Health, livelihoods, and nutrition in low-income rural systems

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Abstract

Background. *Absolute poverty remains a major challenge: the proportion of the world population living with hunger, food insecurity, and undernutrition has fallen, but the absolute number remains stubbornly large. An even larger number of people have enough to eat but suffer from severe micronutrient deficiencies.*

Objectives. *To provide a conceptual framework showing the interdependence of hunger and poverty with ill health among the rural poor.*

Methods. *Review of the relevant health, nutrition, agriculture, and economics literature and organization of the findings into a systems framework.*

Results. *Economic growth is not a sufficient answer to rural poverty. The predicament of poor households can be represented in terms of a self-reinforcing cycle involving nutrition, health, and productivity. The degree of poverty limits the quantity and quality of food intake. Macro- and micronutrient deficiencies interfere with child growth and development and impair immune function, resulting in a predisposition to infectious diseases. Health status strongly influences the quantity and quality of labor and achieved educational status. The high risk of child mortality prevents households from going through the demographic transition to smaller families and better-educated children. The death of a working adult may be catastrophic for the household. This self-reinforcing cycle means that the beneficial effects of an intervention are propagated around the cycle, potentiating its impact. Each main element—nutrition, health, and productivity—also has numerous other determinants and can be influenced by interventions. Interventions that increase the carrying capacity of the household's environment are likely to be more sustainable than "technical fixes," such as lifesaving medical treatment.*

Conclusions. *The self-reinforcing cycle is likely to be self-perpetuating without outside intervention. For any rural area where poverty reduction is planned, the key bottlenecks need to be identified. This can be done by using a causal diagram, as described in this paper.*

Key words: Poverty, rural, health, livelihoods, nutrition, micronutrients

Objectives

The purpose of this paper is to provide a conceptual framework showing the interdependence of health, nutrition, and poverty with economic (especially labor) productivity among the rural poor, including landless residents, whether their livelihoods are derived primarily from agriculture, pastoralism, fishing, or hunting and gathering. Despite their many differences (e.g., degree of poverty, type of land tenure, cultural features), the focus is on the shared predicament of impoverished rural dwellers as a group. The paper uses a systems approach to highlight the self-reinforcing nature of the linkages and to emphasize the interconnections among the key elements [1–4]. This means departing from the usual focus on a single endpoint (e.g., health or economic growth) as explicitly or implicitly a criterion or ethical position [5]. The paper does not attempt to quantify the interconnections and impacts, since in the present state of knowledge, only some of the topics can be quantified with any reasonable degree of confidence; to privilege these would unduly assign the others a lower status. Throughout, the term "health" is used in an inclusive sense, as in health impact assessment (HIA), going beyond the biomedical model, individual behaviors, and health-care interventions to encompass upstream influences on health status (the "determinants of determinants"), as well as "positive" health, including physical functioning

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and psychological well-being [6, 7]. The conceptual framework is intended to be not only an abstract organizing schema, but also a representation of the experience of low-income households—their stories would be traced by pathways in the systems diagrams.

The paper first sets out the relationships among elements of a core nexus: health, nutrition, and economic productivity. It then outlines some of the crosscutting determinants of these elements affecting the whole system, followed by some suggested interventions to help turn the self-reinforcing cycle from a vicious cycle to a virtuous cycle.

The core nexus: Health, nutrition, and economic productivity

The starting point of the conceptual framework is the observation that health status, nutritional intake, and economic productivity are linked in a self-reinforcing cycle (**fig. 1**). Health status affects labor productivity, labor productivity affects nutritional intake, and nutritional intake affects health status. These are the three core elements.

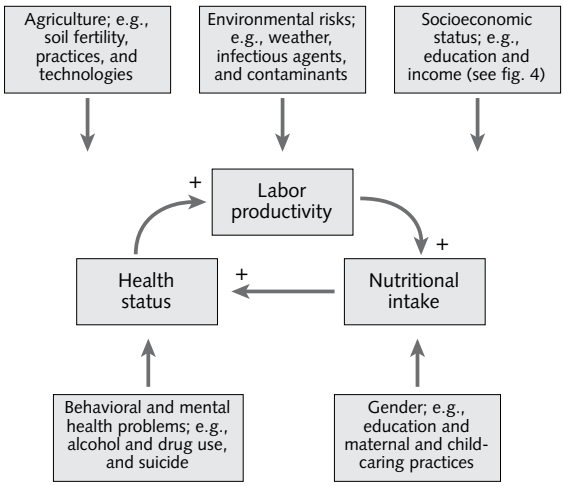

FIG. 1. The core nexus and crosscutting determinants

Health status affects labor productivity

The impacts of health status on labor productivity are depicted in **figure 2**. Low strength and energy reduce the intensity of labor, and impaired infant growth and neurodevelopment interfere with the future intensity and quality of labor [8]. Many infections and infestations, such as tuberculosis and malaria, are debilitating and seriously impair work capacity. Ill health also interferes with schooling and reduces labor time, and sick people require others to care for them, together reducing the educational level and quantity of labor; in

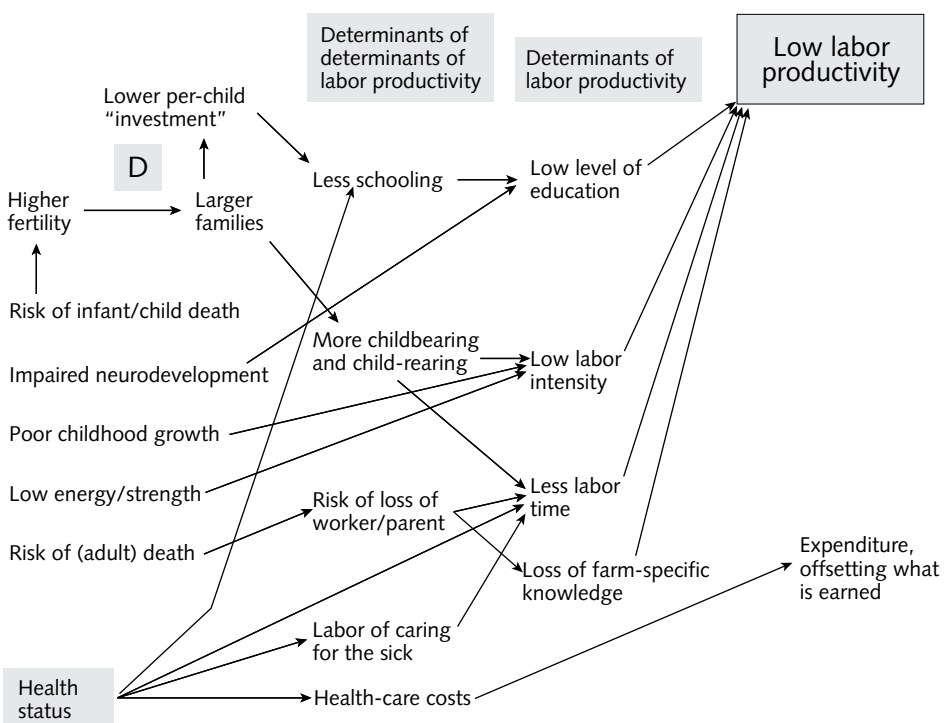

FIG. 2. The importance of health to labor (economic) productivity. D indicates the demographic transition

addition, health-care costs can drain scarce household income [9]. A high death rate among children prevents the demographic transition (indicated by "D" in **fig. 2**), encouraging families to be large in order to provide additional labor plus social security in old age, but thereby perpetuating child labor and low educational levels while increasing mothers' domestic labor [2, 10]. In the longer term, this increases the population size, so that the same carrying capacity (land and other resources) is spread more thinly. The risk of death of a working adult is translated into risk of dramatic and possibly catastrophic loss of household working capacity, with a likely downward spiral ensuing. This has become all too familiar in the HIV/AIDS epidemic [11], but it also holds true more generally.

Labor productivity affects nutritional status

Labor productivity represents the labor time and resources needed for producing household food needs and also for carrying out other nonagricultural and nonfood-related tasks [12]. Greater labor productivity means that more food—and other household goods—can be produced. Labor productivity can also affect household decisions about the types of foods produced, e.g., households may decide against producing some types of crops which are more labor-intensive. Labor productivity thus determines the quantity and types of foods, as well as nonfood items available for the household, and therefore is a determinant of the nutritional status of household members.

Nutritional intake affects health status

Some of the main health impacts of a poor nutritional intake, and consequent macronutrient and/or micronutrient deficiency, are shown in **figure 3**. The fetal period (maternal malnutrition) [13, 14] and early childhood [15] are the periods most sensitive to nutrient deficiencies. Infants are highly vulnerable during the weaning period, especially as weaning foods may have low nutritive value [16]. A particularly important outcome is impaired immune function, which leads to increased incidence and severity of infectious diseases such as pneumonia, diarrhea, and malaria [13, 17]. Malnutrition is known to increase the severity of infections such as malaria [18], tuberculosis [19], and HIV [20].

Micronutrient deficiency is directly linked with poor health status. Iron deficiency causes a large share of maternal deaths; impairs fetal and child growth, immunity, and cognitive development; and causes fatigue in children and adults [21]. Iron-deficiency anemia affects more than half of all pregnant women and at least one-third of children under 5 years of age. Vitamin A deficiency impairs children's growth, immunity, development, and vision and affects almost one-third of children [22]. Zinc deficiency contributes to child morbidity and mortality through increased infections [23]. Sufficient iodine is crucial to fetal brain growth [24].

Nutritional intake is also important because a combination of excessive energy intake (relative to physical activity) and low nutrient density predisposes to several chronic diseases, including type 2 diabetes, ischemic heart disease, and many cancers (**fig. 3**). The increased prevalence of these poor-quality diets—known as

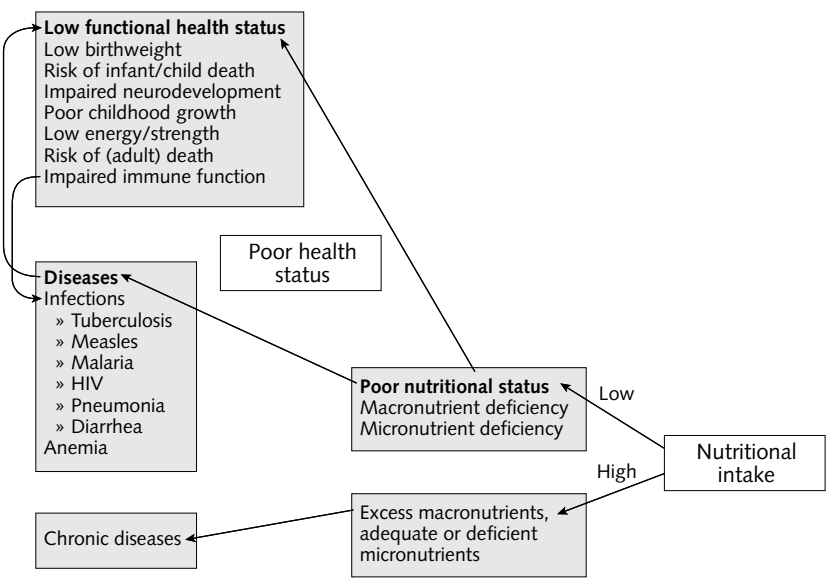

FIG. 3. Health impacts of impaired nutritional intake

the "nutrition transition" or "epidemiological transition"—is harmful, and their impact is becoming manifest throughout the developing world, even among low-income populations [25].

Crosscutting issues affecting the whole system

The presence of several factors in rural settings affects each of the core elements in different ways, affecting the system as a whole (see **fig. 1**).

Agriculture. The quantity of available land, soil fertility, climate and weather, and a huge variety of practices and technologies all influence agricultural productivity. Agricultural productivity is in turn an important determinant of nutritional status in rural settings. Nutritional intake is influenced by crop availability and knowledge as well as by economic level [26]. Increased productivity leads to lower prices, benefiting poor consumers (including urban ones), and usually but not invariably boosts poor producers' revenue [27]. Agricultural labor also carries important occupational health risks among the rural poor. Farmers are at particular risk for injury and for illnesses resulting from zoonoses (infections from animals), such as avian influenza, and from chemicals, such as pesticides. Other rural occupations, such as fishing and nomadic pastoralism, also have specific high risks.

Environmental risk. Poor people are particularly exposed to environmental risks and have few resources to cope with them. The risks include adverse weather conditions (e.g., failure of rainfall); natural disasters; crop and food destruction (e.g., by locusts, rats, or fungi); violence, including conflicts, raids on animals, etc.; diseases of crops or livestock, which are especially grave for people who are reliant on one strain of one crop; and human diseases and their costs. Fungal contamination of stored foods in hot, humid conditions may impair immune development and growth as a result of aflatoxin [28, 29]. Future threats include loss of biodiversity, soil depletion, water shortage, erosion and desertification, and deforestation. Pressure on land and water is likely to increase due to population growth, and to higher demand for meat and consequent intensive livestock production [30]. Global climate change is predicted to decrease rainfall in semiarid rain-dependent parts of sub-Saharan Africa and cause flooding of low-lying areas, such as much of Bangladesh.

Socioeconomic status. Low socioeconomic status affects the interplay of the whole system, but particularly affects labor productivity. These effects are depicted in **figure 4**. Education, income, poor labor conditions, and the use of polluting fuels are all important. The psychosocial impacts of social hierarchies also need to be considered: a large body of evidence from developed societies suggests that low social status impairs health [31]. This is likely to apply at least as strongly in low-income situations. Education is a major pathway from health to productivity and from socioeconomic status to health (**figs. 2** and **4**), and also affects the demographic transition. It has an important role in nutrition, both in raising the acceptability of micronutrient-dense foods and, especially, in improv-

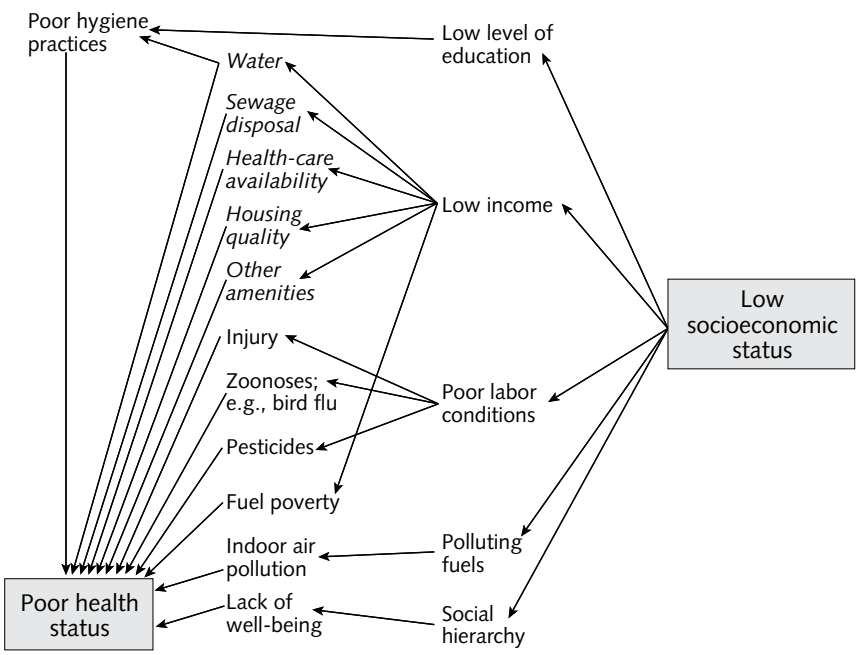

FIG. 4. Health impacts of low socioeconomic status

ing infant-feeding practices (**fig. 5**). Like health, education is part of a self-reinforcing cycle with economic productivity—both are aspects of human capital, with health being more dominant at subsistence level than it is when living standards improve.

Gender. Women have a key role in family health and nutrition, through maternal and child-caring practices such as infant feeding. They often have a major role in agriculture too (especially in sub-Saharan Africa), and they are less prone to leak resources (e.g., by gambling). Time pressure in low-productivity situations may leave insufficient time for hygiene behaviors and for interaction with children. Women are central to the demographic transition, with its promise of fewer children who are healthier and better educated; in some regions this route is blocked by patriarchal domination. It is now generally recognized that female education can play a key role in all these issues and in relation to women's own health. When women have insecure livelihoods, they may resort to commercial sex, with high risks of unwanted pregnancy, HIV, and other consequences [11].

Behavioral and mental health problems. Mental health problems are as frequent among the poor as among anyone else, probably more so given the additional stress [32], and this may be manifest as alcohol and drug use, gambling, crime, etc. In addition, low-income farmers are at high risk for suicide as well as for unemployment. Temporary or permanent escape by migration carries its own risks, such as increased exposure to HIV [11].

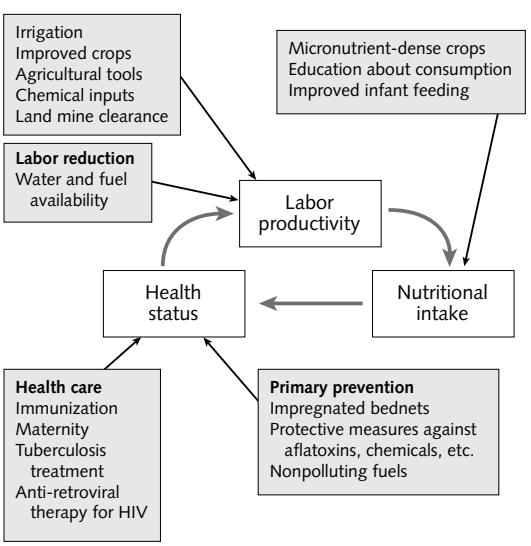

FIG. 5. Examples of interventions

Interventions to promote propagated benefits

Implementing interventions in a self-reinforcing cycle

Health, nutrition, and labor productivity are here shown to be linked in a self-reinforcing cycle, all affected by a range of crosscutting determinants. Such a cycle is an example of positive feedback (see **box 1**) [33]. A disaster in one area of life, such as the fatal illness of a principal worker, is followed by a vicious cycle: a drop in household production and hence a danger of starvation and consequent illness in the surviving household members, and so on. A rather different example is seen in crisis selling; for example, after the recent plague of locusts in the Sahel, starving families were forced to sell their herd animals, but because many were in this position, the prices fell sharply (in terms of economics, this is a backward-sloping supply curve). Similarly, it is common to find that needy people are forced to damage the environment on which they depend, for example, to find fuel where there is a risk of deforestation [4].

Interventions can be implemented to take advantage of the positive feedback loop to create a virtuous cycle. Because of the self-reinforcing nature of the cycle, the effects of a positive intervention are enhanced by being propagated beyond the element where it has its primary influence, with the result that its cumulative

BOX 1. Feedback processes

Feedback occurs when two factors influence each other, e.g., *x affects y* and *y affects x*, or more generally when causal processes operate in a loop, e.g., *x affects y*, *y affects z* and *z affects x* [33].

Positive feedback. Suppose x affects y in a positive direction (more x leads to more y), and y affects x, also in a positive direction (more y leads to more x). This is called positive feedback, and its effect is to amplify whatever is happening in the system, as in the escalation of an arms race. In the case of an intervention, positive feedback amplifies its effects, as in the core nexus of figures 1 and 5. It is important to realize that positive feedback can be harmful or beneficial in its effects—both vicious cycles and virtuous cycles are examples of positive feedback loops.

Negative feedback. Suppose x affects y in a positive direction (more x leads to more y), but y affects x in a negative direction (more y leads to less x). This is called negative feedback, and its effect is to counteract and oppose change. Control systems that aim at stability, such as thermostats, are negative feedback systems. With interventions, negative feedback tends to lessen the effect of the intervention so that there is resistance to change. For example, with expanded production of a crop, the price falls, reducing the achievable revenue.

effectiveness can be far greater than its immediate impact. Positive feedback thus amplifies the effects of intervention.

Interventions also need to consider trade-offs. A fundamental trade-off relates to the demographic transition: although it is desirable to reduce family size and child labor and to increase educational participation, these changes have short-term negative effects on precarious household subsistence. A more technical type of trade-off is found with irrigation schemes and land-clearing for agricultural use, which may increase the incidence of vector-borne diseases, including schistosomiasis (bilharzia) and malaria [34]. Another example is road-building, which is widely recommended for its positive effects on development and access to markets [4]. But roads have health drawbacks that are less often recognized, including indirect effects on risky sexual behavior and crime [35], as well as direct effects on injuries and deaths [36].

Thus, what is needed are positive interventions that take account of feedback processes and trade-offs. Each core element can be influenced by many different types of intervention, with the potential for propagated effects around the loop (**fig. 5**). Some interventions act directly on more than one locus; for example, land-mine clearance reduces injury and also allows agriculture in cleared fields. Further examples of different types of interventions are given below and depicted in **figure 5**.

A corollary of the focus on the core nexus is that it directs attention to particular issues and age groups. Obvious ones include maternal and child health and biological and educational development during childhood, but perhaps less well-recognized is the importance of a focus on youth. It is at this life-stage that choices are formed that affect, for example, sexual behavior, family formation, future livelihood, and possible migration, all of which have far-reaching consequences.

Health care interventions

Health care is clearly an important intervention, not only to save lives and directly relieve suffering, but also to improve nutrient absorption (e.g., by treating hookworm and ascariasis) and raise energy levels by treating malaria, HIV, and other diseases (and thus raising productivity). A great deal is now known about the effectiveness of health-care interventions [37–40]. However, in the absence of such propagated benefits, the value of medical treatment is limited if the patient is returning to conditions that foster ill health.

Preventing illness is clearly better, not least because it means reducing the labor time lost to caring for the sick. Health care has an important role in prevention through immunization, e.g., against measles and polio. Apart from this, however, disease prevention requires strengthening host resistance and/or removing the causal agent. Health care has a limited role here. Even more important, saving lives by medical means (or other "technical fixes") may put additional stress on the available resources by dividing the household's wealth among more descendants, whereas this is not a problem if disease is prevented by agricultural or other means that increase the carrying capacity of the local environment.

Nutritional interventions

Micronutrient interventions include fortification, which is appropriate in some circumstances, and supplementation, although this consumes scarce health-care resources [41]. Food-based approaches to improving nutrition through the agricultural production of staple and nonstaple crops are an alternative [42, 43]. Examples include introduction of green leafy vegetables and vitamin A–rich varieties of sweet potato [44]. Where possible, the introduction of animal-source foods (meat, milk, or eggs) where they were previously lacking [45, 46] or of aquaculture (especially of small fish eaten whole)[47] can sharply increase the intakes of micronutrients such as vitamin A, iron, zinc, and calcium.

Education in infant-feeding practices, weaning foods, and consumption choices for children and adults is also important for nutritional status, as is education on allocating time for and improving the quality of child care [48].

Agricultural interventions

Agricultural interventions that directly improve productivity are beneficial as long as they do not concentrate land ownership or glut the market to cause a price collapse. Numerous such interventions are possible (**fig. 5**) [49], including a wide range of improved agricultural methods and pro-poor agrotechnology. Since the major gains from the Green Revolution were among staples at the expense of other foods [50], the extension of such improvements to micronutrient-rich foods would have major health benefits, either through marketing [51] or own consumption [52]. Large gains can be achieved by economies of scale, such as shared machinery or marketing, if the social organization is appropriate and can be sustained, avoiding elite capture and social exclusion.

Providing access to agricultural markets can also be a positive intervention for a self-sustaining process of improvement: as their production increases, the poor develop sufficient buying power to enter markets as consumers as well as producers, including as nonagricultural rural producers, and to add value locally rather than leaving it to downstream processors. However, this is a consequence, not a means. For

the rural poor to have security in trading, they need a reasonable degree of reliability. Governments often favor cash crops because they generate employment, foreign exchange, and taxes, but this does not mean they are necessarily pro-poor. Markets are more likely to be reliable if they are local or regional and/or are for crops with dependable demand, whereas long-distance trading of nonessentials is prone to catastrophic failure, as was illustrated all too graphically in the coffee price crash [53]. If poor or small farmers are pitted against large companies, such as international traders or supermarkets, their bargaining position is weak (although Fair Trade can mitigate this). The health and safety regulations of rich countries also favor large companies. Cash crops may involve displacement of people [4], and this merely adds to the number of dispossessed. Access to markets may mean exposure to lower-priced produce from elsewhere; this may be especially severe if there is competition from crops sold cheaply because of developed-country subsidies [54]. More generally, markets, especially those involving high levels of risk, create some losers, meaning that overall production may improve but some subpopulations will be excluded from prosperity [55]. Thus, market access, often regarded as wholly beneficial [2, 49], does not universally lead to prosperity.

Another approach is to increase biodiversity rather than depending on single crops and varieties, spreading and thereby reducing the risk of crop failure. It can also contribute to higher intakes of micronutrients and foods with beneficial functional properties, such as omega-3 fats and lycopene [56]. Ecological forms of agriculture also provide benefits. For example, agroforestry can provide fruits, berries, and leaves for human and animal consumption, wood for fuel and building, ecological benefits, and income [57]. Environmentally sound water management practices are important, such as trapping of rainwater in rain-dependent regions, avoidance of water-associated diseases such as malaria [58], and production of fish by aquaculture [47].

Environmental and socioeconomic interventions

Economic growth does not necessarily address the problem of poverty [4, 59], and neither does trade [55]. Specific interventions that take into account socioeconomic inequalities are needed (**fig. 4**). Provision of clean water and sewage disposal, and promotion of good hygiene practices, greatly reduce the gastrointestinal diseases that cause so much preventable illness and death, especially among children [34]. Insecticide-impregnated bednets are highly effective against the spread of malaria [60]. Acute lower respiratory infection (pneumonia), a major cause of illness and death, particularly among infants, is largely attributable to fine particles in indoor air resulting from the use of polluting fuels, and it can be greatly reduced by introducing cleaner stoves [61]. Improved housing quality has broad health benefits and is especially valuable for preventing certain specific conditions, such as Chagas' disease [62]. In societies with grossly unequal land tenure, redistributive land reform would improve the welfare of those with low incomes [10]. Microfinance can allow poor people (especially women) to invest in innovations that they themselves choose. Making water and fuel more accessible reduces the labor time (often of children) required to fetch them, as well as having direct health benefits. Wider benefits to the rural population may result from addressing energy needs and costs, for example, by providing access to electricity generated from biofuels from crop wastes or marginal land or from solar power, and by providing access to technology such as mobile phones and computers.

Conclusions

Implementing interventions to reduce poverty among the rural poor requires good information on the effectiveness and, more broadly on the positive and negative, and intended and unintended, impacts of interventions. It is especially important to learn from those that have been effectively pro-poor [63]. Formal evaluation, such as detailed survey-based investigation, is difficult and expensive [64], but interest in randomized interventions is increasing [65]. There is creative tension between the need for rigorous quantification and the need to take account of important but nonquantifiable understanding. Similarly, many important factors are locally specific, and there is creative tension between seeking generalizable interventions and recognizing local specificities. It is necessary to consider trade-offs as above, starting with the basic trade-off comparing the beneficial impacts of an intervention with its costs in money and other resources [66].

It is particularly vital not to ignore health impacts when considering interventions. Yet institutional segregation has tended to mean that consideration of health has been neglected in rural development in general, although in some cases, health impact assessment (HIA) has been used and mitigation has been possible [67]. There is a need for mainstreaming of health in development planning, just as there is with environmental concerns. Project-based HIAs [35, 67] can be helpful in flagging issues that would otherwise be missed, but it is impractical to perform these for every proposal. In any case, the same issues would tend to recur each time, so that a more efficient approach would be to develop a strategic health assessment (SHA)[68], including quantification where appropriate and possible, that would inform policy at the strategic level.

In the context of absolute poverty, because health is a determinant of the other elements as well as an

outcome, health assessment, whether at the HIA or the SHA level, could be integrated into its broader context using the diagrammatic method presented here. Causal diagrams showing the core nexus and the determinants of its three elements, plus possible interventions, could be developed at the appropriate spatial scale, in collaboration with local communities. This would have the advantage that key bottlenecks could be identified as priorities for intervention on the grounds that they would lead to propagated benefits around the core nexus. It would be immaterial whether they were agricultural, nutritional, health-care, economic, or some other type of intervention, as long as the overall impact would be to foster a virtuous cycle. For example, a health-care initiative would be favored if it led to an increase in carrying capacity (e.g., higher productivity) as well as having direct health benefits. This approach would have the advantage of efficiency compared with expensive multiple-intervention projects [64, 69], which are difficult to implement on a sufficiently wide scale in relation to the size of the problem.

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