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NUTRITION AND AGRICULTURAL DEVELOPMENT

Significance and Potential for the Tropics

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Nevin S. Scrimshaw

Massachusetts Institute of Technology

and

Moisés Béhar

World Health Organization

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The Environment of the Malnourished Child

Leonardo J. Mata

Instituto de Investigación en Salud
University of Costa Rica
Costa Rica

Patterns of interdependence between man and his environment have differed over time. Man first began to intervene in his environment by organized hunting for food and later he began to domesticate animals and plants. Sedentary societies grew with time, decimating wildlife, destroying or endangering primary forests, and inducing significant soil erosion. Metal craftmanship, the development of complex methods of warfare, and growth of industry and sophisticated technology have led to modern patterns of life in advanced societies. Some of these patterns are now being questioned because, through exploitation of the environment, man is compromising his own survival.

Most of the world's population has lagged behind this process of social evolution, and still subsists on traditional agriculture, using rudimentary technology. Such populations are controlled by governments based in urban areas that enjoy a greater degree of development and hold most of the wealth and political power.

THE ENVIRONMENT OF THE MALNOURISHED MAN

Figure 1 illustrates the present status of the world in relation to famine. Bangladesh, India, and parts of equatorial Africa and of Brazil are experiencing a severe food shortage. Other regions of Africa, Asia, and Latin America face prospective famines. The figure, however, was not intended to illustrate the present food crisis but to point out that the affected areas are in the tropics and subtropics, where environmental forces act more strongly and negatively on man, to decrease and often frustrate the effectiveness of his efforts.

FIG. 1. World map, 1974, showing areas of famine (shaded) and of potential famine (lines).

Environmental factors can be classified as *physical*, *biological*, and *social*, with a realization that they are closely interdependent and often inseparable from each other. The physical environment includes soil, water, and air. The biological environment includes the viruses, bacteria, and parasites, many of which cause disease and death in man or in the plants and animals on which he depends. The social environment comprises socioeconomic characteristics that result from societal evolution of traditions, beliefs, and forms of social organization.

THE PHYSICAL ENVIRONMENT

In the tropics and subtropics, compared to temperate zones, man is at some disadvantage. In the tropics, steady high temperatures, humidity, rainfall or drought, erosion, and occasional natural disasters are considered deterrents to progress. Such environments diminish the working capacity and creativity of unprotected man (1). They pose greater demands on human body water and electrolytes, and may be a source of nitrogen loss (10). More importantly, tropical environments favor the vectors of blood and tissue parasites and maintenance of the cycles of hookworm, trematodes, and jungle virus infections. In many areas the climate promotes growth of weeds, insects, and fungi detrimental to food crops.

In the tropics Amerindian civilizations remained at a low level of technological development. The arriving Europeans succeeded in improving yields of cash crops and moved some people from subsistence agriculture to large land holdings. The resulting profound changes in social and family life cannot be denied, nor their effects on the economy, health, and welfare of society (14). The important consideration is that populations still living on subsistence agriculture are characteristically poor. Poverty favors deficient sanitation and poor diets, leading to a high incidence of nutritional and infectious disease, and death.

THE BIOLOGICAL ENVIRONMENT

Man living in the tropics is also at greater risk of developing endemic infectious diseases. Some of these infections may affect the human being from gestation onward. The results presented here were derived from long-term prospective observations in a typical village of Guatemala (7,9). A high incidence of infectious disease was recorded among pregnant women in this village: 27 of 100 pregnancies were complicated by bacteriologically confirmed urinary tract infection, an affliction associated with premature birth and low-birth-weight infants (Table I). Furthermore, diarrhea and dysentery appeared in 36 of 100 pregnancies, and lower respiratory disease was present in 30% of the pregnant

Table I. In- dence of Infectious Diseases in 82 Women Observed Prospectively luring Pregnancy, Santa María Cauqué, 1972–1973

	Respiratory infection		Diarrhea and	Urinary tract bacterial infection	
	upper	lower	dysentery	(> 10⁵/ml)	Other illnesses[a]
Incidence per 100 pregnancies	104 (127%)	25 (30%)	29 (36%)	22 (27%)	20 (25%)

[a]Conjunctivitis, otitis media, stomatitis, skin infection.

females. Deterioration of maternal nutrition during pregnancy because of infection must also affect the developing embryo (15).

Under these circumstances the fetus has greater opportunity to become exposed to infectious agents, or to antigenic components or immunoglobulins synthesized by the mother in the course of her disease. The study of femoral vein blood collected from infants within three to four days after birth revealed 15% of consecutive newborns from four lowland Guatemalan villages with elevated IgM levels (0.19 mg/ml) (Table II), an incidence in excess of occurrence in industrial societies (5). The high rates of elevated IgM values have not yet been explained, but presumably some of these represent congenital infection. In a preliminary study in one Indian village, 1% of the infants were congenitally infected with cytomegalovirus and 1.3% with *Toxoplasma,* while 1.3% were shedding echoviruses at birth (9). The possible consequence of increased risk of fetal antigenic stimulation and congenital infection deserves scrutiny. Intra-

Table II. Incidence of Neonates with High Concentrations of Immunoglobulin M (IgM), Four Guatemalan Ladino Villages, 1972–1973

Village number	Number of infants	Number (and %) with IgM >0.20 mg/ml[a]
1	48	10 (21)
2	52	4 (8)
3	40	6 (15)
4	67	11 (16)
Total	207	31 (15)

[a]Elevated values in cord serum confirmed in blood from infant's femoral vein. IgM was measured by radial immunodiffusion. Data of the Divisions of Environmental Biology and Human Development, INCAP.

uterine infection is known to induce fetal wastage, embryopathy, premature birth, low birth weight, and postnatal sequelae.

The small size of child-bearing women in pc ıural areas, their poor nutritional status resulting from deficient diets and fiequent episodes of infectious disease, and the presence of fetal antigenic stimulation are factors that help to explain the 7% rate of premature birth and the 32% incidence of fetal growth retardation. By itself, poor fetal growth diminishes survival and retards growth of children (10).

Childbirth in rural areas throughout the world offers many opportunities for contamination of the child with maternal feces, an event made more significant by the high rates of maternal infection. More than 8% of five- and seven-day-old neonates were found to be excreting enteroviruses. Early infection with *Shigella* and protozoa also occurs, but is less frequent (9). These infections, however, generally are asymptomatic and short-lived and disappear in days or a few weeks.

The rural neonate has a remarkable resistance to infection attributable to the adequate nutrition and resistance factors provided by breast milk. The situation changes when weaning begins, at two to five months of age, because supplemental foods are easily contaminated by polluted water or by the mother herself as she prepares them.

Milk output in women who do not supplement their own diets diminishes by the second or third month. Weaning is protracted, extending into the second year of life in most cases, and this coincides with the occurrence of weanling diarrhea, a syndrome caused by a variety of infectious agents and a deteriorated nutritional status. The combined effect of inadequate food intakes and frequent exposure to infectious agents results in a succession of infections, each episode further depleting the child. The magnitude of infection correlates directly with the onset of clinical manifestations.

Particularly high rates of diarrheal diseases and respiratory illnesses are observed (Figure 2). It should be recognized that children are continuously being infected and that clinical manifestations occur virtually in a continuum, as Figure 3 illustrates. Children may be ill for as long as a third of their first year of life. These data correspond to a typical highland region devoid of hookworm and of diseases transmitted by snails and arthropods. In many lowland areas, malaria, flukes, and arboviruses enlarge the morbidity spectrum.

The impact of infection on health is evident in a severe case of whooping cough (Figure 4). The child exhibited pronounced weight loss consequent to anorexia and vomiting and metabolic alterations; the nutritional status deteriorated seriously, favoring clinical manifestations of other infectious agents (9). Recovery of the preillness weight did not occur until 40 weeks later. The arrest in growth of this child at such an early age probably resulted in impairment of biological functions. The nutritional status even in well-nourished individuals deteriorates in the presence of any infectious disease and the effects are of still

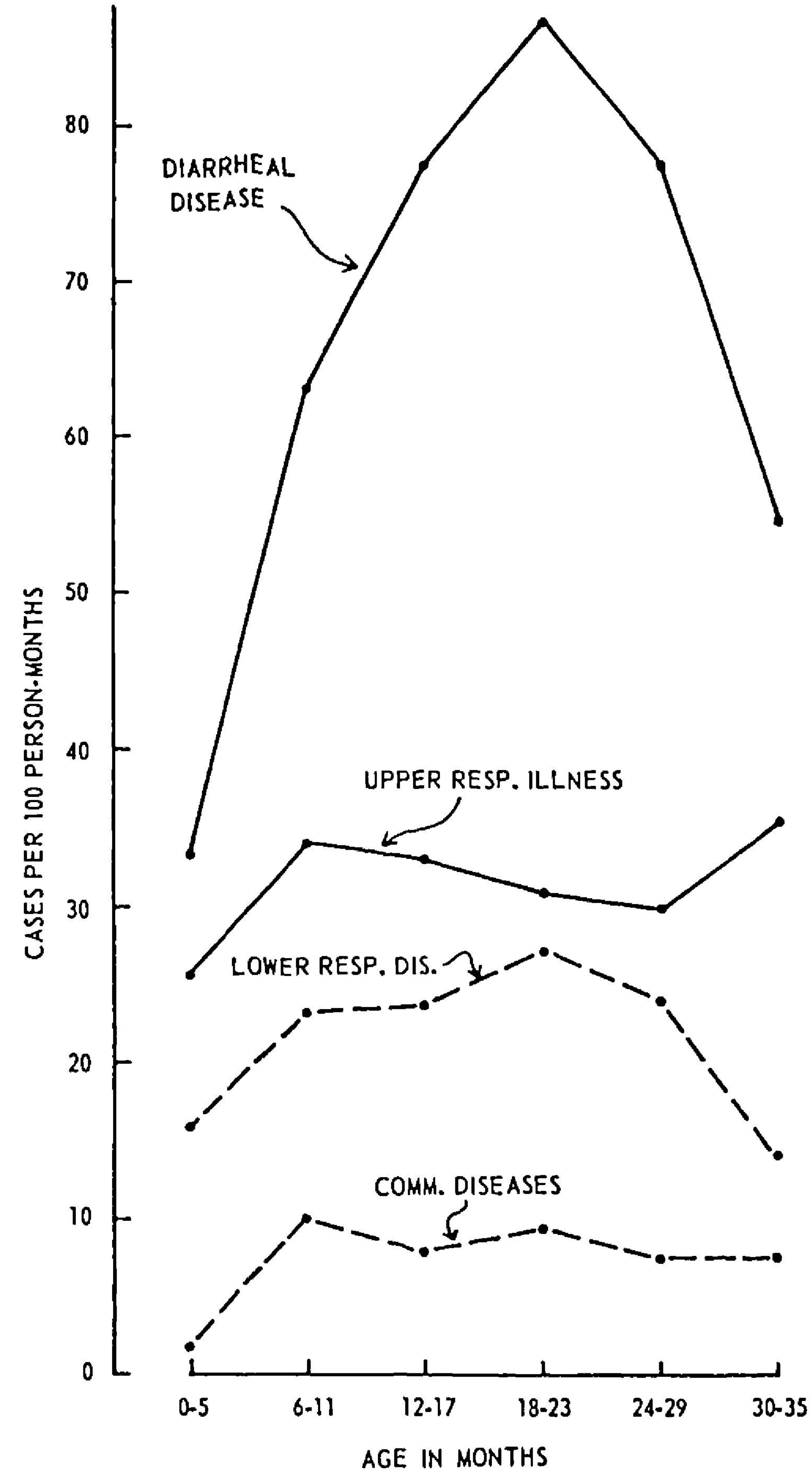


FIG. 2. Rates of infectious diseases, as cases per 100 person-months, in a cohort of 45 children observed from birth to age 3 years. Reappearance of symptoms after 24 hours identified a new case. Santa María Cauqué, 1964–1971.

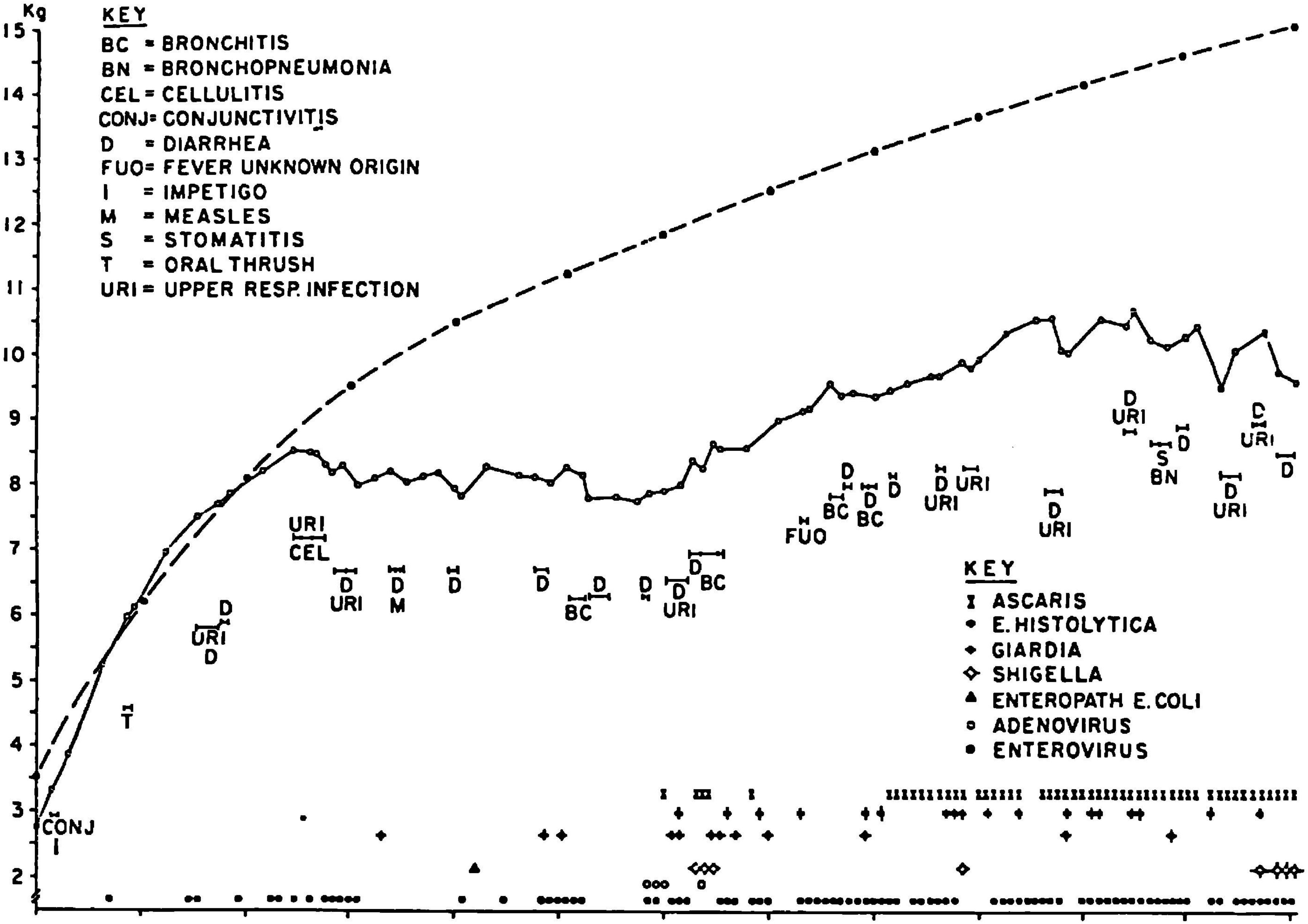
greater consequence to infants and young children, particularly if they are already malnourished.

In less developed societies, the response to an infectious process in the child is often withdrawal of solid food and sometimes the giving of strong purgatives. Infections commonly are accompanied by anorexia, vomiting, increased peristalsis, and systemic manifestations, often resulting in marked reduction of food intake, impaired digestion and absorption, and nutrient depletion (11). Other alterations are loss of tissue—particularly epithelium, blood, muscle, and liver—depending on the type of infection, its localization and pathogenesis. In both intestinal and systemic diseases there is increased loss of nitrogen, amino acids, electrolytes, and vitamins. Adults experiencing severe infectious disease show impaired performance or inability to work at all (2). However, even subclinical or "silent" infections induce stress responses with increased nitrogen excretion in urine (3).

The metabolic alterations associated with infection have been classed as nutrient overutilization, nutrient sequestration, and nutrient diversion. In overutilization there is increased expenditure of glycogen, mobilization of amino acids from skeletal muscle for gluconeogenesis in the liver, increased synthesis of lipids, and overutilization of vitamins. Sequestration of iron in the liver occurs even in the presence of adequate stores of hemosiderin, a phenomenon apparently mediated by a protein factor released by phagocytes. This perhaps contributes to the anemia in children experiencing recurring infections, even when they live in hookworm-free areas and where dietary iron is only mildly deficient or even adequate. Nutrient diversion includes an uptake of plasma amino acids for abnormal synthesis of haptoglobin, tryptophan-oxygenase, tyroxin-transaminase, and other enzymes. Also, the body diverts its biosynthetic pathways to produce the protein, lipids, and carbohydrates needed for viral replication. Thus, by a variety of mechanisms, the high frequency of infections in developing societies contributes in an indirect way to the food shortage observed in developing regions of the world.

On the other hand, malnutrition, whether primary or secondary to interaction with infection, affects the host's immune capacity, an important issue when one considers that a large proportion of the world's population suffers from varying degrees of malnutrition and is concomitantly exposed to far greater risks of infection than well-nourished populations are (16). Present knowledge indicates that the immunoglobulin system is not affected in persons with mild to moderate forms of malnutrition. However, antibody synthesis is impaired in children with moderate to severe forms of protein-caloric malnutrition (PCM), as evidenced by a failure to elicit a B-cell response with viral and bacterial antigens in untreated kwashiorkor patients.

Alterations in T-cell function and in the amplification of the immune response occur in malnourished persons. In moderate and severe forms of PCM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KEY
BC = BRONCHITIS
BN = BRONCHOPNEUMONIA
CEL = CELLULITIS
CONJ = CONJUNCTIVITIS
D = DIARRHEA
FUO = FEVER UNKNOWN ORIGIN
I = IMPETIGO
M = MEASLES
S = STOMATITIS
T = ORAL THRUSH
URI = UPPER RESP. INFECTION
KEY
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E. HISTOLYTICA
GIARDIA
SHIGELLA
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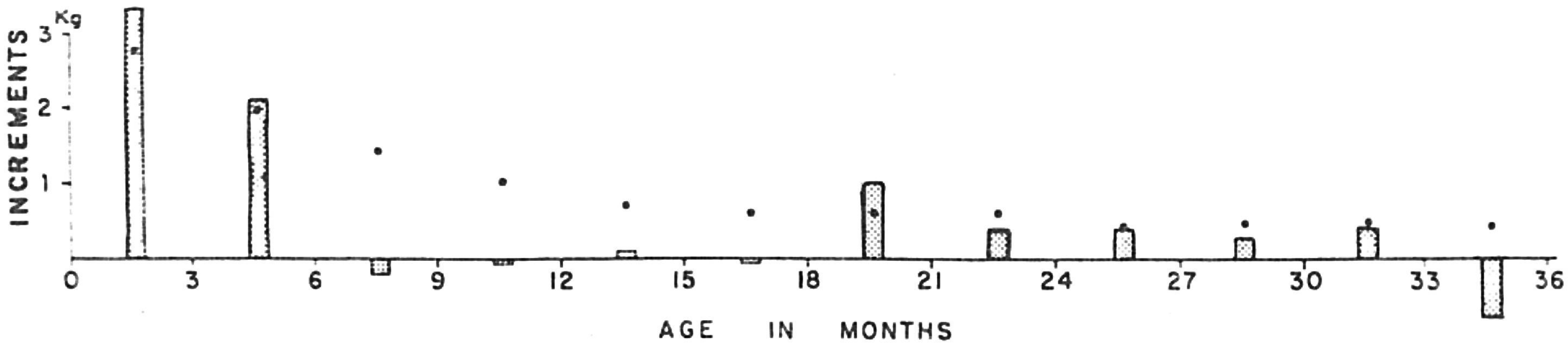

FIG. 3. Weight, infections, and infectious diseases, male child no. 12, Santa María Cauqué. Top: Solid line represents weight of child; broken line is median of the standard. Length of each horizontal line indicates duration of infectious disease. Each mark shows a week positive for the particular infectious agent. Bottom: Observed weight increments (vertical bars) and expected median increments (dots) of the standard (Mata *et al.*, 1971, reference 8).

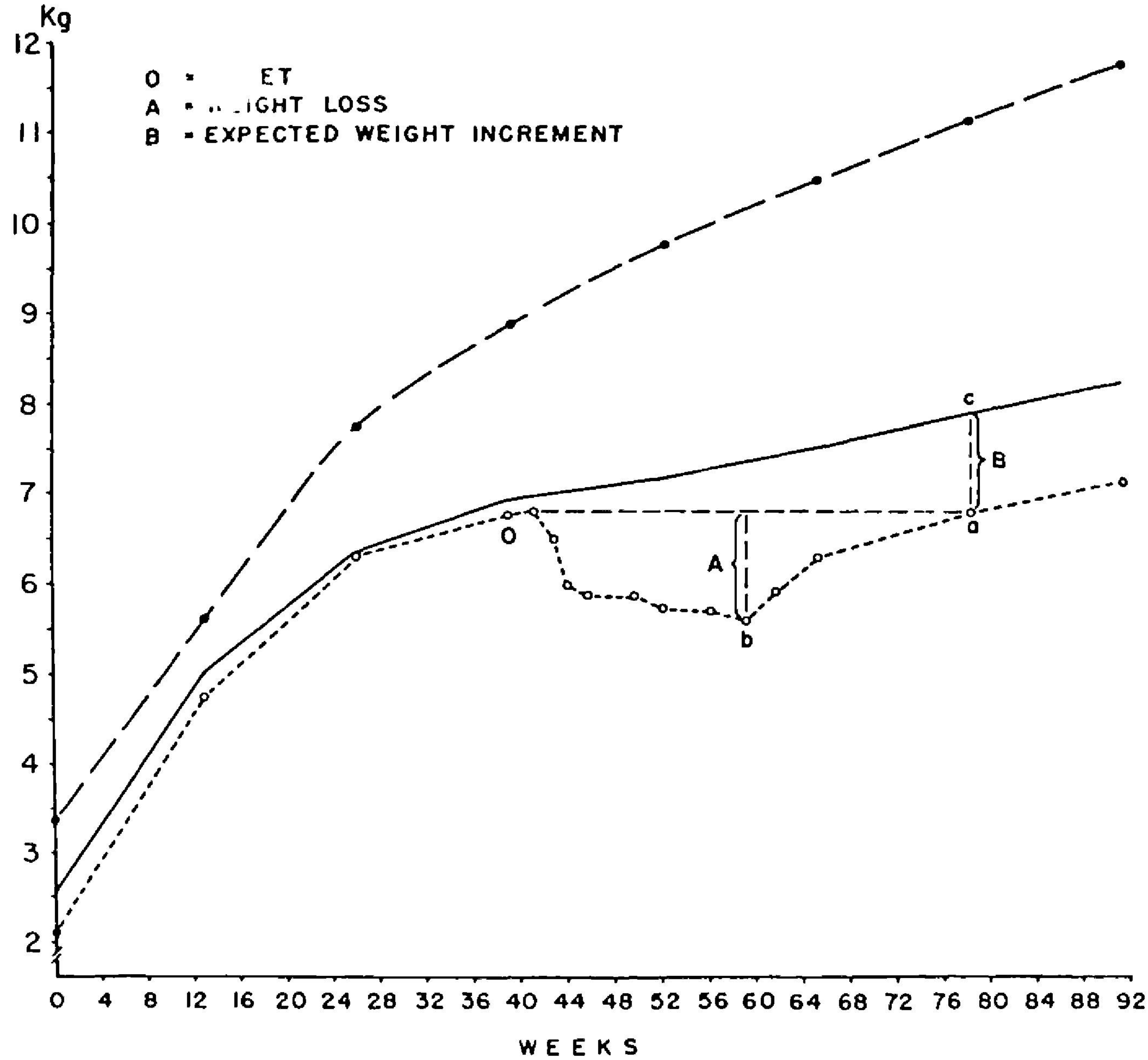

FIG. 4. Whooping cough in a girl of Santa María Cauqué to illustrate deterioration of nutritional status. Adapted from Mata *et al.*, 1972, reference 9).

there is a decrease in the number of immune cells in liver, bone marrow, spleen, Peyer's patches, and lymph nodes; this could explain the failure of malnourished children to mount a leukocyte response to bacterial infection. Alterations in phagocytic cells result in a diminished capacity to ingest and kill bacteria, a phenomenon apparently related more to lack of iron than to protein depletion. It has already been mentioned that iron sequestration occurs during infection.

Furthermore, malnourished individuals have altered or delayed hypersensitivity reactions. Other manifestations of altered cell-mediated immunity in malnutrition are a depressed capacity for blast transformation after challenge with mitogens, a diminished rosette formation, and alterations in factors important for the amplification of the immune response. These are evident, not only in acute PCM, but in underweight children who have experienced fetal growth retardation or early nutritional deprivation (4).

There is no doubt that infection and infectious disease a. important factors in determining the occurrence of malnutrition. Conversely, malnutrition diminishes the host's capacity to resist and become immune to infection. The synergistic malnutrition–infection interaction can be considered the most important phenomenon in the genesis of recurring disease, impaired function, and death.

THE SOCIAL ENVIRONMENT

The frequent interactions between infection and malnutrition in the tropics are related to traditions, low educational level, and socioeconomic underdevelopment, as well as to the characteristics of the physical environment. As long as such deficiencies are not corrected, infection and malnutrition will continue to occur at the present rate or even become worse.

To illustrate, Figure 5 shows illiteracy rates in the six Central American countries, showing that in four of them about half or more of the people cannot read or write (12). It is not surprising that in most rural villages of Central America there is little or no knowledge of how disease is transmitted, of the need to boil drinking water, or how to prepare adequate, hygienic food for weaning infants.

Table III summarizes certain characteristics of a typical community in the Guatemalan highlands, pointing out deficiencies in housing, availability of water, and unsanitary disposal of human wastes—all factors related to transmission of infection.

Furthermore, in the same village, a study made 12 years ago showed that land averaged 10 cuerdas (3.3 acres) per family of five members, an amount

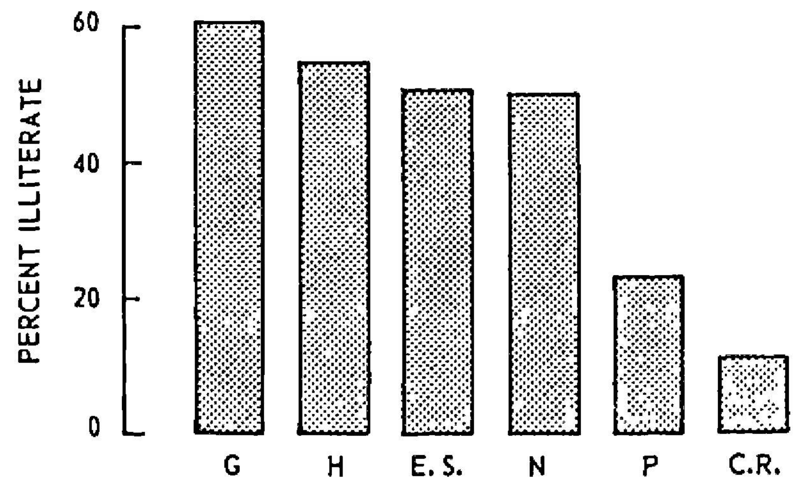

FIG. 5. Illiteracy rates, six Republics of Central America, population census of 1960, SIECA, 1973 (reference 12). (G) Guatemala, (H) Honduras, (E.S.) El Salvador, (N) Nicaragua, (P) Panamá, (C.R.) Costa Rica.

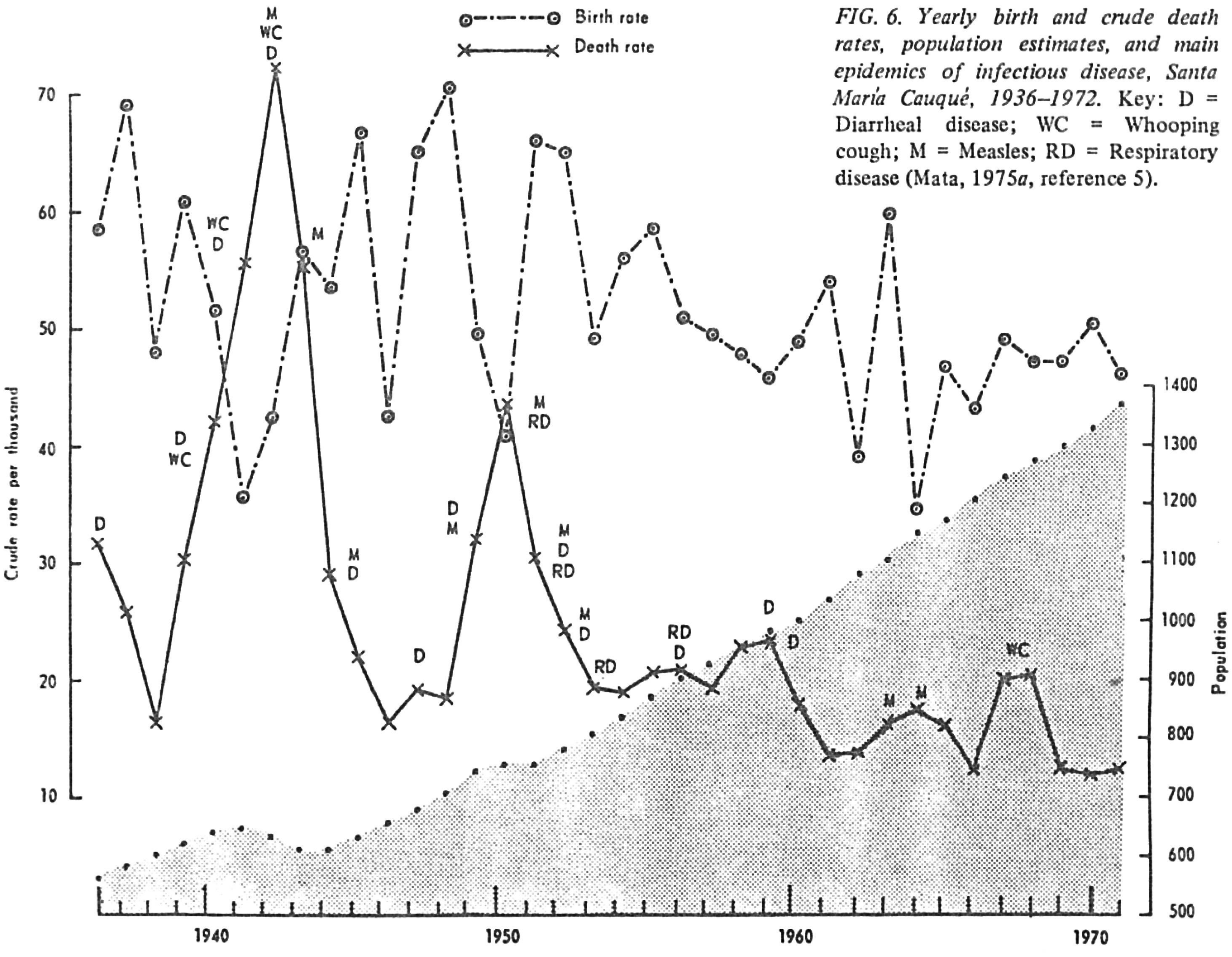

FIG. 6. Yearly birth and crude death rates, population estimates, and main epidemics of infectious disease, Santa María Cauqué, 1936–1972. Key: D = Diarrheal disease; WC = Whooping cough; M = Measles; RD = Respiratory disease (Mata, 1975*a*, reference 5).

Table III. Characteristics of a Typical Highland Village of Guatemala, Santa María Cauaqué, 1967

Features	Percent homes
Earthen floor	86.5
Piped water	7.4
Hearth on floor	88.7
Electricity	30.3
Privy	68.0

permitting cultivation of maize and beans to feed the village for one year. Within a decade the land was subdivided further and many young men in the community are now without land, creating a system of servitude not quite existing a few years ago. In addition, individual men and whole families have migrated to urban centers to live in shantytowns and slums, often under worse conditions than those of the village.

At present, the most pressing problem is the saturation of the carrying capacity of the land. Figure 6 shows that after 1950, deaths primarily due to epidemic diseases declined while birth rates remained high (6). In this village and in Guatemala as a whole the population is growing at a rate greater than 3% per year, without any apparent tendency to decline. Table IV illustrates the present population and population density in Central America and the expectations for the year 2000, figures that speak for themselves.

The economic capacity of villagers is very low, due to population growth, low educational level, primitive methods of agriculture, lack of skill in craftman-

Table IV. Population and Population Density, Central America and Panama[a]

Year	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama	Total[b]
			Population in millions				
1974	5.9	3.9	2.9	2.3	1.9	1.5	18.4
2000	15.7	9.6	8.0	5.7	4.4	3.7	47.1
			Inhabitants per km^2				
1974	55	186	26	18	38	20	34
2000	145	457	71	34	88	49	94

[a]SIECA, 1973 (reference 12).
[b]For Central America and Panama.

Table V. Mean Gross Domestic Product, U.S. Dollars per Caput, Selected Regions of Guatemala[a]

Region	1951–1952	1965–1966	% change in 15 years
Dept. Guatemala[b]	847	1071	+ 26
Dept. Sacatepéquez	197	123	– 38
All Guatemala, except three depts.	144	104	– 28
Rural Guatemala	142	105	– 26
All Guatemala	265	329	+ 24

[a]Adapted from Smith, 1973 (reference 13).
[b]Mostly Guatemala City.

ship, and little or no village industry or other types of economic development to employ landless people. The impoverishment of the population is evident in the steady decrease in gross domestic product noted for most of rural Guatemala, even before the recent onset of inflation. The country as a whole shows a gain in the gross domestic product, clearly concentrated in Guatemala City (Table V).

SUMMARY

The study of the relation of man to his environment in developing countries emphasizes the inevitable need for societies to recognize the true causes of infection, malnutrition, and poverty. The need is for improvement in the quality of human life in less developed nations, a recommendation easy to prescribe but difficult to accomplish. Although our pool of knowledge is incomplete, it is adequate to suggest ways to diminish infection, increase food production, utilize food more efficiently, improve education, and provide systems of justice to protect the classes most in need.

The physical environment in tropical and subtropical regions, and the socioeconomic characteristics of the population inhabiting such regions, favor maintenance and transmission of a variety of viruses, bacteria, and parasites that make agricultural progress and social development difficult, and that contribute to poor fetal growth, nutrient wastage, and deficient postnatal physical growth, accounting for most of the childhood morbidity and mortality. In this regard, infections contribute indirectly to the overall food problem in a similar fashion as pests do in terms of food losses and spoilage. The overall effect could be comparable or greater than that resulting from an inadequate capacity to produce or to purchase the food needed.

Thus, my objective has been to stress, within the whole environment, the importance of infection and the need to diminish it. Ways to control and prevent infection are readily known. They have to do with education of the population to improve personal and environmental hygiene. Economic investment is necessary to improve housing and water supply systems, waste disposal, and such preventive measures as immunization programs. Although such measures may appear expensive when first implemented, they have long-lasting effects and many require minimal expenditure once they are established. Large segments of the population stand to benefit, and other development interventions can then be introduced. However, these measures should not be implemented singly. They should be accompanied by community development, family planning, social legislation—in other words, the holistic approach to health and welfare. To do otherwise may aggravate the problem by stimulating demographic growth, perpetuating malnutrition and infection, and maintaining underdevelopment.

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