a strong price responsiveness of food demand, changes in nutritional status due to moderate price changes of individual foods are minor in most cases. Thus, consumers are, *ceteris paribus*, well able to adjust their consumption patterns to short-term price increases of a particular food item by substituting it with relatively cheaper foods of similar nutritional value, so that the effects on nutritional status can be weakened essentially, except for vitamin A and vitamin B12. Vitamin A and vitamin B12 status is more vulnerable to price changes of foods characterized by a low substitutability as key providers of these vitamins, which include certain vegetables and meat and fish products. Exceptions also exist for price variations of foods, for which the income effect of a price change in food demand is stronger than the substitution effect, identifying the foods as hardly dispensable components in the diets of most households. This is typically the case for the major staple food in populations, where the largest share of household budgets is devoted to satisfy calorie requirements at low expenses. In Malawi for instance, maize possesses a very low substitutability as source of dietary energy. Therefore, decreasing real incomes resulting from a maize price shock involve only a low reduction in the consumption of maize but a high reduction in the consumption of other foods such as vegetables and animal-source foods,

contributing to the aggravation of the problem of micronutrient malnutrition, especially among the poorest. However, the nutritional effects of any price change are very diverse. Depending on the patterns of food consumption, they vary by nutrient both in direction and magnitude, so that a price reduction of the major staple food can even entail an increase in the prevalence of some vitamin deficiencies, *ceteris paribus*. What is important to notice is that our analysis is limited to partial price changes. Thus, simultaneously soaring prices of several key foods - as happened in the current food crisis - can of course have large negative impacts on the nutritional status of particularly the poor, owing to considerable losses in real income.

Household food and nutrient consumption varies systematically depending on a large variety of sociodemographic factors. Of particular importance is the role of women in household decisions on the allocation of the budget. Female decision-makers are more concerned with the nutritional health of household members than males, implying that women empowerment positively affects the reduction of malnutrition. In mostly illiterate societies, basic education in the sense of schooling has *per se* no promotive effect on nutritional status, which goes against the findings of some previous studies but is not implausible. Our results further suggest that regional and local circumstances, including agricultural production conditions, infrastructural endowments, and physical access to and seasonal availability of foods, have considerable impacts on the nutrition situation in sub-Saharan Africa. These household- and location-specific factors have to be taken into account when designing and targeting economic policies and direct intervention strategies addressing food insecurity and nutritional deficiencies.

Policy Implications and Directions for Future Research

From the findings, general policy and research recommendations emerge: Economic growth can substantially contribute to the alleviation of micronutrient malnutrition. Higher real incomes allow deficient people to afford the consumption of more expensive and nutritionally healthy foods such as animal-source foods, vegetables, and fruits in addition to their subsistence nutrition. The positive impact on the nutritional status of particularly the poor is considerable. Thus, also from a nutrition perspective, stable economic growth, and pro-poor growth in particular, is absolutely fundamental for improving people's well-being in developing countries in the long term. A sustainable, large-scale reduction in undernourishment and micronutrient deficiencies therefore calls for a sound growth policy. Hence, investments in expanding physical infrastructure, reducing transaction costs by promoting proper institutions, liberalizing agricultural markets, and good governance have indirect nutrition-beneficial returns. In addition to an appropriate economic framework, direct interventions are needed for an immediate response to the problem of micronutrient malnutrition in a way which does not impair growth of real incomes (see further details below). Price policies are generally not suited to tackling the problem of malnutrition effectively. As instruments for improving food security, governments should use producer and consumer price subsidies only with great care. Subsidies naturally involve losses in economic efficiency and often considerable difficulties of targeting. An example for where a policy of serious price interventions failed in these matters is Malawi, where maize subsidization even contributed to aggravating the famine in 2002 (Stevens et al. 2002). Furthermore, our study on Malawi has revealed that price subsidies can have undesirable nutritional side effects as a result of household dietary adjustments to relative food price changes. These effects are especially pronounced for the major staples, but they also occur for other foods. The nutritional consequences of subsidization in favor of an individual food can be even counterproductive, particularly when people suffer from multiple nutritional deficiencies, as is

often the case. The relative price decrease of such an intervention makes consumers demand more of this food potentially at the expense of substitute - possibly more micronutrient-rich - foods and thus contributes to narrowing the dietary diversity and eventually increasing micronutrient malnutrition. Moreover, the permanent subsidization of a particular staple food guides consumers into a stronger eating habit dependency on it in the long term and exposes them to higher vulnerability to price fluctuation, calling for even more price control. For improving the nutritional status as a whole, income-related policies such as employment and food-for-work programs and targeted income transfers showed to be generally better suited than price policies and should be therefore considered as preferred alternatives in addition to food aid in emergency cases.

Targeted nutrition interventions are required to directly control micronutrient deficiencies. Programs promoting home gardens, small-scale livestock husbandry, aquaculture, and school feeding projects have been successful interventions for improving the availability of nutrient-rich food at household and community level in rural regions. The year-round availability of and access to food at regional level can be improved by strengthening local food markets, upgrading physical infrastructure, and dismantling institutional trade barriers. Furthermore, special nutritional awareness and education campaigns particularly for women are important to communicate superior nutritional knowledge. The reduction of primarily vitamin A deficiency but also deficiencies in iron, zinc, iodine, and possibly folate require more specific additional actions. Apart from food supplementation among the most vulnerable population groups, industrial fortification of food products and biofortification should be considered as large-scale, medium-term strategies. Mass fortification of commonly traded meal ingredients such as salt and oil can be a possible avenue, if deficient people have access to markets in which fortified foodstuffs are sold and if they regularly demand these products. Given the high shares of staple foods in sub-Saharan African diets, biofortification of the typical staple crop, as is done in the HarvestPlus Challenge Program of the CGIAR, offers a promising strategy to also reach self-sufficient farm households in remote areas. Finally, a superior health system is necessary for an early diagnosis of micronutrient deficiencies and treatment with supplements.

Sound nutritional impact analyses need to consider micronutrient aspects. In analyses on the nutritional impacts of economic policies or external shocks in developing countries, the traditional consideration - usually limited to food availability and calorie sufficiency - should be extended to explicitly take account of micronutrient issues. As this thesis has highlighted, the effects of changing socioeconomic conditions on people's nutritional status are diverse and tend to differ significantly in the responses of calorie and micronutrient intakes. Given that the expectation of a close comovement of the demands for calories and (some) micronutrients does not hold true in most cases, a broader view comprising the most devastating forms of nutritional deficiencies is mandatory.

Nutrient demand models are useful analytical tools in the initial stage of developing nutrition-beneficial economic policies, but require extensions and specifications for evaluating particular actions. Food demand models extended to incorporate nutrient consumption are helpful tools for analyzing the nutritional impacts of policies in populations at large. When based on available food consumption data, they offer a very cost-effective and proper way of obtaining general information, essential in the initial stage of the development of successful strategies. Thus, this dissertation has established a comprehensive basis that can act as entry point for follow-up research. For instance, to gain more concrete knowledge of how soaring food prices on the world market affect the nutritional status of the rural poor in Malawi and

how to smooth out these nutritional impacts, more focused effort is needed; this is, however, beyond the scope of this thesis. Methodologically, such an analysis would necessitate, inter alia, the disaggregation of the presented demand model according to income classes and possibly differentiated into net consumers and net producers, as well as its combination with supply and trade models. More detailed work is required in this direction to better utilize economic instruments in order to tackle the problem of micronutrient malnutrition effectively.

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