



Micronutrient deficiencies and gender: social and economic costs¹⁻³

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ABSTRACT

Vitamin and mineral deficiencies adversely affect a third of the world's people. Consequently, a series of global goals and a serious amount of donor and national resources have been directed at such micronutrient deficiencies. Drawing on the extensive experience of the authors in a variety of institutional settings, the article used a computer search of the published scientific literature of the topic, supplemented by reports and published and unpublished work from the various agencies. In examining the effect of sex on the economic and social costs of micronutrient deficiencies, the paper found that: (1) micronutrient deficiencies affect global health outcomes; (2) micronutrient deficiencies incur substantial economic costs; (3) health and nutrition outcomes are affected by sex; (4) micronutrient deficiencies are affected by sex, but this is often culturally specific; and finally, (5) the social and economic costs of micronutrient deficiencies, with particular reference to women and female adolescents and children, are likely to be considerable but are not well quantified. Given the potential impact on reducing infant and child mortality, reducing maternal mortality, and enhancing neuro-intellectual development and growth, the right of women and children to adequate food and nutrition should more explicitly reflect their special requirements in terms of micronutrients. The positive impact of alleviating micronutrient malnutrition on physical activity, education and productivity, and hence on national economies suggests that there is also an urgent need for increased effort to demonstrate the cost of these deficiencies, as well as the benefits of addressing them, especially compared with other health and nutrition interventions. *Am J Clin Nutr* 2005;81(suppl):1198S-1205S.

KEY WORDS Micronutrients, micronutrient deficiencies, vitamins, minerals, vitamin and mineral deficiencies, cost-effectiveness, cost-benefits, gender, sex, women, children

INTRODUCTION

Micronutrient deficiencies are so important to public health outcomes, particularly in the developing world, that a series of global goals have been established, and significant amounts of donor and national funds have been directed at them. A recent report highlights the magnitude of the problem and attempts to demonstrate the economic and health costs of vitamin and mineral deficiencies through a series of country-specific reports (1). It also demonstrates the cost-effectiveness of known micronutrient interventions and the need for greater funding. To achieve the Millennium Development Goals (2), improving the status,

health, and welfare of women will be critical (3). Women comprise the majority of the world's poor (4). In poor households, women play a critical role in ameliorating the effects of poverty, especially for infants and young children. Clearly, the reduction of micronutrient deficiencies, given that they have an impact on infant and child mortality; maternal morbidity and mortality; and development, growth, and economic and social well-being, needs to be aggressively tackled, not least to reflect the legal human right of women and children to adequate nutrition, including micronutrients.

However, given the emphasis particularly by most donor countries on economic rationalization of the past recent decades, there has also been a consistent call to demonstrate the cost benefit of programs addressing micronutrients, especially compared with other health and nutrition programs. The assumption that such interventions are cost-effective has heavily relied on statements from the World Bank which suggested that the cost of micronutrient deficiencies might be up to 5% gross national product (GNP) whereas interventions might only cost 0.3% of the GNP (5). A recent report, the "Copenhagen Consensus" resulted from economists setting priorities among a series of proposals for confronting ten major global challenges, by prioritizing the use of a hypothetical \$50 billion made available to governments in developing countries. Providing micronutrients through a combination of public health and private sector programs was ranked second, after control of human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) (6).

This article explores the overall social and economic impact of micronutrient deficiencies by identifying and systematically bringing together available information on: (1) micronutrient deficiencies and health outcomes; (2) micronutrient deficiencies

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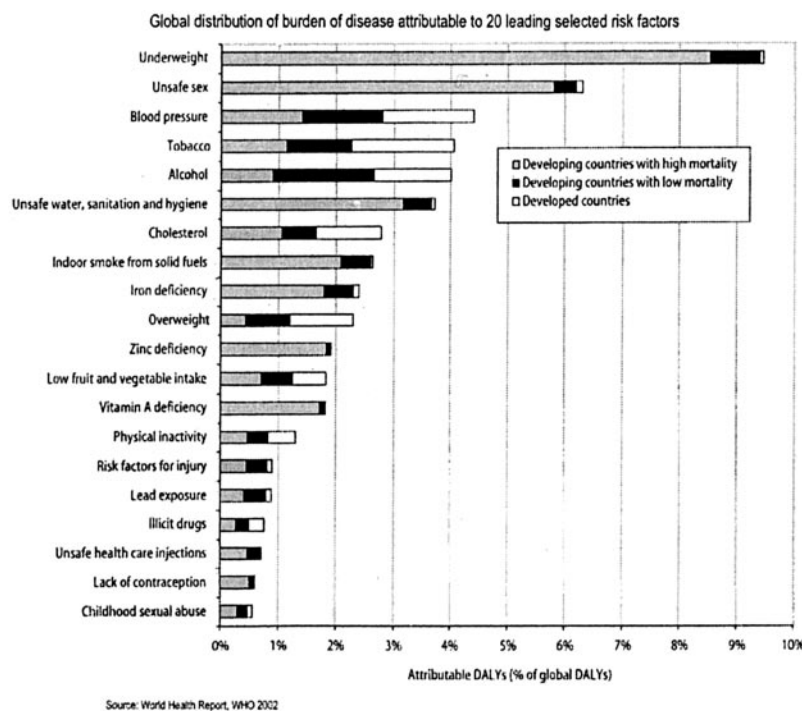


FIGURE 1. Global distribution of disease burden by leading risk factors [World Health Report, WHO 2002 (55)].

and economic costs; (3) health and nutrition outcomes and sex; (4) micronutrient deficiencies and sex; and finally, (5) the social and economic costs of micronutrient deficiencies, with particular reference to women and female adolescents and children. Conclusions are then proposed along with policy and programmatic implications. The background information was drawn from the experience and information available to the authors, various reports, especially from multilateral agencies and by literature reviews using the key phrases micronutrients, vitamins, sex, women, socioeconomic status and cost. Most of the information comes from lower income country data, with limited information from socially disadvantaged populations in more affluent countries.

MICRONUTRIENT DEFICIENCIES AND HEALTH OUTCOMES

The adverse effects of micronutrient deficiencies and excesses in children up to reproductive age and beyond are well known and well documented, although some questions inevitably remain. The adverse effects include both functional and health outcomes involving growth and development, mental and neuromotor performance, immunocompetence, physical working capacity, morbidity, mortality, and overall reproductive performance and risk of maternal death (7). Affecting the size of the health impact are nutrient-to-nutrient interactions of micronutrients, age, sex, and other host and environmental conditions such as pregnancy, genetics, overall nutrition, infections, and social conditions such as economic status. For the purposes of this article, it is only necessary to point to the extensive evidence base of established reviews. All the micronutrients of public health importance have also undergone re-positioning with regard to their public health impact over the last several decades. The Global Burden of Disease estimates showed that among the 26 major risk factors of the

global burden of disease (8), iron deficiency ranks ninth overall, zinc deficiency is eleventh, and vitamin A deficiency, is thirteenth (Figure 1).

Iron deficiency remains a public health challenge despite its long-recognized negative impact on the health and productivity of women (and of adult men). Its role in impairing the cognitive development in infants and young children has provoked a renewed interest in treating and preventing iron deficiency, although questions of effective and safe delivery remain (9). Iron deficiency in the 6–24 mo age group is impairing the mental development of 40%–60% of the developing world's children (1). Widespread iron deficiency negatively impacts on national productivity with losses of up to 2% of the gross domestic product (GDP) in worst affected countries (1). Iodine deficiency in pregnancy is causing as many as 20 million babies per year to be born mentally impaired. This has been estimated to lower the average IQ of those born in iodine-deficient areas by 10–15 IQ points, which then adversely affects school performance, decreases productivity, and results in an enormous economic burden to nations (1, 10). Vitamin A is recognized as a major factor in reducing excess mortality from infectious diseases in developing countries, while deficiency remains the commonest cause in some countries of preventable childhood blindness (11). Its importance in public health terms has become more apparent in terms of a likely role in women's health (12) and its elimination is a major 2010 UN goal (13). Zinc has recently been established as both important for the treatment of diarrhea but likely to have a role, along with other micronutrients, in prevention of both diarrhea and respiratory diseases (14). Folate has long been known to be important in the etiology of neural tube defects and anemia, but the role of folic acid has now been expanded to the prevention of cardiovascular disease, and as an essential component of flour fortification in most countries with fortification (15).

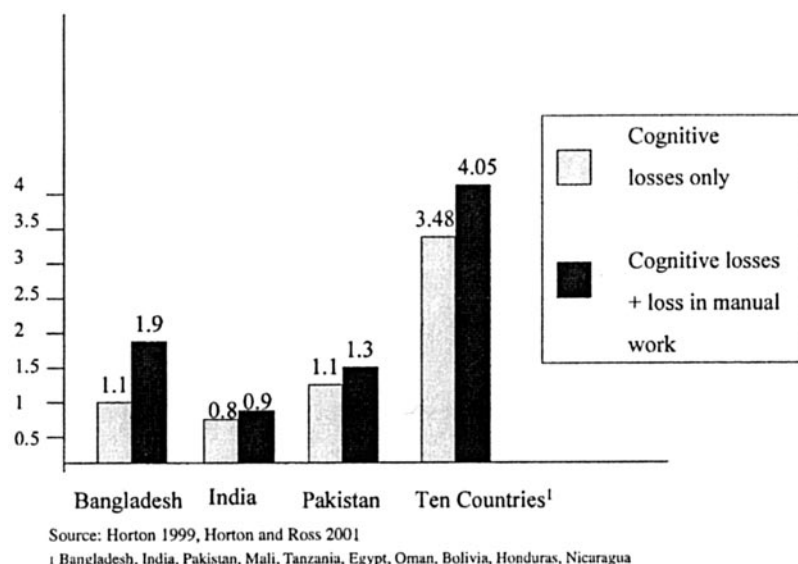


FIGURE 2. Percentage of estimated loss in gross national product (GNP) due to iron deficiency [Ross & Horton 1998 (24), Horton 1999 (56)].

Given that single micronutrient deficiencies rarely occur in isolation, the public health importance of other micronutrients such as vitamin B12, riboflavin, and the role of multi-micronutrient formulations are receiving increasing attention (16). $\approx 70\%$ of US pregnant women take multi-micronutrients as recommended medical practice, and there seems no clear reason why women in low- and medium-income countries should be denied the presumed benefits of this, especially if the dosage is given at no more than one recommended daily allowance (RDA). Higher doses need further investigation, especially in high HIV-endemic areas (17, 18), but may well have a role in delaying progression of HIV infection to AIDS (17).

MICRONUTRIENT DEFICIENCIES AND ECONOMIC COSTS

Developing countries are emphasized in this article because vitamin and mineral deficiencies are both highly prevalent in developing countries and because such deficiencies have major negative biomedical outcomes. However, there is also evidence that vitamin and mineral deficiencies are still highly prevalent in developing nations (such as China, Indonesia and Vietnam) where the availability of staple foods (and thus energy deficiency) are no longer problems. Some evidence shows vitamin and mineral deficiencies continue to be prevalent among lower income population groups in developed countries, such as the United States (19) and Europe (20). Karp (19), points out that, of the over 13 million children in the United States whose families live below the poverty level, $\approx 10\%$ have overt micronutrient malnutrition.

In developing countries, intakes of expensive animal-derived foods are often not accessible to the poor and this substantially reduces intake of vitamins and minerals (21), whereas in industrialized countries, the poor diets in lower socioeconomic groups affect micronutrient intake more through low intakes of fruits and vegetables (20). In the Philippines, Bouis (22) showed that vitamin A deficiency was associated more strongly with a lack of knowledge than with low income, in contrast to iron deficiency,

which was mainly economically determined. In pregnant women in rural Tamil Nadu, women's intakes leading to low micronutrient intakes were most affected by eating customs and socioeconomic status (23). Poor people are more likely than others to suffer from micronutrient malnutrition, but micronutrient intake does not necessarily improve in step with increasing income (5). However, with increasing improvement in the quality of the diet, micronutrient status will generally improve.

As part of the development of the "PROFILES" package, Ross and Horton (24) developed algorithms for estimating the economic costs of anemia due to cognitive delays in children, lower productivity among adults, and premature births. The analysis suggested that the median value of productivity losses due to iron deficiency was about \$4 per capita or 0.9% of GDP (24). On a per capita basis, losses are greatest in rich countries, where wages are higher, even though iron deficiency is less widespread. Nevertheless, the estimated cost to South Asia, where the prevalence of anemia is highest, was estimated to be around \$5 billion annually (Figure 2). The dominant effect for all countries is the loss associated with cognitive deficits in children (24). Horton, using an econometric model, estimates that just 3 types of malnutrition—protein-energy malnutrition, iron deficiency and iodine deficiency—are responsible for 3%–4% of GDP loss in Pakistan in any given year and 2%–3% of GDP loss in Vietnam. Maternal anemia is responsible for 20%–22% of maternal deaths due to complications of pregnancy and unsafe birthing situations (25). Productivity of adult anemic agricultural workers (or other heavy manual labor) is reduced by 1.5% for every 1% decrease in hemoglobin (Hb) concentration below the established threshold for safe health (26) (see Figure 2).

The World Bank summarized the benefits of micronutrients in terms of cost per life saved and productivity gained per program (Table 1). For saving lives at least cost, targeted supplementation to at-risk groups (pregnant mothers for iron, under-fives for vitamin A) is more cost-effective than fortification, although the latter is a more sustainable solution in the long run as incomes rise and households gain access to higher-quality primary health

TABLE 1Costs and benefits of micronutrient interventions: returns on nutrition investments¹

Deficiency/Remedy	Cost per life saved (US\$)	Discounted Value of productivity gained per program (US\$)	Cost per DALY gained (US\$)
Iron deficiency			
Supplementation of pregnant women only	800	25	13
Fortification	2,000	84	4
Iodine deficiency			
Supplementation (repro-aged women only)	1,250	14	19
Supplementation (all people under 60)	4,650	6	37
Fortification	1,000	28	8
Vitamin A deficiency			
Supplementation (under 5 only)	325	22	9
Fortification	1,000	7	29
Nutrition Education	238		
Nutrition education and maternal literacy	252		

¹ DALY = disability-adjusted life year.

care. Nevertheless, properly targeted supplementation is justified while fortification programs are in the early stage and expanding coverage, as long as the targeting principles reflect risk assessment and are consistently applied. Food-based interventions have the potential to be the most sustainable interventions for micronutrient deficiencies, although they are unlikely to be sufficient in the short term in poverty and emergency settings. The multiple benefits of food-based approaches are clear but rarely factored in. They include increases in intake of many nutrients, improved food security, female empowerment, and increased cash incomes that are likely to be spent on children's nutrition and girls' education. An observational study in rural India found that the micronutrient-rich food consumption by pregnant women, specifically that of milk, green-leafy vegetables, and fruits, were independently associated with the size of the infant at birth (23).

In addressing the returns on investments to reduce micronutrient deficiencies, Hunt (27) has concluded the following for the 4 micronutrients of public health interest.

Iodine

By eliminating iodine deficiency in previously iodine-deficient areas, the average economic gain produced by the increase in cognitive development is similar to the average economic gain in preventing a low birth weight child, with a benefit-cost ratio, per deficient women, of greater than one (28). Studies from Germany, India, Latin America, and the United States have shown the benefits of different interventions to reduce iodine deficiency (10). In Ecuador, people with moderate deficiency were consistently paid less for agricultural work (Greene 1977 cited in 26). More recently, WHO looked at the cost-effectiveness and benefit-to-cost ratios of micronutrient interventions, especially fortification and salt iodization programs; both of which were identified as having very high benefit-to-cost

ratios (29). Depending on the assumptions made, the benefit-to-cost ratio is from 40 to 400:1 (10). The mortality risk associated with iodine deficiency is the least well-known; limited results indicate a possible 8% benefit in child mortality reduction (30).

Vitamin A

Meta-analyses of field trials of mass vitamin A supplementation to children 6 to 59 mo of age have indicated an overall reduction in child mortality by 25%–35%, despite less consistency in the rates of reduction in morbidity, with greater reduction in severity than incidence of illness (31). Impacts on morbidity are also mediated by presence or absence of other deficiencies such as iron and zinc. In contrast to low birth weight, the benefits from the productivity gains over decades of work (from preventing blindness) are relatively small in comparison to benefits from reducing early mortality. A series of careful country studies on costs of vitamin A supplementation programs for under-5-year-old (Ghana, Guatemala, Nepal, Peru, and Philippines), revealed that the unit costs of the vitamin A supplement (\$0.04 per child for 2 doses) represent 5% of the delivery costs when the full program is costed (32). Though additional therapeutic benefits have regularly been noted in clinical settings, e.g. the now standard practice of providing vitamin A to children suffering from measles and the use of vitamin A to treat clinical signs of xerophthalmia, the estimation concentrated on the benefits from the prophylactic provision of vitamin A. The worldwide average is now estimated to be \$1.50 for 2 doses of vitamin A per child per year, highly cost-effective given the role of vitamin A deficiency as a primary risk factor in infant and child mortality. Eliminating vitamin A deficiency would save 16% of the global burden of disease in children (30).

Iron

The estimation of the benefits of reducing iron deficiencies must incorporate the fact that iron deficiency anemia can affect adult worker productivity directly, as well as through its impairment of child development. Behrman and Rozenweig (28) assumed a 5% across the board loss of labor productivity due to current anemia in addition to the gains through reducing low birth weight. However, increased benefits come at increased costs, because to obtain these additional ongoing productivity gains, there must be continued interventions over the work life in addition to the one-time intervention to reduce the number of low birth weight infants being born by antenatal supplementation to mothers. Eliminating severe anemia in pregnancy is estimated to potentially reduce the maternal disease burden by some 13%.

Zinc

Daily supplementation with zinc at home has been shown to reduce infant mortality by 70% and it is now recommended treatment for diarrhea, along with oral rehydration therapy (14, 33). There is little reported experience on delivery mechanisms suitable for large scale interventions (except, perhaps, with multiple fortification).

Noting that potential investments appear under-resourced, Behrman and Rozenweig have also noted the high rates of benefit-to-cost ratios and that the 'gains appear to be particularly large for reducing micronutrient deficiencies in populations in

which prevalences are high' (28). The portion of the global burden of disease (mortality and morbidity, 1990 figures) in developing countries that would be removed by eliminating malnutrition is estimated by Mason, Musgrove, and Habicht as 32% (30). This includes the effects of malnutrition on the most vulnerable groups' burden of mortality and morbidity from infectious diseases only. This is therefore a conservative figure, but nonetheless much higher than previous estimates, mainly due to now including micronutrient malnutrition (30). Seen in relation to the overall disease burden (all population groups, all causes, all developing countries), eliminating micronutrient malnutrition (in children plus anemia in reproductive age women) would save 18% of the global burden of disease, with eliminating child underweight an additional 15% (30).

HEALTH AND NUTRITION OUTCOMES AND SEX

Women and young girls are disadvantaged in health outcomes in the developing world whereas this may not be the case in the more industrialized world where women routinely outlive men. This does not preclude the possibility of social disadvantage, and an excess of some diseases such as depression (4). In most affluent countries, being a single mother is a strong risk factor for poverty or socioeconomic disadvantage. Globally, being a single mother or widow, and thus heading a female-headed household, almost invariably results in reduced income and increased likelihood of living in poverty (34). In their sample of South African female-headed households though, Lemke et al found that this did not necessarily mean they were less likely to have adequate food (34).

That many women are systematically discriminated against, or that a lower value is placed on women in many societies, is indisputable based on routine statistical indicators such as female-to-male life expectancy, and literacy (3) and with evidence, especially from South Asia, that they have less control over economic resources, than women in Norway or even Latin America (35). Regional differences in low birth weights may also reflect women's status. This is important because low birth weight is the best single predictor of malnutrition (and likely some key limiting micronutrients) because it is associated with poor growth in infancy and throughout childhood (36), and increased subsequent mortality. Low birth weight may also lead to increased obesity and noncommunicable disease morbidity and mortality later in life (37). Maternal mortality ratio is a shocking 50 and 80 times higher in South Asia and sub-Saharan Africa than in the United States or Europe (38).

Sex disparities are reflected throughout the life course. Where antenatal sex identification is increasingly performed, as in China and South Asia, there is a striking imbalance in male-to-female birth ratios (3, 39), presumed to be due to female feticide. The differences in ratios of girls to boys having primary education are well documented and vary strongly across countries. The adult literacy rate in South Asia for women as a percentage of those for men is 62%, compared with 72% in the Middle East and North Africa and in sub-Saharan Africa (13, 36). Across differences in wealth, not only is it harder for a girl living in impoverished circumstances to get primary education, but even if she does receive it, it is likely to be of shorter duration. She is more likely to be pulled out of school for family needs, and less likely, in most countries, to go onto higher education (3).

It has been pointed out—eg, by the UN Secretary General—that women are being particularly severely impacted by the HIV/AIDS epidemic as they are biologically, socially, and culturally more HIV-susceptible than men. HIV rates are 20% higher than men in sub-Saharan Africa, and much higher in younger age groups, with nearly 60% of those living with HIV/AIDS in sub-Saharan Africa being women (40). They are also less likely to avail themselves of health services for the treatment of opportunistic infections and more likely to forego food consumption in their household than men (41).

In settings that experience little nutrition improvement despite economic growth, social discrimination against women is common (42). In Pakistan, for example, widespread discrimination against girls and women is high and child malnutrition rates are among the highest in the world, as is the proportion of low birth weight infants, at 25%. Meanwhile in Thailand, where nutrition has improved remarkably in the last 2 decades, women have very high literacy, high participation in the labor force, and a strong place in social and household-level decision-making. Within India, women have similarly better relative status in Kerala compared with other states, and Kerala has better health, social and nutrition indicators, and not coincidentally, the highest levels of female education (42).

MICRONUTRIENT DEFICIENCIES AND SEX

As previously noted, the evidence that infant, young child, adolescent, and adult females have significantly worse health and nutrition is strong, while this depends on the region concerned and social and status factors (35). There is surprisingly little information on micronutrient deficiencies and their relation to sex, although assumptions of sex discrimination are common. A recent review noted that while it is important to recognize that important differences do exist in prevalence rates for various micronutrient deficiencies by sex, physiology also plays a role in the expression of deficiencies, but such differences are not easily generalized (43). For example, 3 broadly accepted "facts" are often repeated in the micronutrient literature. The first is that boys are "at greater risk of xerophthalmia (night blindness and Bitot's spot) than are girls" (11, 44). The second is that women of reproductive age suffer a higher prevalence of iron deficiency than men do (45). The third is that "girls have a higher prevalence [of iodine deficiency] than boys," especially from adolescence onward (46).

There certainly is evidence to support such claims. Vitamin A deficiency is commonly reported to be up to 10 times more common in males than females (44). Similarly, there is a well-documented higher risk of anemia in women of reproductive age due to menstruation and repeated pregnancies (45), with pregnant women at greater risk of being iron deficient when anemia is identified as a clinical manifestation (25). That said, few recent studies confirm empirically that the vitamin A status of boys is significantly lower than that of girls, but that seems to depend on the environmental, epidemiologic, and disease profiles of communities, as does iron deficiency anemia among men and children between 5 and 18 y of age (43). Indeed, most studies tend to assess micronutrient status of children without disaggregating by the sex of child, and focus on the status of mothers without considering the status of fathers or sons. The undifferentiated aggregation of people into broad categories of "children" or "women" can obscure wide variation in conditions as individuals



proceed through the life cycle in different socioeconomic, cultural, and agro-ecological contexts.

Examples of micronutrients linked to sex disadvantage include the significantly higher risk of mortality among night-blind women compared with non-night-blind women even after the end of the pregnancy and the resolution of night blindness (38). Anemia affects 50%–70% of women during pregnancy and in severe forms will increase the risk of maternal mortality by up to 20% (1, 9). In a review on iron intake from India, it was reported that the intake of iron was <50% of the RDA for children 1–6 y old. For pregnant and lactating women, the intake was 37% and 49% of RDA respectively (47). In South Asia, and other areas where portions of the population are living in poverty, multiple micronutrient deficiencies coexist (16). It has been noted that even when females [in Asia] are apparently meeting energy and protein needs, they may still be at risk of micronutrient malnutrition due to lower intakes of more expensive animal foods, fruits, and treats of higher nutrient density (23). Nevertheless, the recent review by Webb et al (43) suggests that generalizations are not possible due to an enormous geographic and cultural variation, even for India.

In Bangladesh, this sex discrimination can actually have an unexpected impact in that while girls may receive a less favored diet, this might mean more dark green leafy vegetables so their levels of vitamin A are better than comparable boys and the levels of vitamin A deficiency less (43). Research from Mexico, however, showed no significant sex differences in dietary quality or quantity in infants and preschoolers even under conditions of economic and demographic stress (48). Nevertheless, school girls consumed significantly less energy per day than boys and less of all micronutrients examined, presumably because of lower total dietary intake. The authors concluded that the lower food intakes of girls did not appear to be due to purposeful diet discrimination, but rather to culturally patterned sex roles involving lower activity (48).

SOCIAL AND ECONOMIC COSTS OF MICRONUTRIENT DEFICIENCIES BY SEX

There is insufficient information on the costs of micronutrient deficiencies to people as individuals and communities. Using the PROFILES software package (Academy for Educational Development), estimates have been made for several countries. A recent example is Sierra Leone, where it was concluded that in the absence of adequate policy and program action to reduce anemia rates in women, the monetary value of agricultural productivity losses associated with anemia in the female labor force over the next 5 y would exceed \$94.5 million; the present value of the future productivity losses associated with the intellectual impairment resulting from intrauterine iodine deficiency exceeds \$42.5 million; and over 38 000 deaths of Sierra Leonean children under 5 y of age will be attributable to vitamin A deficiency (49).

In an economic costing exercise in Nepal the authors identified that the cost of death averted by vitamin A being provided in the country by Female Community Health Volunteers was \$327 (50). Quite apart from the social benefits of empowering these poorly educated women, the program was identified as reducing the incidence and severity of diarrheal diseases and measles, which in turn reduces the need for Ministry of Health services, thereby saving the Government of Nepal \$1.5 million—which

when cost savings have been factored in, had saved the government \$1.5 million or annually \$167 000 (50). Cost-effectiveness studies undertaken on the national vitamin A distribution programs in Ghana and Zambia found the costs per death averted were \$277 and \$162 respectively (51, 52).

There are also major costs of micronutrient deficiencies associated with humanitarian crises. Women are typically overrepresented in terms of negative impacts of today's complex emergencies—roughly 70% of refugees and people displaced inside their own countries by armed conflict are women and children. Wherever crises have resulted in compromised access to food, the threat of acute micronutrient deficiencies rises; if a population is already deficient in vitamins and minerals when an emergency unfolds, the impact is worse than if preexisting conditions had been satisfactory. In Bangladesh, for example, a higher intake of vitamin A was associated with a lower risk of severe malnutrition among children directly affected by floods (53). In Indonesia, although the drought and economic crisis of the late 1990s did not have a significant impact on child anthropometry (weight-for-age), child iron status deteriorated sharply during the crisis and still had not recovered to its precrisis level 5 y later (21). The damage to cognitive development and attained schooling among these children is likely to be long lasting.


Studies on women's status and childhood nutritional status, although not addressing micronutrient status directly, have concluded that there is good evidence to show that a woman's status impacts on the nutritional status of her child. Because women with higher status (relative to men) have better nutritional status themselves, they are better cared for and provide higher quality care to their children (35). Across countries, relative resources controlled by women tend to increase the share spent on education (54). Educated girls and women have fewer children, seek medical attention sooner for themselves and their children, and provide better care and nutrition for their children (3).

CONCLUSION

It has been shown that: (1) micronutrient deficiencies lead to poor health outcomes; (2) micronutrient deficiencies are responsible for economic costs at individual, community, and national levels; (3) sex affects health and nutrition outcomes; (4) sex may effect micronutrient deficiencies, at least in some cultures, and that where there is a difference it is usually females who are disadvantaged; and, (5) there are major social and economic costs of micronutrient deficiencies, and consequently, benefits of addressing them. What has not been conclusively shown, although the evidence points that way very strongly is that these costs—both social and economic—are greater for females. Where it has been demonstrated, it has not been well quantified. The usual quantitative approaches used in assessing health and nutrition risk may miss this sort of information, as sex and intra-household relations, social networks and informal sector activities are often not uncovered by conventional statistical methods (34, 43, 54).

The 2003 Human Development report was able to conclude that generally, while some progress had been made, “sex inequality undermines women's capabilities in education and health” (3). More attention to the context-specific nature of micronutrient deficiencies is called for as a first step toward more reliable prevalence estimations and a more rational basis for targeting public health action. The countries with the worst health and

nutrition conditions, Asia and sub-Saharan Africa, would gain most from the broad public health benefits of better nutrition (30). Because it is increasingly accepted that an integrated approach is required to tackle many vitamin and mineral deficiencies (including dietary diversification, fortification and supplementation integrated into programs to control intestinal parasites and malaria, as well as environmental, sanitation, and political interventions), more attention needs to be paid to the ecological, economic, and cultural factors that influence the local consumption and absorption of nutrients *by sex*.

To achieve sustainable improvement of the nutritional status of children, women's status should be improved in all regions, but especially in South Asia, followed by sub-Saharan Africa. However, women's health must also be improved for their own sake so they are able to lead a productive, healthy, and vital role in their societies, which would, in turn, reap the economic and social benefits. One important way of doing this is to ensure that women and female adolescents and children achieve the various micronutrient goals. Investing in female nutrition through long-term, comprehensive life-course based programs will help break the intergenerational cycle of malnutrition, reduce the cost of micronutrient deficiencies; and have multiple other benefits for women, children, their households, and ultimately for nations. 

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