

The role of livestock products for nutrition in the first 1,000 days of life

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Implications

- Meat, milk, and eggs are nutrient-rich products that could efficiently boost nutrient-poor diets either as part of the normal diet or if access is increased through interventions.
- The scientific evidence for the role of livestock products in improving nutrition is limited, especially during the first 1,000 d of life in low- and middle-income countries.
- Beyond producing food, the livestock sector has additional positive and negative impacts on human health, the environment, societies, and economies that must be understood and managed.

Key Words: eggs, first 1,000 d, meat, milk, nutrition

Introduction

Dietary patterns across the world are extremely diverse, with diets of most people in low- and middle-income countries being suboptimal from a nutritional standpoint. It is in these countries that the highest levels of undernutrition are recorded, with children being the most affected. Although stunting (i.e., children short for their age) rates are declining globally and regionally, significant disparities in such rates exist between and within countries. Moreover, the absolute number of stunted children in Africa continues to increase ([Development Initiatives, 2018](#)). Iron-deficient anemia has risen to 32.8% globally and nutrient intakes are typically deficient in poor settings. Poor people in poor countries often subsist on suboptimal diets based on cheap staples and have limited access to nutrient-dense foods such as pulses, fruit, or meat ([Murphy and Allen, 2003](#); [Thompson and](#)

[Meerman, 2010](#); [Muhihi et al., 2012](#)). As a result of these circumstances, individuals do not receive sufficient nutrient intakes to sustain optimal well-being. Some research has shown that it is not unusual to begin feeding children livestock-derived food (particularly milk) before 6 mo of age when they should be exclusively breastfeeding ([Micere et al., 2016](#)). With that said, recent surveys confirmed that almost 40% of children above 6 mo living in informal settlements in peri-urban Nairobi did not consume cow's milk daily. Furthermore, meat and other livestock-derived products were each eaten by less than 5% of these children and only in very small amounts ([Grace et al., 2018](#)). This is not an uncommon reality in Africa.

Over the past decades, investments have been made to address the various forms of undernutrition present in many countries across the world. The shift from food security (access to enough food) to nutrition security (access to enough nutritious food) has prompted the development of interventions to increase nutrient intake. These interventions include food fortification as a means to improving the nutrient content of diets. Little attention has been given, however, to the specific role of livestock products such as meat, milk, and eggs (and their derived products) on nutrition and their potential to help achieve nutrition security goals. Media outlets in recent years, primarily in high-income countries, have increasingly been flooded with reports that are critical of the role of meat, in particular, and livestock-derived foods (e.g., milk and eggs), in general, as part of diets. Their environmental footprint, as well as their suggested negative effects on health, are ostensible arguments used to promote a shift to diets containing little to no animal-sourced foods. Environmental and sustainability concerns exist related to livestock production that require serious reflection relative to the evolution of farming systems and dietary patterns in industrialized countries ([Willett et al., 2019](#)). Underlying this may be more fundamental and immutable concerns over the use of animals ([Perry and Grace, 2015](#)). Nonetheless, in many low- and middle-income countries, the livestock sector is a key contributor to national economies (representing between 15% and 80% of agricultural domestic product) and represents a potential pathway out of poverty and an essential livelihood for millions of people ([World Economic Forum, 2019](#)). In countries where high volumes of livestock production accompany important undernutrition problems, it would represent a significant missed

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opportunity to not harvest livestock-derived food products to optimize the nutrition of the most vulnerable. This article will summarize the current state of knowledge on the role of livestock products for nutrition, with emphasis on the first 1,000 d of life for individuals living in low-income countries. The nutritional importance of livestock products, the evidence base for their impact on health and nutrition, and the major externalities concerned with their production will be considered.

Nutritional Importance of Livestock-Derived Foods

Livestock-derived foods possess a specific nutrient composition that matches well the human body's needs, particularly during the critical first 1,000 d of life covering the period from conception through pregnancy up to 2 yr of age (Dror and Allen, 2011). Livestock-derived foods could have an important role in reducing stunting and some key micronutrient deficiencies. Indeed, eggs, milk, meat, and offal are all nutrient-dense food products that contain high-quality proteins and several highly bioavailable vitamins (e.g., vitamin B12, only available in foods of animal origin, preformed vitamin A, and vitamin D) and minerals (e.g., iron, zinc, and calcium). Animal-source foods provide these nutrients at sufficient levels and with a great degree of digestibility, what makes them particularly adequate for young children as well as pregnant and lactating women who are in stages of rapid growth and development and have high micronutrient requirements but small intake volumes (Grace et al., 2018). Animal protein is a high quality, easily digested protein that possesses a high biological value, which is conducive for greater net protein utilization compared with nonanimal proteins. Animal proteins have a more balanced essential amino-acid profile relative to human tissues (WHO, 2007). A study in Malawi found that stunted children had lower serum levels of several essential amino acids commonly deficient in nonanimal proteins (Semba et al., 2016) which are the most common type of proteins in the diets of the poor in low-income countries. In addition, different studies have found that intake of milk and meat can have positive effects on nutrition and functional outcomes such as cognitive development, as shown in the next section. For all these reasons, livestock-derived foods can be interesting targets for interventions to reduce the biological impact of malnutrition, including poor growth or micronutrient deficiencies (Figure 1).

On the other hand, livestock-derived foods are controversial from a nutritional point of view. In recent years, there have been warnings against consumption of livestock-derived products owed to their suggested negative health effects. Although there is a general agreement on the need to avoid overconsumption, some of the recommendations to dramatically reduce consumption, for example of eggs or milk, have been later nuanced, whereas others, for example those about consumption of red and processed meat, remain strong, although far from contested (WCRF/AICR, 2007; Red meat and processed meat / IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2018; Willett et al., 2019). Chronic, noncommunicable diseases, such as cardiovascular

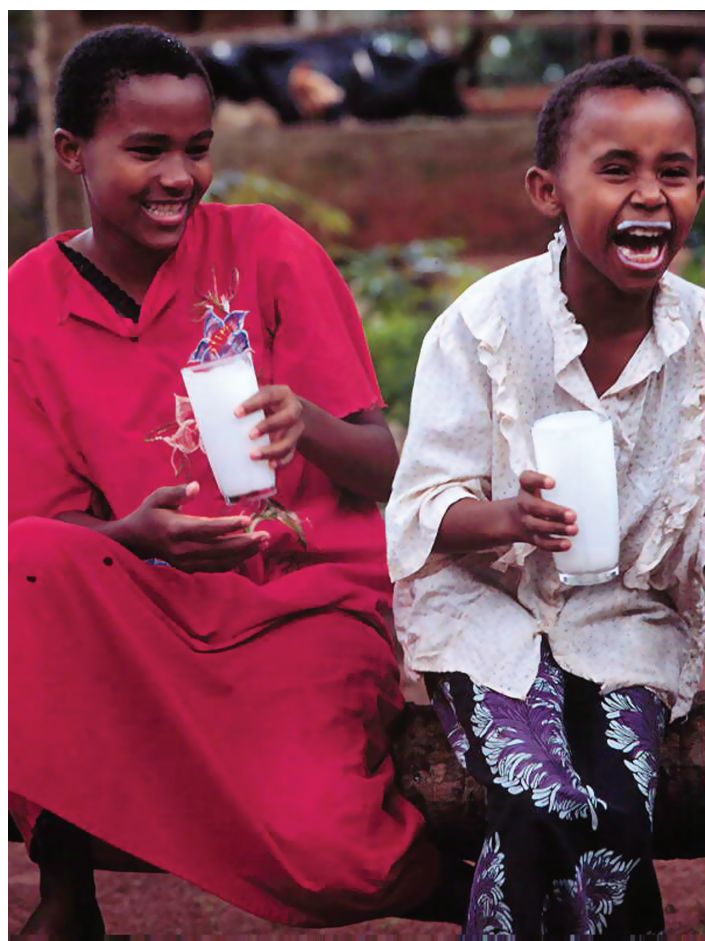


Figure 1. Consumption of dairy products by children in poor settings can support healthy growth. Credit: ILRI/Dave Elsworth.

disease or cancer, have risen sharply around the globe over the past few decades. Different studies have reported associations between consumption of livestock-derived foods and prevalence of obesity, cardiovascular disease, and diabetes; however, the data remain inconclusive, inconsistent, and not sufficient to explore effects in different life stages or nutritional contexts.

There is a significant dearth of scientific information examining the impact and trade-off of livestock-derived food consumption during the first 1,000 d of life in poor populations. The World Health Organization promotes “healthy diets” that protect against under- and overnutrition as well as noncommunicable diseases, by recommending higher intakes of fruits and vegetables and lower intake of animal fat (WHO, 2015). However, for a majority of the poor populations of low- and middle-income countries, the intake of livestock-derived food is so limited that the potential benefits of an increase in intake likely outweigh any potential health risks, provided intakes remain within healthy limits.

Contribution of Livestock Products to Nutrition in Low- and Middle-Income Countries

There is little debate about the fact that livestock products are a good source of highly bioavailable essential micronutrients

and, as such, diets containing these foods are believed to be well placed to help achieve required micronutrient intakes. The scientific literature reveals a relatively large body of literature confirming the link between intake of livestock products and positive nutritional outcomes. The majority of this evidence is however derived from observational studies, which cannot prove a “causal link” exists between intake and the observed improvement in nutritional indicators. In other words, the research does not demonstrate that the observed change in nutritional indicators was undoubtedly due to meat, milk, or eggs consumed, although they may indicate it strongly. On the contrary, available randomized controlled experimental studies can provide more conclusive evidence. Unfortunately, these studies are few, likely due to the complex nature of feeding interventions and difficulties to ascertain compliance with treatment, the complex design of such studies, the required large sample size necessary to detect meaningful effects, and their potential ethical implications. Furthermore, the effect that consumption of livestock products has on nutrition is affected by the composition of the entire diet, and therefore is context specific. Results from trials conducted in high-income countries, where diets are more diverse and nutrient-rich, will not necessarily speak to the role livestock products play with regard to nutritional status of individuals in low- and middle-income countries. Also, although determining the absolute effect of supplementing diets with livestock products compared with diets without them is relevant, it would be equally important to determine the relative effect of their consumption compared with other nonlivestock products (Figure 2).

Various authors have tried to consolidate the findings of randomized controlled trials to provide understanding relative to whether livestock products can be claimed as essential for nutrition for the young. Grace et al. (2018) provide a summary

of the existing literature on the topic with the focus on Africa and South/South-east Asia. A more recent review by Shapiro et al. (2019) examined the role of animal-sourced foods on stunting and other nutritional indicators. Compared to the earlier review, the latter identified the latter identified only three additional articles for research conducted in Ecuador, China, the Democratic Republic of Congo, Guatemala, Pakistan, and Zambia (Shapiro et al., 2019). Both reviews presented similar studies and reached similar conclusions. An overview of the findings is presented in this section.

Effects on the first 1,000 d of life

Adequate quantity and quality of nutrients are necessary for the period of time from conception, through pregnancy, and up to 2 yr of age for individuals to not only survive, but to thrive throughout life (McDonald and Thorne-Lyman, 2017). The potential impact of consuming nutrient-rich livestock products at this age is of utmost importance for adequate development, especially in contexts where diets are little diverse and nutrient poor.

Inadequate micronutrient intake during gestation has far-reaching adverse consequences through fetal programming (e.g., impaired growth of fetuses and infants and high risk of metabolic syndrome). Micronutrient supplementation can reduce the risk of being born with low birth weight but there is virtually no literature investigating the role of livestock product consumption relative to nutritional outcomes of pregnant women or their off-spring in Africa and South/Southeast Asia. Old studies conducted in Asia have reported direct effects of animal protein intake on milk output of breastfeeding women and infant breastmilk consumption. For example, a study in Burma (Khin-Maung-Naing and Tin-Tin-Oo, 1987)



Figure 2. Supplementing nutrient-deficient diets with livestock-derived foods can have a wide range of health and social benefits.

found that women consuming diets supplemented with unspecified animal protein (twice a day for 2 wk) have higher milk output and their babies ingest more milk than women without such supplementation. In Sri Lanka, women consuming skim milk powder during lactation had longer duration of exclusive breastfeeding. Although not specifically stated by the authors, the longer duration of breastfeeding could be attributed to a higher milk output stimulated from supplemental milk powder (Tennekoon et al., 1996). The evidence is weak and outdated, so further research on the benefits of consumption of livestock products for pregnant and lactating women is warranted.

Randomized control trials relative to the impact livestock products have on the first 2 yr of life are also limited. The scarce literature seems to suggest that, at these early stages of life, intake of milk is particularly important for linear growth. One of the largest randomized control trials conducted to date showed that toddlers in rural areas of Kenya whose diets were supplemented with cow's milk grew taller than children consuming the usual diet or a diet supplemented with beef (Neumann et al., 2013). A very recent study in Ecuador by Iannotti et al. (2017) showed that supplementing nutrient-scarce diets of children 3 to 9 mo of age with one egg per day for 6 mo increased child height. The study also found increased concentrations of essential micronutrients in the plasma and the prevalence of stunting was reduced by 47% in the egg-supplemented children compared with children on the traditional diet (Iannotti et al., 2017).

The available evidence for the role of livestock products consumed by pregnant and lactating mothers and children during the first 2 yr of age in low- and middle-income countries is relatively limited. That said, many studies have found positive associations with various nutritional outcomes. Although excess intake of protein could be an issue for health, the studies reviewed did not expose any potential adverse impact of consuming moderate amounts of foods of animal origin during this critical period of growth and development. Most studies however have weak designs which limit their capacity to accurately evaluate the impact of animal foods. Conducting research and, particularly randomized control trials, among these groups is particularly difficult due to stringent ethical considerations and health risks that make it challenging to design studies that will provide robust, sufficient scientific evidence.

Effects on children and adolescents

More research has been conducted targeting school-aged children, revealing results that are mixed. Several studies have recorded improvements in nutritional outcomes from diets supplemented with livestock products compared with the base diet. Milk is believed to improve linear growth in children (particularly in malnourished children), mediated by the stimulation of insulin-like growth factor (Hoppe et al., 2006; Dror and Allen, 2011). Consumption of livestock-derived foods has also shown positive impact on functional outcomes. For example, research looking at the effects of meat supplementation in children has suggested that consuming meat could improve cognitive development. The improvements in cognitive ability could

be a result of meat providing a highly bioavailable source of the necessary combination of micronutrients that may have been missing or undersupplied by the traditional diet (Gupta, 2016).

Milk supplementation has been associated in various studies with improved height. This was demonstrated in a study by Mathews et al. (1974) conducted in New Guinea among children 8 to 12.5 yr of age who were fed 25 g of skim milk powder daily for 8 mo. After 8 mo of supplementation, the children had greater height and weight compared with the control group. On the other hand, diet supplementation with 500 mL of plain milk over 6 mo in Vietnam led to improvements in weight and a reduction in underweight prevalence (Lien et al., 2009). The idea that milk stimulates growth had already been suggested by De Beer (2012) based on the results of a meta-analysis of studies examining milk supplementation and linear growth. De Beer concluded that there was moderate evidence to suggest that dairy product supplementation stimulated growth. The most likely effect was 0.4 cm per annum additional growth associated with 245 mL of milk daily (de Beer, 2012).

The amount of meat, milk, or eggs consumed, and the duration of supplementation are likely critical factors behind the observed effects. Intake of high amounts of livestock products for sustained periods has resulted in a positive influence on micronutrient status. The study on milk supplementation in Vietnam (Lien et al., 2009) found improved levels of ferritin and reductions in vitamin A and zinc deficiencies after daily supplementation with regular milk over 6 mo.

A large randomized control trial in Kenya (Grillenberger et al., 2003; Siekmann et al., 2003; Hulett et al., 2014) among primary-school children (6 to 14 yr of age) assessed the effects of milk, meat, or energy supplementation on micronutrient status and a variety of anthropometric and development outcomes. The study found a negligible influence of milk on child linear growth; however, younger (≤ 6 yr) and stunted children showed a greater rate of height gain, indicating that milk supplementation may have limited impact on growth among healthy children, yet the influence of milk consumption can be more prominent among younger and (or) ill children. After 1 yr of the intervention, only the levels of vitamin B12 (but no other micronutrients) in blood experienced a noticeable increase (Siekmann et al., 2003) compared with the control group. Specifically, these meat and milk supplementation interventions led to a marked decrease in prevalence of low plasma vitamin B12 diagnosis among participants (i.e., 8.9% in the milk group and 4.5% in the meat group, compared with the baseline prevalence of 40.2% and 56.2%, respectively). Meat and milk are among the few products that contain vitamin B12, which is a key element to support cognitive development. Also in this study, meat improved cognitive performance, school test performance, leadership behavior, and physical activity (Whaley et al., 2003; Sigman et al., 2005; Neumann et al., 2007). The influence of meat on cognitive development is thought to be related to greater intake of vitamin B12 and a more bioavailable source of iron and zinc. Together with high-quality protein, these may facilitate specific mechanisms such as the speed of information processing in learning tasks.

Other (Nonnutritional) Considerations of Livestock Product Consumption

Globally, the livestock sector is one of the most important in terms of land-use, economic value, employment, and use of animals. Unsurprisingly, livestock production can have many impacts, both positive and negative, on societies and ecosystems beyond providing food. Livestock production brings a range of economic, societal, and environmental benefits, some of which are summarized in Table 1. Most of those impacts are particularly important in low- and middle-income countries, where livestock production is the primary source of income and livelihoods for many families, especially in rural areas (Swanepoel et al., 2010).

Although this paper focuses on the nutritional benefits of livestock products in the first 1,000 d of life, a balanced discussion must also pay attention to the negative impacts associated with livestock production. Unsurprisingly, these are the issues that have received most attention over the past decades. Although it is difficult to bring these issues to a common metric, it is likely that the impact of foodborne disease may have the highest ongoing burden, whereas the greatest potential for catastrophic loss (or existential risk) may stem from the contribution of livestock production to climate change and to the emergence of global pandemics. The landmark first assessment of the global burden of foodborne disease (Havelaar et al., 2015) conducted by the World Health Organization considered 31 food-related hazards. It concluded that foodborne disease has a health burden comparable to malaria, HIV/AIDS, or tuberculosis. Most of this burden (98%) falls on developing countries and 40% on children less than 5 yr of age. Although information on source attribution (that is, what foods are responsible) is weak, livestock products are disproportionately represented as causes of foodborne illness (Grace, 2015; Hoffmann et al., 2017). Foodborne disease and health hazards found in livestock products (such as aflatoxins) may also directly contribute to poor nutritional status in infants in low- and middle-income countries. A 9-country study found that 25% of stunting could be attributed to experiencing more than four episodes of diarrhea before the age of 24 mo (Checkley et al., 2008). Studies find a strong peak in diarrhea after the introduction of supplementary foods and find that weaning foods often have high levels of microbial contamination and adulteration (Kumi et al., 2014). Aflatoxins may directly contribute to stunting, and there are demonstrated associations between higher toxin levels in food and poorer growth in several

contexts, including children consuming milk with aflatoxins in Kenya, although a causal relation is yet unproven (Leroy, 2013; Hoffmann et al., 2017).

Livestock production, especially in intensive systems and if accompanied by land-use change, can lead to the emergence of zoonotic diseases (Taylor et al., 2001; Jones et al., 2013). Around 75% of new and emerging human diseases (including many antimicrobial resistant organisms) are zoonotic (Blancou et al., 2005). These have the potential to sicken and kill large numbers of people and to damage economies. Emerging pandemics are considered to represent one of the few important risks to societal collapse (Taylor et al., 2001).

Another existential threat to humanity is climate catastrophe, which, under the most extreme scenarios, could make large parts of the world uninhabitable. Although estimates vary, the livestock sector is made responsible for up to 14.5% of anthropogenic greenhouse gas emission (Gerber et al., 2013). Livestock production also has implications for other planetary boundaries, notably biosphere integrity, freshwater consumption, land system change, and nitrogen and phosphorus flows (Rockstrom et al., 2009; Steffen et al., 2015). Production of other foods, especially those requiring high levels of inputs and of low nutritional value (e.g., greenhouse grown, irrigated lettuce), also has environmental effects but a review of the scientific literature seems to suggest that many experts in the sustainable-diets field consider diets low in livestock products and high in fruit, vegetables, and legumes offer the greatest co-benefits in terms of human nutritional outcomes and environmental sustainability (Grace et al., 2018; Willett et al., 2019).

As well as environmental, there are important societal impacts of livestock production. Animal welfare is an increasing public concern raised by consumers, especially in high-income countries. Animal welfare conditions currently vary across countries and production systems, and depend on socio-economic and regulatory settings, as well as on religious and cultural traditions, consumer and civil society organizations pressure. However, animal welfare is often especially problematic in intensive systems of low- and middle-income countries. Other social consequences of intensification include rural abandonment, poor working conditions, low wages, vulnerability of migrant labor, and occupational hazards (HLPE, 2016). These can be exacerbated by economic risks in the form of dependence on external inputs, including feed and energy, market concentration, price volatility, inequitable distribution of value added, as well as the difficulty of internalizing externalities in price signals.

Table 1.
Benefits of keeping livestock beyond their involvement in food production

Economic	Environmental	Social
Obtain access to credit	Provision manure	Psycho-social well being
Draft power	Nutrient recycling	Biophilia
Transport	Landscape amenity	Traditional foods
Asset accumulation	Improving pasture land	Cultural events
Household energy production	Carbon sequestration	Ritual and religion
Non-edible byproducts (hides, horns, fiber, etc.)		Exercise
Construction material		Sport and recreation

Understanding the optimal role of livestock products in diets in the first 1,000 d of life requires a holistic understanding of all the positive and negative impacts of the production and consumption of meat, milk, and eggs. Few studies to date have examined comprehensively the links between production and consumption of livestock products and economic, social, or health sustainability in low- and middle-income countries or the trade-offs between the different aspects of sustainability. For example, advocates for action against climate change recommend shifting from red meat to chicken as this is associated with less greenhouse gas emitted per kilogram of meat produced. Furthermore, white meat (such as poultry breast meat) is often claimed to be healthier than red meat (such as beef or pork). Yet, according to [Scherer et al. \(2018\)](#), the shift to poultry consumption will bring increases in net animal suffering. As mentioned earlier, intensively kept livestock, as is often the case in poultry systems, are associated with disease emergence. One recent study estimated that the annual cost of an influenza pandemic was equivalent to the cost of climate change ([Fan et al., 2016](#)). This implies, a shift towards increased poultry meat consumption at scale could result in nonnegligible increased risk of pandemic and their associated animal suffering and economic loss. None of these aspects of sustainability are considered in recent long-standing recommendations to shift consumption from red meat to poultry.

Towards Promotion of Meat, Milk, and Egg Consumption in the First 1,000 d of Life in Low-Income Countries

There is limited robust evidence regarding the effect of consuming livestock products during the first 1,000 d of life, particularly in low- and middle-income countries. That said, evidence from studies on older children and the fact that foods of animal origin represent the most significant source of specific nutrients such as vitamin B12 suggest that consumption of these products would provide nutritional benefits during the first 1,000-d period, possibly without any negative health effects (if intakes are not excessive). Furthermore, it is believed that even low amounts of meat, milk, or eggs can make a difference for these individuals with high nutrient requirements. Yet, the scientific evidence-base to support these claims is far from optimal. Greater capital should be invested into well-designed research projects that possess sufficient power to determine optimal amounts of these foods to achieve the largest benefit to human development and well-being. It is also imperative to determine the relative importance of nutrients derived from foods of livestock origin versus other food products and their contribution to human nutritional outcomes.

Moreover, beyond the nutritional considerations, promoting intake of livestock products among resource-limited populations will require specific feasibility and sustainability studies be conducted to ensure those foods are available and affordable to the target populations. Drawing policy recommendations on consumption of livestock products for nutrition of vulnerable women and children will require an analysis of the

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Paula Dominguez-Salas is a veterinarian and a public health nutritionist with a focus in developing countries. She now works as a human nutritionist to optimize the impact of livestock development programs at the International Livestock Research Institute (ILRI) in Nairobi, Kenya, and is assistant professor in nutrition-sensitive agriculture at the London School of Hygiene and Tropical

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Delia Grace is an epidemiologist and veterinarian with more than 20 yr' experience in developing countries. She graduated from several leading universities and currently co-leads research on human and animal health at the International Livestock Research Institute (ILRI) based in Nairobi, Kenya. Her research interests include food safety, emerging diseases, gender studies, and animal welfare. Her career has spanned the private sector, field-level community development, and aid management. Her research program focuses on the design and promotion of risk-based approaches to food safety in livestock products. She is also a key player on ILRI's Ecohealth/One health approach to the control of zoonotic emerging infectious diseases and agriculture-associated antimicrobial resistance.



relationship between price of a food and its likely consumption among poor populations. Intake of meat, milk, and eggs in low-income countries is driven primarily by affordability

constraints—these foods are an expensive commodity that is consumed often in small amounts and only in special occasions in accordance with cultural acceptability. These products are also often subject to food proscription. Promotion of their consumption will require tailored recommendations that respect cultural habits and strategies to promote the availability and reduce the cost of these products. The growing differences in meat and milk intake between children in richer (who may already be eating high amounts already) and poorer families in those countries should also be dealt with to avoid exacerbating the double burden already experienced by many low-income countries (WHO, 2017). Finally, promoting the consumption of livestock products cannot occur without accounting for the possible health, environmental, and economic externalities. Investments in sustainable and environmentally friendly livestock production systems and strong food safety systems are required in these countries to holistically maximize the utility of livestock food for nutrition.

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