

Review

Understanding the interaction between farm labor productivity, and health and nutrition: A survey of the evidence

Kwadwo Asenso-Okyere^{1*}, Catherine Chiang², Paul Thangata¹, Kwaw Andam³ and Daniel Ayalew Mekonnen¹

¹International Food Policy Research Institute, P. O. Box 5689, Addis Ababa, Ethiopia.

²International Food Policy Research Institute, 2033 K Street, Washington, D.C. 20006-1002, USA.

³The World Bank, Washington, DC, USA.

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Good health is an asset for agriculture, as healthy people can produce more and good nutrition contributes to it. Conversely, agriculture is an asset which contributes to good health and nutrition, and resilience. When both health and agriculture thrive, a reinforcing cycle of health can result, but when either suffers, the cycle becomes one of lowered agricultural productivity and lowered health. Agricultural development and practice can exacerbate the incidence of disease through an interaction with disease vectors and parasites. When disease afflicts farmers, their productivity is reduced and they remain in poverty. Beyond the direct impacts due to loss of labor, illness undermines long-term agricultural productivity in a number of ways: when illness leads to long-term incapacitation, households may respond through withdrawal of savings, the sale of important assets (such as jewelry, textiles, breeding animals, farm equipment, and land), withdrawing children from school, or reducing the nutritional value of their food consumption. All of these responses can have adverse effects on the long-term labor productivity of household members. The good news is that there are many global efforts to combat disease and these are paying off with long term prediction of falling incidence of disease in many regions of the world.

Key words: Agriculture, farming, health, disease, nutrition, labor productivity.

INTRODUCTION

Agriculture continues to be one of the most important drivers of poverty reduction and the bedrock for economic growth, especially for the billions of people in developing countries. In agriculture-based countries, the sector generates, on average, 29% of the gross domestic product (GDP) and employs 65% of the labor force (World Bank, 2007). Three-quarters of the world's poor live in rural areas, particularly in Asia and Africa (Ravallion et al., 2007), and depend on agriculture as their primary source of livelihood. Studies based on cross country estimates found that agricultural growth contributes significantly to reducing poverty and hunger. The countries with extremely alarming hunger situation among the poorest in the world (Grebmer et al., 2010).

The World Bank (2007) suggests that, GDP growth originating in agriculture is at least twice as effective in reducing poverty as GDP growth originating outside agriculture.

According to World Bank (2007), developing countries accounted for about 79% of overall agricultural growth between 1980 and 2004; and the major contributor to growth in Asia and the developing world in general was productivity gains rather than expansion of land devoted to agriculture. Sub-Saharan African agriculture in particular did not contribute much to this success, as agricultural growth largely emanated from area expansion. However, this is not sustainable as land becomes increasingly scarce due to population pressure and deforestation contributes to climate change and promotes the breeding of disease-carrying vectors, especially mosquitoes. Hence, the big challenge is to have farm productivity grow in such a manner that food supplies can grow to accommodate the rising demand for food arising

*Corresponding author. E-mail: k.asenso-okyere@cgiar.org.
Fax: 251 11 646 2927.

from population growth, rising incomes, and urbanization.

Agriculture's role in human livelihood also means that, agricultural development has strong linkages with other fields of development practice and research, including health and nutrition. The importance of good health is summarized in a popular saying, "The wealth of a nation is the health of its people." Therefore, the success of agricultural livelihoods depends on the health of its workforce. At the same time, different agricultural production systems have different impacts on health, nutrition, and well-being of the people. Households can use income from agricultural production for improved access to health products and services, and agriculture provides food and nutrients for energy and maintenance of good health; but on the other hand, agriculture-associated infections affect nutrient absorption and people's nutritional status. Hence, knowledge and understanding of these interactions and their consequences will be useful in planning development programs in agriculture and health.

THE CONTRIBUTION OF FARMING TO HEALTH AND NUTRITION

Agricultural production is a determinant of health, primarily through the consumption of food produced and through intermediary processes related to income and labor. In addition to providing some or all of the household's food needs, agriculture provides income for farmers and farm laborers. Income enables them to purchase and gain access to food, water, land, information and education, and health-related services which in turn determine their overall nutrition and health status. On the other hand, agricultural labor, which is relatively intensively utilized, can affect nutritional status due to high energy expenditure and by usurping time that could be otherwise spent on child care, food preparation, and other nutrition-related activities. Farm labor, particularly when inefficiently utilized, can also detract from time, that could be productively spent on income-generating activities, educational, or other endeavors. Labor exposes producers to a range of occupational health hazards, such as accidents, diseases, and poisoning from pesticides as well.

Agriculture's major output, food, carries diseases caused by contamination by pathogens during agricultural production. Consumption of milk contaminated by *Mycobacterium bovis*, which is present in animals in most developing countries, has long been regarded as the principal mode of TB transmission from animals to humans (Acha and Szyfres, 1987). *M. bovis* and *Mycobacterium tuberculosis* have been found in milk samples in Ethiopia, Nigeria, and Egypt, highlighting the serious public health implications of potentially contaminated milk and milk products in developing countries where proper food hygiene practices are lacking (WHO,

1994; Idrisu and Schnurrenberger, 1977; Nafeh et al., 1992). One way of reducing the effects of the contaminants is to boil the milk before consumption, but in many milk-producing communities, milk is consumed fresh.

Agricultural output also affects health through availability of nutritious food. Quality and diversity of food produced influence access to micronutrients and dietary diversity. Food that is poor in micronutrients cannot provide adequate nutrition for people, making them susceptible to disease. Certain types of food, like fats and oils, and others which contain dangerous substances like aflatoxins, have given rise to diet-related chronic diseases.

Mycotoxins are toxic secondary metabolites of fungal origin and contaminate agricultural commodities before or under post-harvest conditions. When ingested, inhaled, or absorbed through the skin, mycotoxins cause lowered performance, sickness, or death of humans and animals (Wagacha and Muthomi, 2008). High on the list of mycotoxins is aflatoxins, which pose serious health, economic and agricultural problems in developing countries (Bankole and Adebajo, 2003). Aflatoxin chemical poisons are produced mainly by the fungus *Aspergillus flavus* and are found as contaminants in foods such as cassava, peanuts, corn, rice, cottonseed, and other grains that underwent stress factors during plant growth, late harvesting of crops, high ambient humidity preventing thorough drying and poor storage conditions. There is a high level of aflatoxin exposure in countries in Sub-Saharan Africa and Southeast Asia (Jolly et al., 2007). Data from several West African countries show that, more than 98% of children and adults have detectable amounts of aflatoxin in their blood (Montesano et al., 1997; Wild and Turner, 2002). Aflatoxin contaminated diet has been linked with the high incidence of liver cancer in Africa (Oettle, 1964; Bababunni et al., 1978). According to Miller, 40% of the productivity lost to diseases in developing countries is due to diseases exacerbated by aflatoxins (Miller, 1996).

Agriculture also contributes medicinal plants which help treat diseases. In areas where orthodox medicine is not available or where they are available but the people cannot afford it, they seek disease treatment from traditional herbalists who use medicinal plants. For instance, because of the high treatment costs and difficulties with access, only a small percentage of households with people living with HIV or AIDS are currently using pharmaceuticals and supplements and instead depend on local capacities and resources, including plant-based medicine sourced from the forest (Willumsen and Kettaneh, 2005; FAO, 2003). Examples of medicinal plants include the bark of *Prunus africana* tree which is used in the treatment of prostrate disorders; *Artemisia annua* (sweet wormwood) used in treating malaria, and the African tree *Melaleuca alternifolia* (tea tree) which contains an antifungal substance that combats *Candida albicans*, the bacteria responsible for fungal skin problems

and mycosis (a condition that commonly affects the eyes of AIDS patients). The WHO estimates that, about two-thirds of the world's population, and 80% of Africa's population, sometimes use herbal or traditional medicine. Therefore, medicinal plants constitute a fundamental component of traditional healthcare systems in rural communities throughout Africa.

Improperly managed agricultural systems have resulted in water pollution and food contamination and their associated human diseases. Water pollution arises from dumping or seepage of waste, including agricultural waste and agrochemical effluents, into standing or flowing water, and food contamination results from lapses in agricultural production and post-harvest management. The contamination can result in health problems, even acute diseases with high mortality rates at young ages and early onset of chronic diseases at middle ages. Agriculture-related accidents can also result in temporary or permanent disability or death.

Water for agriculture is critical for food security. However, in many parts of the world agricultural production is threatened by water scarcity. Most farmers construct wells or harvest water and store it in dugouts and bunds. These water storage receptacles provide favorable aquatic habitats for mosquitoes. Projects aimed at providing water for agriculture through dams and irrigation schemes have also led to increased breeding of disease-carrying vectors. In Burundi, malaria parasite prevalence was estimated at 24 to 69% in irrigated rice fields compared with 5 to 30% in nearby non-irrigated fields (Mutera et al., 2006). Similar findings were obtained from studies in East and West Africa (Mutero et al., 2004). Fish ponds have also been found to contribute to malaria transmission, as evidenced by a study in the Peruvian Amazon (Maheu-Giroux et al., 2010) and Côte d'Ivoire (Matthys et al., 2006). Schistosomiasis which causes chronic illness is often associated with water resource development projects, such as dams and irrigation schemes, and rivers where the snail intermediate hosts of the parasite breed. The parasite then spreads to people and causes disease as farmers collect water to irrigate their fields, women and children collect water or stand in the water to wash clothes, people wade through the water to cross from one bank to another, or children swim in the water for recreation.

The health of farmers and farm workers may be at risk if they work with animals as they contract zoonotic diseases. More than three-quarters of the human diseases that are new, emerging, or re-emerging at the beginning of the 21st century are caused by pathogens originating from animals or from products of animal origin (FAO/WHO/OIE, 2004). Disease ecology shows that, disease spread and the emergence of zoonotics are largely the product of human activity, and therefore, of human choices. Intensification of animal production tends to increase disease risk. The consequences of animal diseases include direct economic costs, such as the loss

of animal production and products. In the 1980s, a foot and mouth outbreak caused the Kenyan dairy farming sector to suffer a 30 percent loss of milk production (Le Gall, 2006). In 1997 to 1998, abortion by cows caused by Rift Valley fever virus undermined birth of calves and milk production, and milk exports declined by 75% in East Africa (Le Gall, 2006). The 2003 to 2004 outbreak of highly pathogenic avian influenza in Southeast Asia resulted in more than 140 million dead or destroyed birds and losses exceeding US\$10 billion (OIE/FAO/WHO, 2007). Since late 2003, the H5N1 strain of avian influenza has been responsible for 4,544 documented outbreaks in poultry farms in 36 countries. These outbreaks have been associated with 269 human cases and 163 fatalities (as of January 2007) (World Bank, 2007).

Pesticide use has been increasing in developing countries and so has pesticide poisoning in farmers. In addition, to increase the quantity of pesticide used, farmers use stronger concentrations of pesticides, they have adopted increased frequency of pesticide applications, and they increasingly mix several pesticides together to combat pesticide resistance by pests (Chandrasekera et al., 1985; WRI, 1998). Due to lack of training in pest management or in safe methods of storage, handling, and application, many farmers contract pesticide-related diseases (Antle and Pingali, 1994). Farm workers who do not wear protective clothes or equipment are in danger of inhaling the fumes from chemicals and damaging their skin and eyes. Deaths resulting from exposure to pesticides are not uncommon. Estimates from the Food and Agriculture Organization (FAO) (2000) show that, approximately 3 million people are poisoned and 200,000 die from pesticide use each year. Evidence also points to negative health and productivity impacts resulting from pesticide use. For example, in Tanzania, a study of vegetable farmers reported that 68% of farmers who used pesticides reported having felt sick after routine pesticide application (Ngowi et al., 2007).

In Zimbabwe, it was found that pesticide acute symptoms significantly increased the direct cost of illness in cotton growers (Maumbe and Swinton, 2003). The time spent recuperating from illnesses attributed to pesticides average 2 to 4 days during the growing season. Combining production data from a farm-level survey and health data from the same population of farmers in two rice-producing regions of the Philippines, Antle and Pingali (1994) found that, pesticide use has a negative effect on farmer health, while good farmer health has a significant positive effect on productivity. A study of potato production in Ecuador showed similar results (Antle et al., 1998). In that study, results indicate that despite the role that insecticides play in controlling the Andean weevil insect pest, a reduction in the use of the principal insecticide (carbofuran) used to control the pest, could raise productivity of potato production and also

improve farmers' health.

Impact of health and nutrition on farm labor productivity

The linkage between agriculture, and health and nutrition is bi-directional, and so health and nutrition also affect agricultural systems. Poor health brings hardships to households including debilitation, substantial monetary expenditures, loss of labor, and sometimes death. Poor health lessens the farmer's ability to innovate, experiment, and operationalize changes in agricultural systems. A farmer who is ill cannot attend a farmer field school or interact with an extension officer to learn about new technologies and improved practices, and so may lack the knowledge to innovate. Most often, innovation requires the purchase of improved seed, fertilizer, or other inputs, or use of machinery, and this may not be affordable for poor farmers after spending their money on healthcare. When the innovation involves additional labor (for example, farming practices like planting in lines), it is difficult for households with sick members to adopt the practice. Experimentation on technology adoption and improved practices would be too costly for a farm household that is spending a lot of money on healthcare and is losing labor to illness.

Health also affects agricultural output, particularly its demand. Malnutrition and disease patterns influence market demand for food quantity, quality, diversity, and the price people are able or willing to pay. Nutrition affects people's health and is an important factor in farm labor productivity. Past nutritional status predicts the probability of developing chronic diseases and consequently, influences labor force participation (Sur and Senauer, 1999). The nutrition and health status of adults affects the duration of labor force participation and the intensity of work effort. Poor health will result in a loss of days worked or in reduced worker capacity, and is likely to reduce output (Antle and Pingali, 1994). Limited access to food may occur in a household if individuals are too ill or overburdened to produce or earn money to buy food (Kevenge-Ettinger et al., 2010). Based on the premise that wages reflect the marginal productivity of labor, Sur and Senauer (1999) looked at the link between nutrition and health, and labor productivity by estimating wage equations from individuals participating in the wage labor force in rural Bangladesh. Height, which was used as an indicator of long-term health status, was found to be a significant determinant of labor force participation in agricultural wage labor but not for non-agricultural wage labor. Good nutrition has been found to be crucial for both children's physical and cognitive development and for their productivity and earnings as adults. The Lancet reported that boys who benefited from a randomized nutrition intervention during conception and in their first two years of life earned 50% more wages than those of

non-participants, when both groups became adults (Hoddinott et al., 2008).

A study in Brazil simultaneously explored the effect of four separate dimensions of nutrition on urban wages (Thomas and Strauss, 1997). The relationship among wages, per capita calories, per capita protein, body mass index (BMI is measured as weight in kilogram divided by height in meters squared kg/m^2), and height were examined. Research results revealed that, height is associated with higher wages for both self-employed men and those who work in the market sector. Moreover, being taller and having a higher BMI is compensated most in self-employment. It was noted that, many of the self-employed in urban Brazil work as manual laborers and returns to strength are large in such vocations in which a lot of energy is required.

A common mechanism households adopt to cope with the burden of high medical costs is reducing consumption of basic needs, including food (Pitayanon et al., 1997). If consumption reduction is substantial, this can lead to malnutrition which increases susceptibility to opportunistic diseases for AIDS patients. Malnutrition weakens the immune system, increasing the risk of ill-health, which in turn can aggravate malnutrition. The World Health Organization identifies malnutrition as "the single most important risk factor for disease." In developing countries, poor nutrition is a massive problem making people more susceptible to diseases.

A study on the effect of nutrition on labor productivity in rural Sierra Leone was one of the first attempts to test the nutrition-productivity relationship using total farm output as the measure of productivity. A Cobb-Douglas production function was estimated to test the hypothesis that, farm output is influenced by effective family and hired labor hours, variable non-labor inputs, fixed capital, and land. It was found that calorie intake had a significant positive effect on farm labor productivity with a calorie-output elasticity of 0.34 at the sample mean (Strauss, 1986). Using household survey data in India, Deolalikar (1988) estimated both a wage equation and a farm production function to examine the empirical relationship between nutrition and productivity. It was found that calorie intake or short-term nutritional status was not a significant determinant of wages and farm output, but that weight-for-height, which was used as a medium-term indicator of health and nutritional status (measured in kg/cm), significantly influenced both the wage and production function equations. The study concluded that, the medium-term effects of better nutrition are quite large and positive, although the short-term effects are insignificant. In a Sri Lankan study that analyzed the effect of nutritional status on rural wages, it was found that per capita calorie intake had a positive significant effect on productivity for men but not for women (Sahn and Alderman, 1988). The different result may be due to differences in the work done by men and women on farms.

Re-examining the nutrition-productivity relationship taking seasonal variability into consideration using data from India, Behrman and Deolalikar (1989) found that, calorie intake is an important determinant of wages in peak seasons, while weight-for-height is a more important determinant during lean months. During peak season's energy is required to carry out strenuous and time consuming work and so calorie intake becomes very important. Examining the link between nutrition and productivity in the Philippines with height as the predictor of long-term nutritional status, Haddad and Bouis (1991) found that, while height is a significant determinant of wages, energy intake as determined from a 24 h food recall survey was not a significant predictor of wages.

Research carried out in Ethiopia estimated the impact of health and nutritional status on the efficiency and productivity of cereal growing farmers (Croppenstedt and Muller, 2000). Results showed that, the distance to the source of water as well as nutrition and morbidity status affects agricultural productivity. Ulimwengu (2009) used a stochastic production function to analyze the relationship between farmers' health impediments and agricultural production efficiency in Ethiopia. Healthy farmers were found to produce more per unit of inputs, earn more income, and supply more labor than farmers affected by sickness. As expected, the model results show that, production inefficiency increases significantly with the number of days lost to sickness. Using a quasi-experimental design along with a generalized linear model (GLM) for longitudinal data, Audibert and Etard (2003) estimated the worker productivity benefits of health in Mali. They assumed that the family members and the hired labor who are working in the fields are imperfect substitutes because of the cost of hired labor and the low agricultural yield. Results showed an increase of 26 percent in the production per family labor person-day in the experimental group who received treatment for schistosomiasis relative to the control group who received a placebo. Unlike other studies which looked at health indicators related to past and time-invariant health (such as height due to investment during childhood), current health and changes in health caused by unexpected illness or external input were considered in their study.

Empirical evaluation of morbidity impacts on individual labor productivity has been limited to a few diseases. As quantity and quality of labor are affected during duration of an illness, capacity to produce agricultural output often is reduced, resulting in lower labor productivity. As suggested by theoretical literature, household farm production will decline (and shift to less labor-intensive crops) because of loss of productive labor due to illness.

While numerous studies have focused more on estimating the economic burden of illnesses (direct and indirect¹ costs), the available empirical literature

evaluating effect of morbidity on agricultural production has shown varying results.

HIV/AIDS

Attempts have been made to estimate the extent of rural labor loss due to AIDS mortality. The U.S. Department of Agriculture has estimated that the reduction in numbers of agricultural laborers in Southern Africa will reduce agricultural labor productivity by 12% per year, which will result in a 3.3% loss in grain output (ILO, 2004). Moreover, FAO (2004) using epidemiological data projected that by 2020 the nine most severely hit Sub-Saharan African countries would lose from 13 to 26% of their agricultural labor force to HIV and AIDS.

A survey in Zambia found that heads of HIV-affected households reduced their cultivated land area by 53 percent, resulting in reduced crop production (ILO, 2000). A study in western Kenya that examined the impact of HIV and AIDS on labor productivity found that HIV-positive workers plucked 4 to 8 kg/day less tea in the last year and a half before they died compared to HIV-negative workers (Fox et al., 2004).

Absenteeism also occurs as a result of time reallocated to care for an ill household member, including children. A household impact study of HIV and AIDS on families in the Free State province of South Africa found that household members spend 7.5 h a day or about 2700 hours per year which is equivalent to 113 person days a year taking care of the ill (Booyesen and Bachman, 2002). In rural Zimbabwe, the average time spent in taking care of bed-bound AIDS patients is 38.5 h per week or about 2,000 hours per year which is equivalent to 83 person days a year. A study in Rwanda indicated that reduced labor time as a result of HIV related illness among women and increased time women devote to caregiving to members living with AIDS resulted in a decline in production of beer bananas (a cash crop), a source of income for women (Donovan and Bailey, 2006).

Malaria

Compared to HIV infection, which generally causes steadily deteriorating health, lost labor time due to malaria is lesser, because malaria affects children more than adults, whereas it is the opposite for HIV. Studies have shown that per malarial attack, depending on the severity, typically entail a loss of four working days, followed by additional days with reduced capacity for about four episodes per year (Brohult et al., 1981; Picard and Mills, 1992). This means about 16 working days are lost in a year. Another study found that, a bout of non-fatal malaria will typically last for 10 to 14 days, including

¹ Direct costs refer to household expenditure linked with seeking treatment, including non-medical expenses such as transport or special foods. Indirect

costs refer to the loss of household productive labor time for patients and caregivers valued using the going wage rate.

4 to 6 days of total incapacitation with the remainder characterized by headaches, fatigue and nausea (Hempel and Najera, 1996). In Oyo State of Nigeria, the estimated average number of workdays lost per malaria episode by productive adults in agrarian households was 16 days for an average of 4 bouts per year which is about 64 days per year (Alaba and Alaba, 2009).

Meanwhile, farmers engaged in intensive vegetable production in Côte d'Ivoire suffering from malaria were absent from work for up to 26 days in a 10-month period or about 31 days per year (Girardin et al., 2004). In rural households of Nigeria, farmers lost an average of 22 days of farm labor to malaria illness in a year (Ajani and Ashagidigbi, 2008). A study of farmers engaged in intensive vegetable production in Côte d'Ivoire showed that, those suffering from malaria produced about half the yields and received half the incomes of healthy farmers (Girardin et al., 2004). Studies reported number of days lost per episode to take care of a child with malaria. These varied from 12 days in Ethiopia, to 5 days in Ghana and 4 days in The Gambia. WHO estimates that an African child has on average between 1.6 and 5.4 episodes of malaria fever each year. Using the average of the two (3.5 episodes), number of lost days per episode was converted to number of lost days per year. (Cropper et al., 1999) in Ethiopia, to 17.5 days in Ghana (Asenso-Okyere and Dzator, 1997) and 14 days in The Gambia (Aikins, 1995). Variations in number of productive days lost to malaria depend on the severity of the malaria episode, a person's general health and nutritional status, proximity to health facilities, and ability to seek healthcare during malaria episodes (Brinkmann and Brinkmann, 1991; Chima et al., 2003; Asenso-Okyere et al., 2009).

TB

A survey in Uganda on subsistence farmers found that, 95% of them reported a decline in production due to reduced capacity to work due to TB (Saunderson, 1995). A study in urban Zambia found that before treatment, about 46% of TB patients and 30% of caregivers were absent from work due to illness, missing an average of 48 days of work in a year. About 31% had to cease work completely (Needham et al., 1998). A study in India looking at rural and urban areas found that, the number of work days lost to TB depended on age, literacy, type of income and region. The average number of work days lost per year was 83 days (82 days for females and 85 days for males), with 48 days before treatment and 35 days during treatment (Rajeswari et al., 1999). Patients in rural areas who were between 15 to 25 years old had the lowest number of mean days lost (61 days) in a year. For those aged 26 to 45 years, about 94 workdays were lost in a year and it was highest for individuals aged 46 or more, at 105 days in a year. In the same study, the

impact on children of tuberculous patients was examined. It was found that about 8% of schoolchildren in rural areas of parents with TB discontinued their studies due to the burden caused by their parent's illness.

Soil-transmitted Helminth infections and schistosomiasis

Schistosomiasis causes chronic illness that can damage internal organs and, in children, impair growth and cognitive development, which can negatively affect their productivity and income earning ability during adulthood. Available literature seems to show that, not all types of diseases have significant negative labor productivity effects. One study in Santa Lucia examined the productivity effects of five parasitic diseases (schistosomiasis, ascariasis, trichuriasis, strongyloidiasis, and hookworm infection) using earnings per week as a measure of productivity and the parasite load as measure of disease morbidity (Baldwin and Weisbrod, 1974). Results show that parasitic infections, except schistosomiasis, appear to cause few statistically significant adverse effects on agricultural labor productivity. A follow-up study three years later still found that, schistosomiasis negatively influences productivity but its estimated impact was lower than the earlier study (a loss of 14% of the daily earnings of male workers) compared to the previous study of 30% (Weisbrod and Helminiak, 1977). Looking at schistosomiasis disease alone, an experimental study of sugarcane workers in an irrigated estate in Tanzania found a significant difference in economic productivity of about 3 to 5% between uninfected and infected schistosomiasis workers (Fenwick and Figenshou, 1971). A study of schistosomiasis in the northern and southern portions of Leyte Province in the Philippines found that, the total days lost per person per year was 45.4 days (Blas et al., 2006).

In southern Ghana, adult male farmers untreated for guinea worm disease were estimated to lose about five weeks of work time per year as reported in the study but we converted to days per year which is 35 days (Belcher et al., 1975), while people infected with the same disease in Nigeria were estimated to lose an average of 117 days (3.9 person months) per year. Research in the Ondo state of Nigeria in 1997, involving 500 cocoa farmers infected with guinea worm, found that on average, a cocoa farmer infected with guinea worm disease lost 19 bags of potential harvest due to disease morbidity, which was valued at about 4,884 naira at that time (about US\$ 64 in present value terms) (Adewale et al., 1997). This would be substantial amount of loss of (9,566 bags) of potential harvest for the 500 farmers worth about 2,442,000 naira at that time (or US\$31,845 in present value terms).

A study in a coffee plantation in southwest Ethiopia also found that, disease has negative labor productivity

effect (Kim et al., 2006). Male workers suffered significant losses in economic productivity (in the form of lower daily wages earned) as a result of onchocercal skin disease (OSD). Specifically, it was found that depending on the severity of OSD (and controlling for such factors as age), daily wages were 10 to 15% lower than workers without OSD (Kim and Hailu, 1997).

HOUSEHOLD ADJUSTMENTS TO ILL-HEALTH

It may not be correct to generalize that all illnesses in a household negatively affect farm labor productivity. Contrary to general assertion, a study in Mexico found that, malaria did not have any effect on farmers' production due to coping processes² in which intra-household labor is reallocated (Conly, 1975). Similarly, research on sugarcane workers in Cameroon found that, due to reallocation of intra-household labor, production was not affected from either malaria or schistosomiasis (Gateff et al., 1971). Another study found a similar effect among female cotton pickers in Sudan, where schistosomiasis did not reduce farm production because healthy family members increased their working hours to compensate for reduced farm production, so as to cope with the reduction of labor productivity (Parker, 1992). Research on the impact of schistosomiasis in rice-growing households in Mali found that, "changes in health have no direct effect on rice production", implying that contraction of schistosomiasis does not incapacitate workers in rice fields (Audibert and Etard, 1998). A Côte d'Ivoire research on coffee and cocoa found that, malaria infection seems to have no effect on coffee and cocoa crops, neither directly through the production nor indirectly, through a coping process such as the resort to hired labor. Authors posed that, this may be due to the fact that coffee and cocoa crops are less labor consuming than rice or cotton crops (Audibert et al., 2009).

As some of the literature has shown, a number of factors can limit the extent to which lost labor time due to illness will reduce farm output, such as the nature of crop and whether the farmer can fully replace lost labor. When family and hired labor are not perfect substitutes or when there are liquidity constraints, it is likely to reduce output (Antle and Pingali, 1994). In cases of temporary disability of a farmer, the household workforce may provide a cushion for the period of absence of the disabled member, limiting the loss of output. For instance, a Sudan study found that, 62% of the loss of work hours in all sectors due to malaria and schistosomiasis was compensated for by family members, and malaria labor hours, lost to agriculture were fully compensated for. Noteworthy though is that, the study found withdrawal of labor by men was primarily replaced by women and children, who

had to put in 20% more time than was lost to reach the same output (Nur and Mahran, 1988). This put an extraburden on women who are already commonly responsible for other household tasks. Furthermore, the involvement of children in farming activities may disrupt their development or contribute to child labor. Child labor is defined as any work performed by a person below 18 years of age, which deprives the person of the basic human rights, and is abusive, hazardous, exploitative, and harmful to the health, safety, morals, and total development of the child. It must be noted that depriving children of their education in order to work is child labor and it is in contravention of the International Labor Organization (ILO) Convention 138 and 182. Moreover, even if labor hours lost to agriculture can be completely compensated for, there may be costs associated with labor substitution (opportunity cost), depending on the value of the activities from which the substituting labor is withdrawn (Over et al., 1992).

While illness can affect a farmer's/agricultural worker's performance, studies have pointed out that, variations in number of productive days lost due to different diseases can be affected by a person's age, gender, general health and nutritional status, and ability to seek health-care. While labor is lost due to sickness, the cumulative results of impact studies caution against unwarranted generalizations on the effect of morbidity on agricultural production. A better understanding about interactions and responses will shed light on how context-specific many of them are. Although, morbidity may not automatically affect household agricultural production, future agricultural output of households and nutrition of members may be negatively affected given regressive cost burdens that chronic and long-term illnesses such as TB and AIDS impose, particularly on poor agricultural households.

When illness of a productive household member results in death, this leads to a permanent loss of one source of labor in the farm household. In Mozambique, it was found that death of a household head increased the likelihood of the use of child labor (Mather et al., 2004). In Zambia, increased involvement of children in farming activities in households with an AIDS death was observed (FASAZ/FAO, 2003). A household death further affects labor availability as healthy individuals divert their time and energy from the farm to mourn and attend to the funeral and related matters. All these have an impact on agricultural production. In some patrilineal societies in Eastern and Southern Africa, women lose their farming lands when their husbands die (Drimie, 2003; Aliber and Walker, 2006). In households, the death of an adult household member leads to loss of indigenous knowledge and experience which are usually not recorded.

When a household member gets sick, arrangements are made to take care of the person and this may further aggravate the household labor situation. In Northern Zambia, AIDS-affected households, particularly those headed by women, reduced the total area under cultivation due to labor shortages (FAO, 2003). In

² The coping process is the process by which the household succeeds in compensating for the loss of family worker productivity due to ill health.

Tanzania, women spent 60% less time on farming activities taking care of their husbands suffering from AIDS (Rugalema, 1998). In Ethiopia, women were found to spend about 100 h a week which is equivalent to about 4 days nursing AIDS-affected household members, largely at the expense of their children and their farms (ILO, 2000). This care giving burden can also affect technology adoption, largely because of lack of labor for farm activities. In the Tigray region of Ethiopia, the opportunity costs of caring for sick family members significantly affect adoption of productivity-enhancing technologies (Ersado et al., 2003). Often children are withdrawn from schools for varying periods to help with care giving or household chores (especially girls).

Beyond the direct impacts due to loss of labor, illness undermines long-term agricultural productivity in a number of ways: when illness leads to long-term incapacitation, households may respond through withdrawal of savings, the sale of important assets (such as jewelry, textiles, breeding animals, farm equipment, and land), withdrawing children from school, or reducing the nutritional value of their food consumption. All of these responses can have adverse effects on the long-term labor productivity of household members.

GLOBAL EFFORTS TO CONTROL DISEASE

Global efforts have been intensified to combat HIV/AIDS, malaria and other diseases especially after the United Nation's summit of 2000. The Millennium Declaration in 2000 was a milestone in international cooperation, inspiring development efforts that have improved the lives of hundreds of millions of people around the world (United Nations, 2010). The UN's 2010 Millennium Development Goals report indicate that, the spread of HIV appears to have stabilized in most regions, and more people are surviving longer. Similarly, the global burden of tuberculosis is falling slowly - incidence fell to 139 cases per 100,000 people in 2008, after peaking in 2004 at 143 cases per 100,000. The report also indicated there has been a major increase in funding and attention to malaria. For example, external funding dispersed to malaria-endemic countries rose from less than \$0.1 billion in 2003 to \$1.5 billion in 2009.

Consequently, the production and distribution of insecticide-treated mosquito nets has greatly increased, resulting in a larger number of households owning at least one insecticide-treated mosquito net. As a result, more than a third of the 108 countries at risk of malaria (nine of them African and 29 non-African) documented reductions in malaria cases of over 50% in 2008, compared to 2000 (United Nations, 2010). These global efforts to control diseases are believed to have contributed directly or indirectly to the growth of agricultural productivity, either through the improvement of health of farm labor or by freeing household resources for food, agricultural inputs, and other needs of the household that

would have been spent on health care otherwise. Improved health care is helping to slow down the relentless pace of the AIDS epidemic, particularly with the advent of ARVs. "HIV was a death sentence and is now a manageable chronic disease like diabetes or high blood pressure", says Dr. Templeman of AgriAids (www.agriAids.org.za).

"There is light at the end of the tunnel, if there is continued investment of resources in disease control," said Gabriel Rugalema, senior officer for HIV/AIDS at FAO. "Levels of HIV infections have stabilized and are actually falling in many countries. Incidences of malaria are falling worldwide, even in countries where it is endemic such as The Gambia."

A 2009 report from WHO says that, the percentage of the global population falling ill to TB is dropping annually, though growth in drug-resistance from the parasite presents a major challenge (CTA, 2009). Reports from the International Scientific Council for Trypanosomiasis Research and Control (ISCTRC)³ indicate that, Africa is winning its battle against sleeping sickness. Aerial spraying and localized use of insecticide has eradicated the tsetse fly that carries the *Trypanosome brucei gambiense* and *Trypanosome brucei rhodiense* from 36,000 km² of land across Angola, Botswana, Namibia, and Zambia (CTA, 2009).

In an effort to increase access to malaria services and attain the Millennium Development Goal of combating malaria and other diseases by 2015, Africa is making dramatic progress in tackling malaria from different angles. For instance, infection rates in Zambia, more than halved from 2001 to 2008, due to widespread distribution of mosquito nets, targeted spraying of insecticides and better and cheaper diagnosis and treatment, said Rob Newman, director of the WHO Global Malaria Program (The Daily Monitor, 2010).

According to Newman, eight African countries have halved their infection rates in the last decade: Eritrea, Rwanda, Botswana, Namibia, South Africa, Swaziland, Cape Verde, and Sao Tome. There are programs in their infancy in much bigger countries like Democratic Republic of Congo and Nigeria. About 74% of African nations have waived taxes on anti-malaria drugs, 64% have removed taxes on insecticide-treated mosquito nets, while about half have waived taxes and tariffs on nets, netting materials and insecticide (The Daily Monitor, 2010).

The African Leaders Malaria Alliance (ALMA) views malaria as a ferocious public enemy, that must be fought until it is eliminated. They have resolved to do that through universal average coverage with indoor residual spraying, long-lasting insecticide-treated nets, rapid diagnostic tests, and artemisinin combination therapy (ACT) (The Daily Monitor, 2010). The University of California San Francisco (UCSF) health experts have outlined a three-part strategy and action plan to eliminate

³ www.au-ibar.org/isctrc.html

malaria from the world⁴. The strategy includes aggressive control on the hardest hit areas, progressive elimination on areas where it has already been reduced, and research and development of new interventions and technologies as tools in the effort. All these initiatives pinpoint to a reduction in malaria prevalence in Africa.

It is heartwarming to know that, the use of derivatives of artemisinin (extract of the ancient medicinal plant *A. annua*) combined with other drugs (artemisinin-based combination therapies – ACTs) have shown good efficiency in parasite resistance. This has led to efforts to increase cultivated production of Artemisinin in the short run and to develop, through biological and chemical research, synthetic substitutes in the long run (Dalrymple, 2009). Scientists are developing a biological control method for malaria that uses larvae-eating fish to control mosquito populations in rain-fed pools. Tanzania's Tropical Pesticide Research Institute is working with the US-based Poseidon Science Foundation, to investigate the best way to mass produce and distribute the fish embryos for use in the areas where malaria is endemic (CTA, 2009).

Avian influenza has generally been dealt with by culling birds, but health authorities are now trying to look up the supply chain to identify possible sources of infection; according to David Nabarro, the United Nations senior coordinator for avian and pandemic flu. "We are finding that, if we have a much clearer understanding of the patterns of movement of the virus, and in particular build-up points, we can then do much more sophisticated control strategies that have less economic damage for poorer people and more impact", said Nabarro (The Daily Monitor, 2010).

The good news is that, scientists at the African Agricultural Technology Foundation, Kenya and the United States Department of Agriculture, and International Institute for Tropical Agriculture have collaboratively demonstrated the ability of a natural fungus (atoxigenic strains) found in Nigeria, to significantly reduce concentration of aflatoxins in maize (Rural21, 2009). This biological control strategy offers a viable option for mitigating the negative effects of aflatoxins on human health. It is suggested that, the strategy of using food additives to protect farm animals from aflatoxin, may also provide effective and economical new approaches to protecting human populations (Williams et al., 2004).

CONCLUSION

This paper reviewed the various ways in which farming, especially farm labor productivity, and health and nutrition are linked, and also looked at the global efforts to control diseases. Poor farm households tend to be vulnerable to malnutrition and poor health, and poor health reduces

agricultural productivity. Farming systems also interact with the environment, and by so doing affect human health. On the other hand, farming produces foods, fibers, and plants with medicinal properties essential for human life and health. Based on the different studies reviewed, the general conclusion is that, poor health (defined broadly in terms of nutritional and health status) has significant impacts on farm labor productivity.

The issue of farm labor productivity cannot be over-emphasized now with increasing population, rising incomes and expanding urbanization, demand for food keeps increasing and so supply should also increase to eliminate hunger and malnutrition from the world. However, it is predicted that yields from rain-fed agriculture in some countries could be reduced substantially due to climate change. It is also predicted that, long-term climate changes such as, more pronounced El Niño cycles and global warming (Sachs and Melaney, 2002) are likely to affect distribution patterns of infectious diseases; for instance, there is likely to be an increase in mosquitoes which will increase the spread of malaria, dengue and yellow fever.

Therefore, serious attention has to be paid to factors that affect farm labor productivity including nutrition and health. At the same time, the burden of disease can be lowered if the incidence of disease is reduced with carefully planned agricultural development programs that do not produce negative externalities for the health sector. There is the need for further studies on a broader and more systematic approach to understanding the interaction between health and nutrition, on the one hand, and farm labor productivity, on the other. The ensuing knowledge can be used or adopted for the formulation and design of health and nutrition, and agricultural sector policies and programs.

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⁴ Source: The Lancet, November 5, 2010 issue (UCSF's First Bay Area Global Health Summit Stimulates, Solidifies Ideas, By Kate Darby Rauch)

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