LOST PARADISES
AND THE
ETHICS OF RESEARCH
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THE NEXUS OF YANOMAMÓ GROWTH, HEALTH, AND DEMOGRAPHY

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Our goal in this chapter is to provide a synthetic overview of studies on Yanomamó health from an ecological perspective, with a special emphasis on emerging medical problems that are primarily a consequence of recent contact with non-Yanomamó. As we shall document, throughout most of their recent history the Yanomamó can be characterized as a high-mortality and high-fertility population that has been subjected to a variety of infectious and parasitic diseases common to other Amazonian populations. Ecologically, these illnesses appear to be the primary factors limiting Yanomamó population growth. Our goal is to begin an assessment of the degree to which diet and disease affect Yanomamó growth and development and morbidity and mortality rates. Just as important, we hope to document the consequences of the introduction of novel diseases on are already highly parasitized people and the steps the governments of Brazil and Venezuela are taking to regulate contact with outsiders and how they are responding to introduced diseases.

We begin with a description of Yanomamó anthropometrics and diet. The Yanomamó are one of the smallest people in all of Amazonia. The cause of their short stature as well as some interesting variations among Yanomamó populations is unknown. In the 1970s a number of anthropologists (e.g., Gosn 1974; Harris 1977) suggested that the Yanomamó were suffering from an inadequate protein intake, which may account for their short stature. Research by Lizzet (1977a) and Chagnon and Hames (1979) demonstrated that protein intake was more than adequate, and Lizzet (1977b) documented overall caloric and micronutrient sufficiency. Nevertheless, the causes of short stature are unclear, and dietary insufficiency in the form of inadequate calories may play a role in some areas.

We next turn to an examination of the traditional infectious and parasitic diseases that affect the Yanomamó. Throughout human history such diseases have had an enormous impact on human population structure, and the Yanomamó are no exception. As we shall demonstrate, the Yanomamó are affected by a wide variety of diseases, but their degree of affliction is probably no greater than that of other native peoples who live in an equatorial environment, the most disease-ridden of all human habitats (see Low 1990 and references therein: Mackintosh 2001). We distinguish between traditional and introduced diseases. By traditional diseases we mean those diseases that appear to predominate regular contact with non-Indian populations. Most important, they include a variety of intestinal parasites and malaria. Introduced diseases are those that seem not to have afflicted the Yanomamó until they came in contact with whites. Some of these diseases, such as measles and influenza, seem to sweep rapidly through the population and disappear, only to reappear through continued contact with outsiders. Other introduced diseases such as tuberculosis and hepatitis are chronic illnesses that spread slowly from village to village, causing widespread illness, debilitation, and death. Unlike measles and influenza, these chronic infectious diseases persist in villages indefinitely unless public health officials mount well-designed campaigns for their eradication.

Finally, two richly detailed demographic investigations of the Yanomamó (Melano 1982; Early and Peters 2000) have the ability to inform us about mortality and survivorship, two fundamental dimensions of life that are correlated with health. These studies indicate that infectious disease is the main health problem, and it appears to have a major effect in the early years of life.

Throughout, we consider the responses of anthropologists, missionaries, nongovernmental organizations, and state bureaucracies in treating diseases over the short and long term and in controlling Yanomamó contact with outsiders who habitually introduce diseases. Regulation of outside contact and effective monitoring and treatment are critical dimensions for enhancing Yanomamó health.
Yanomamí Growth

By Amazonian and world standards the Yanomamí are of small stature. The general literature on growth has consistently documented a negative correlation between socioeconomic status and adult stature and weight (Huss-Adomeit and Johnston 1985: Begin 1999). The implication is that poverty leads to reduced dietary quality, an increase in disease, or both (Jiménez 1980). It is particularly difficult to untangle the role of nutritional intake and disease and their synergistic relationship. One attempt to document this relationship (Mastoor et al., 1980 in Huss-Adomeit and Johnston 1985: 486) reports that common illnesses were associated with a reduction of 20 percent in food intake; Jenkins’s study of children in Belize (1981) demonstrates the negative growth effects of chronic diarrhea, as do Dodge and Dufour (1991) for Shipibo Indians.

A consistent finding of the several studies of Yanomamí growth is that the Yanomamí are small even by tropical forest standards. Comparative research on this topic was undertaken by Holmes (1995). Table 7.1 contains the ethnic groups Holmes compared to her two Yanomamí groups (Patima and Coyotweter). To this we have added other Yanomamí studieis (Spieseman et al. 1972; Cobo 1973; Holms, field data 1977; Cebes and Mancilla-Carvalho 1991) and data reported by Santos and Costa (1996) on the Surui. Table 7.1 clearly indicates that of the six tropical and subtropical native South Americans surveyed, Patima Yanomamí men and women are the smallest and lightest in the sample. Notably, the two villages surveyed by Holmes contain the lightest and shortest Yanomamí ever documented. We will return to this finding later.

Dietary insufficiency is an obvious hypothesis for small stature. Raising her attention on weight-for-height curves and arm and fatfold measures, Holmes (1985) notes that children from ages one through twelve are moderately to severely undernourished, whereas children are relatively heavy, indicating stocky body proportions. She also notes that young children and older adults do not manifest good nutritional status. In an earlier report based on a similar survey, published in 1984, she makes the following assessment: “Few clinical signs of malnutrition were present in the population. It was not uncommon to find very small children (that is, short or light for their age) who would be classified anthropometrically as malnourished, traveling through the forest for several hours carrying heavy loads without signs of physical exhaustion” (Holmes 1985: 387).

Recent research by Huguenin et al. (2001) on fatfold thickness in the lowland village of Cejll undergoing short-term food scarcity may provide a context for interpreting Holmes’s results. The village of Cejll, located near the mouth of the Carrao River on the Orinoco, suffered a short-term horticultural crop as a consequence of garden flooding brought on by the El Niño weather phenomenon in 1988. Children ages two to nineteen years had triceps skinfolds in the range of three to eight millimeters (mm) and subscapular skinfolds in the range of seven to sixteen millimeters (mm). A figure from Holmes (1985: 252, her figure 6) on triceps measurements from highland groups shows a similar range (this assessment is interpolated from the figure, since no tabular or summary measure is presented). Data collected earlier in this non-food-
stressed lowland villages by one of us (Haines) indicates that boys in these villages had significantly greater skinfold thickness than those of the food-stressed village of Ceraú (Haines et al., 280). Similar, the difference between the girls in the two villages was not statistically significant (p = .59), although they were greater in the non-stressed village and appear to be greater than measurements in Holmes's highland villages. These comparative findings show that the skinfolds of children in the food-stressed villages of Ceralia are similar to those found by Holmes in her highland groups and that the skinfolds of children in non-food-stressed lowland villages are greater than either. This suggests that food may be scarce in highland villages and is reflected in the skinfold measures of children.

Interestingly, Holmes (1984: 398) documents an apparent lack of relationship between an individual's parasite load and nutritional status. To explain this unlikely finding, Holmes speculates that low nutritional status may protect against parasitic infection, although, if this is correct, Holmes should have found a positive association between parasite load and nutritional status. This mirrors an argument made by Kent and Weinberg (1989) concerning low iron levels in Third World women as a mechanism to protect against bacterial infections. We will return to this hypothesis later.

In a comparative examination of growth and nutrition in more than a dozen Amazonian groups, Defoor observes for the Yanomamo: "Indeed, they are the shortest people in Amazonia" (Defoor 1994: 156). In reference to the small stature of Yanomamo adults, Tierney (2000: 60) quotes Defoor as generalizing that this is evidence of "long term nutritional inadequacy or generally poor environmental conditions, especially ones in which chronic or repeated infections are prevalent." This quotation is accurate but misleading, since Defoor is speaking of height for age, which is a measure of stunting in children and not indicative of "poor environmental conditions" for adults. Indeed, height for age, measurements are never made for adults as indicators of relative health. The proper measure for adults is weight-for-height (i.e., BMI). The body-mass indices shown in table 7.1 indicate that the Yanomamo are in the healthy range (18.5-24.9) according to the Centers for Disease Control (Centers for Disease Control 2002).

How do we account for this result in light of the fact that most biomedical researchers (e.g., Neel et al. 1977; Neel 1978) report that the Yanomamo are well nourished and healthy, and the main dietary study we have (Lizot 1977) suggests that the Yanomamo diet meets or exceeds international dietary standards? Research on two exceptionally small populations, the Pajekins and the Mountain Ok of New Guinean summarized in Bogin (1999), has implicated genetic variation in the production of a growth hormone (IGF-1) or sensitivity to its effects. At this point there is nothing to suggest that hormonal variation plays a role among the Yanomamo, for no such studies have been done. The three Yanomamo villages with smallest stature come from highland areas (Parima and Coyowetani in Venezuela and Saramurutu in Brazil), both at about 1,000 meters, whereas those with the tallest stature (Kendi, Naxawaia and Ocamo) are in the Maroni lowlands (see table 7.1). The mean in lowland villages are seven to ten centimeters smaller than Holmes's Parima population. This implies a negative altitude gradient that may be correlated with dietary and disease patterns. There is suggestive evidence that lowland villages (Bogin 1999) may have better access to food resources. Other than archaeological data, which are more prevalent at high altitudes, our review of epide'miological investigations suggests that there is no discernible relationship between altitude and disease pressure.

Rebecca Holmes is the only anthropologist who has attempted to deal with the issue of small stature among the Yanomamo. In her most recent assessment of their stature, weight, and growth, she argues that the Yanomamo may be "small and adaptive" (Holmes 1995: 140). In part, her argument parallels the "small but healthy" position taken by Stini (1971) and Seckler (1982): small body size is an adaptation to chronic undernutrition and disease. This hypothesis states that populations under food and disease stress facultatively adjust their growth to adapt to these problems. As Holmes herself notes, this perspective has generated considerable criticism (see, for example, Maroteck 1989). Holmes also believes that there also may be a genetic component to Yanomamo stature (Holmes 1995: 132, 136).

In an attempt to explain small stature among native South Americans Salzano and Calligari-Jacques (1988: 116), their table 6.1 demonstrate that of the forty-three native ethnic groups they surveyed, only three are shorter than the Yanomamo. They note a statistically significant north-south geographic patterning such that northern groups such as the Yanomamo are significantly smaller than southern groups (Salzano and Calligari-Jacques 1988, their figure 6.1). The meaning of this pattern is unclear. The authors do not correlate this geographical pattern with genetic markers, linguistic grouping, or ecological factors. The only interpretation at this point is that the small stature of the Yanomamo is consistent
Epidemiological Context

with their geographic position in South America. Consequently, it is uncertain what factors disease, nutrition, and genetics play separately or jointly in determining Yanomamo stature in comparison to that of other Amazonian peoples or within the Yanomamo. Nevertheless, it is an important finding that may help us identify the ecological or genetic factors that underlie this relationship.

Disease Patterns

The most important threat to Yanomamo health and quality of life is the presence of infectious diseases, the most threatening of which are those of European and American origin. Some of these diseases have spread to the Yanomamo through direct contact, while others may have been introduced prior to actual contact through trade with neighboring Amerindian groups. The most important of these are the mycobacterial infection tuberculosis, the hepatitis viruses (both B and delta), and other viral infections such as measles and parasitic infections such as onchocerciasis and a variety of intestinal helminths. Finally, although malaria has been present in the Amazon for hundreds of years, contact with non-Amerindians appears to lead to the introduction of new strains that have a devastating effect on the Yanomamo.

The presence of infectious agents among the Yanomamo is a perpetual drain on the body's nutritional and defensive resources. Whether this drain is marginal or detrimental depends on the severity of the symptoms of each species, possible interaction between infectious agents, the number of species infecting each individual, and the severity of such infections. Many infections that would not be fatal if those infected had access to proper medical care can cause severe problems, and even be life-threatening in the absence of such care.

Knowing which diseases affect the Yanomamo and the overall prevalence of these diseases in each village is only the first stage in developing adequate health care programs. One must be able to predict the changes that are likely to occur in the pattern of disease and pathogens dispersion as the Yanomamo become more sedentary and have greater exposure to Western diet and lifestyle. For this purpose, a leader native Amerindian people of the same region may provide a model for the effects on health of the acculturation process. Indeed, some Yanomamo groups that have begun this transition, such as those near mission stations, may also serve for comparison to those groups that still have limited exposure to Westerners. We will attempt to synthesize some of the data currently available on each of these groups in order to make a preliminary comparison of this nature.

Hepatitis

Of grave concern among the Yanomamo are the hepatitis viruses. Both hepatitis B (HBV) and hepatitis delta (HDV) have been identified among the Yanomamo. According to infectious disease experts in the United States, most cases of HBV worldwide (94 percent of adult infections) 70 percent of infections among children; see http://www.cdc.gov/nцииd/diseases/hepatitis/b/fact.html are overcome after about six months, after which the carrier becomes immune (antibodies to the virus are present in their blood), but the viral antigens are not and may no longer become ill with the infection or transmit the infection to others. For infants infected at birth, about 90 percent become clinically infected, and up to 6 percent of adult infections may become chronic. In 15 to 20 percent of all cases that remain chronic, liver damage can be a life-threatening concern. This danger is even greater for those infected with HDV, which is more severe. HDV requires the presence of HBV to replicate and seems to reduce the likelihood that a concurrent HBV infection will become chronic. However, it does cause a more acute infection. Of cases in individuals who are chronic for both HBV and HDV, 70 to 80 percent develop liver damage, rather than the 15 to 25 percent of carriers of HBV alone. Given the fact that the Yanomamo generally do not have immediate access to the type of emergency medical care for those suffering from severe liver damage, they are undoubtedly more susceptible to mortality associated with the disease than are people who live elsewhere.

In Ocamo and Marawa villages, HBV was first introduced in 1966 by an American missionary who had reused needles in administering multivitamin complexes to himself and to the Yanomamo in the village (Torres and Mondolfo 1991). It is unlikely that the viruses were present prior to this time. By the time of a JIBS study in these villages, Torres and Mondolfo 1990, 84 percent of eighty Yanomamo who were randomly tested had been infected. A full 30 percent of the samples showed active infection (hepatitis B surface antigen or [HbsAg]) was present in their blood, meaning that they either were chronically or newly infected. Over half (54 percent of the samples from the two villages were from persons who had been infected and already developed immunity at the time of the study. One can see from figure 7 that the number of active infections (either chronic or acute) does not decrease appreciably with
...which some would expect in a population where the virus is endemic. Furthermore, in the same study, 40 percent of those infected with HBV also tested positive for HIV. As noted previously, this is a common infection, and some smokers are asymptomatic and can develop liver damage associated with HBV.

Koves and Mousolfki (1999) also studied thirty-six serum samples that had been collected in 1975 and preserved. In this case, samples had been collected only from individuals with acute liver damage; thus, the prevalence of HBV or HIV infections in this group is likely to be higher than among the general population. In this study, 97 percent had been exposed to HBV, and 54 percent had had active infection at the time the samples were collected. After the test for HBV, enough serum remained to test for HIV in only six of the samples. These were tested for the presence of hepatitis B antigens, which were present in all six cases prior to its description in the medical literature in 1977.

The risks posed by the presence of HBV and HIV among the Yanomamo are serious. The damage associated with chronic HBV is severe, and that with HIV even worse. Because the viruses are spread through contact with saliva, blood, and sexual fluids, the intimate nature of interactions among the Yanomamo makes it likely that the disease will spread more quickly than in groups where this contact is not as common.

Ernstede contact among the Yanomamo includes the universality of female feeding practices, in which food for infants, body paint mixed with saliva, early onset of sexual activity, and the sharing of chewing tobacco and instruments used to pierce the body.

Tuberculosis

Tuberculosis, like the hepatitis viruses, was very unlikely to have existed among the Yanomamo prior to contact and is currently a major threat to their health. Although tuberculosis affects primarily the lungs, it can also spread to the gastrointestinal, genitourinary, nervous, and lymphatic systems, as well as to the bones and skin. This range makes it a particular threat. Tuberculosis, which forms when microorganisms attempt to engulf the Mycobacterium tuberculosis bacilli, may heal through fibrosis and calcification, and in some cases, the infection can remain active until reinfection or other exacerbation of the disease, when a chronic and progressive form may develop.

Drug therapies for tuberculosis are very often successful, and, though less effective than treatment, inoculation with bacille Calmette-Guérin (BCG) vaccine can prevent infection. However, some drug-resistant strains of the bacterium have developed. These are often associated with improper use of drug therapies, but the formation of resistant strain is preventable if proper care is taken with the administration of treatment.

For some groups of Yanomamo, particularly those in Brazil, the disease is likely being contracted through contacts with Brazilians, although some suspect that tuberculosis was first introduced among some Yanomamo through contacts with other Yanomamo from the Apin and Aj slot regions (Peters 1980), who had likely first contracted the disease from contacts with whites or with other native groups. However, the disease was first introduced, directly or indirectly through non-Yanomamo, in prevalence is high. Sicaa et al. (1990) found a prevalence of 0.4 percent (40 cases out of 9,205 people in a study of five Yanomamo villages in Brazil, which is 100 times higher than the average for Amazonas State. Brazil. Peters (1980) found that among 290 Yanomamo, 3.4 percent had active disease (1980: 276). In addition, he noted there were 40-50 [of 280 Yanomamo examined] suspect cases, either of the pulmonary or intestinal variety (Peters 1980: 276), or about 16 percent of the population. Apparently those diagnoses were made by a doctor from the National Division of Tuberculosis (Peters 1980: 260).
outbreak of dengue epidemic, in the other outbreak, the patients experienced an epidemic of dengue fever. Patients with dengue fever had a higher level of antibodies against dengue virus, but they were not protected from future infections. This suggests that the virus can cause more severe disease in certain individuals. In the second outbreak, the patients experienced a more severe form of dengue fever, with higher fever, more severe symptoms, and a higher mortality rate. The reason for this difference is not clear, but it may be related to genetic factors or the severity of the patient's immune response.

Epidemiologic Context

The study area was a rural village in the southeastern region of Thailand. The village had a population of approximately 5,000 people and was located near the border of Thailand and Cambodia. The study was conducted during the 1980s and 1990s, when dengue fever was a major public health problem in the region. The study aimed to understand the factors that contribute to the spread of dengue fever and to develop strategies for controlling the disease.

Methods

A cohort study was conducted among residents of the village. A total of 500 households were selected for the study, and all household members were interviewed. Blood samples were collected from all individuals and tested for antibodies against dengue virus. The study also monitored the incidence of dengue fever in the village over a period of several years.

Results

The incidence of dengue fever was higher in the study population than in the general population of the region. The study found that the risk of acquiring dengue fever was higher in individuals who had previously been infected with the virus. This suggests that immunity to dengue fever is not complete and that individuals may be at risk of reinfection with the virus.

Discussion

The results of the study highlight the importance of understanding the epidemiology of dengue fever. The study suggests that interventions aimed at reducing the transmission of the virus, such as mosquito control programs, may be effective in reducing the incidence of dengue fever in the study population. However, more research is needed to understand the factors that contribute to the spread of dengue fever and to develop effective strategies for controlling the disease.
Species of black fly of the genus Simulium serve as the vector for the parasite, including S. picatum, S. mayschlosi, and S. niellum, although the role of the latter as a vector is undetermined. The prevalence of onchocerciasis seems to increase at higher altitude. In a study of biting sites at these three species in Bolivia, the biting sites of both S. picatum and S. niellum increased in altitude (Groot et al., 2001). This may be related to the fact that the larval stage of the fly requires fast-flowing, highly oxygenated water, which is more likely to be found in higher altitudes.

The prevalence of this disease was greatly reduced from one village to another. Groot et al. (1997) found that onchocerciasis had not yet appeared in several villages inhabited by the Yanomamós. In Tucutoabo, however, prevalence of the disease, as determined by palpation, vision tests, skin biopsy, and radioimmunoassay in Peruvian, was 63 percent. In Saktar, prevalence was 28 percent, and in Samaquiri, it was 24 percent.

Onchocerciasis may be on the rise, however. Groot et al. (2001) measured the prevalence of the disease in several villages as well. Although there were not the same villages as those examined by Barret et al. (1976), prevalence was much higher. They found high rates of infection in highland villages (24 to 40 percent), although in at least one lowland village (Oxumto), the rate was considerably lower (2.4 percent).

Treatment of onchocerciasis is relatively straightforward: vermicid can aid an individual in getting rid of the infestation. However, the real likelihood of reinfestation makes vigilance and repeated treatment necessary to prevent long-term physical damage. For this to occur, trained care workers must be available to administer medications and to ensure that they are used effectively.

Malaria

Malaria is one of the most serious threats to Yanomamo health. In several studies conducted among the Yanomamo, Plasmodium falciparum has proven to be the most common malaria pathogen (Perez Mateo 1998; Torres et al. 1988, 2000). This species accounted for 68.6 percent of all infections in one study (Torres et al. 2000) and 57.1 percent in another (Perez Mateo 1998). Torres et al. (1988) found that the titers of antibody to P. falciparum were higher than those to P. ovale in all but two cases out of fifty-nine studied.

This contrasts with the species distribution common elsewhere; even in Venezuela as of 1991, the average Venezuelan distribution of infections in 1992 was 76 percent P. ovale and only 24 percent P. falciparum. This is significant, as in the Yanomamo area, P. falciparum, unlike P. falciparum, can remain dormant in the liver and thus relapse; the infection caused by P. falciparum is often much more acute, sometimes fatal.

Among some Yanomamo groups, virtually everyone has been infected with malaria at one point. Torres et al. (1998) found that up to 90 percent of blood samples taken from individuals in Ocamo and Mariara had antibodies to both P. falciparum and P. vivax. The presence of active infection determined by the detection of Plasmodium species in thick blood smear with any of the Plasmodium species, however, was found in only 3 out of 110 samples, suggesting either a high level of immunity among adults in this area or a pattern of sporadic periodic epidemics.

Indeed, Perez Mateo (1998) found higher levels of P. falciparum and P. vivax in younger age groups than in adults in Ocamo and Maraira in 1992 (Figure 7.2). Of 33 individuals between age six months and ten years of age, 17.1 percent had active P. falciparum infection, and 14.1 percent had active P. vivax infection. Of 156 individuals between the ages of ten and fifteen years, non-paras was infected with either species. Only those over fifteen years (6 age, 3.0 percent had P. falciparum infection, and only 1.8 percent had P. vivax infection). This suggests, though not with certainty,
that some of those in the older age-groups have acquired immunity to active malaria infection.

This immunity may have some benefits for the village as a whole if adults do not become ill; if they can give better care to ill children. Basic economic functions continue to be fulfilled, such as procurement of food and water. On the other hand, the prolonged or repeated infection required to acquire immunity, takes a heavy toll on those living in hyperendemic areas such as Ocampo and Maraca.

In contrast, areas that are not hyperendemic, while spared from high prevalence of infection much of the time, may experience severe periodic outbreaks of the disease. In a study comparing malaria outbreaks in Covenas and Malotewat, Lievens et al. (1999) found that the prevalence of active malaria was very low in August and September 1993, and again in May and July 1994. During these two sampling periods, a total of 1 case of active P. falciparum infections were found in 350 (4.4 percent) samples from both villages. After severe outbreaks in October and November 1994, however, Covenas had a prevalence of active falciparum malaria of 45.2 percent (out of 62 individuals) and Malotewat of 85.7 percent (out of 70 individuals). While this proportion of the population of a village ill, sex and economic hardships is a likely result. Ill parents, particularly mothers, cannot provide as well for ill children. Procurement of food and water becomes problematic. Those who are well may flee the village rather than staying on to care for the sick and risking infection themselves.

The most immediately life-threatening complication of malaria is the often extremely febrile state excluded by those suffering current infection and associated dehydration. Many other complications are common, however. These include splenomegaly, or enlargement of the spleen; acute hemolytic anemia, a form of anemia caused by the destruction of a large quantity of red blood cells; hepatomegaly, or enlargement of the liver, which can lead to hemolysis of the portal veins, which conducts blood from digestive organs to the liver, and potentially cirrhosis, a disease in which the tissue of the liver becomes fibrotic, resulting in a loss of normal function. Torres et al. (1998) found that 44 percent of individuals in the villages of Ocampo and Maraca suffered some degree of splenomegaly. An estimated 25 percent of all malaria cases resulted in hyperparasitic malnar splenomegaly. This syndrome was associated with hemolysis in the same villages (Torres et al. 2000). Prior to the study, in just one year, 38 of the 500 inhabitants (7 percent) of Ocampo and Maraca had required evacuation for emergency transfusions due to severe hemolytic anemia.

Peña Maio (1998) found that anemia was ubiquitous in Maloca in 1992. Of the total population of 1013 individuals, 91 percent suffered from anemia. Adults, particularly women, were more likely to suffer from anemia than were children. On the other hand, children aged six months to ten years were more likely, at 94 percent of all individuals in this age range, to suffer from splenomegaly than were adults, at 88 percent of all individuals. The presence of splenomegaly in this population was strikingly high, at 72 percent and 45 percent suffered from moderate to severe splenomegaly (see figure 7.2). This is most likely due to repeated infection with Plasmodium parasites.

Other Parasites
Some of the most ubiquitous and persistent health problems facing the Yanomamos is the presence of a vast range of parasitic infections. Some of these, such as Entamoeba coli, are nonpathogenic and common to the intestinal flora. Others have been equilibrated within their hosts while they do sap nutrients and can cause some serious health problems, they are generally not life-threatening. These include many species of intestinal helminths, such as Ascaris lumbricoides and Necator americanus, as well as a variety of roundworms, flukes, tapeworms, and filarial worms and protozoa.

Many of these parasites are contracted primarily through oral-fecal contact, often this involves soil in which eggs or larvae (in the case of worms) or cysts (in the case of protozoan infections) have been deposited. Many of these are equipped to enter the new host through the skin, particularly that of bare feet, but they can also infect hands and subsequently be ingested. The other primary mode of transmission is through infected water. Thus, sanitation practices are of great importance in determining the severity and prevalence of infection. The Yanomamos, being swidden agriculturalists, have been prone to move periodically, thus evading areas in which infective agents have built up in the soil for several years. As the Yanomamos become more sedentary, unless conventional measures are taken to ensure proper sanitation, or as pit latrines, these infections are likely to increase.

Macroparasites
Ascaris lumbricoides. The genus Ascaris includes the hookworms, of which A. lumbricoides is one of the most common. Hookworm is CONTAGIOUS.
through the skin, from fecal material deposited in the soil. Once resident in the intestine, it attaches itself to the mucous membrane and consumes the blood of its host. The most severe effect of hookworm infection is loss of blood, which can result in iron deficiency anemia and, in very severe cases, malnutrition. In the case of a mild infection, the side effects may be minimal.

Holmes (1984) found that in two Yanomamo Venezuelan villages, the rates of infection were, respectively, 20 percent and 40 percent, somewhat lower than the rates of 70 percent and 80 percent found by Lawrence et al. (1980) in Mavaca and Takanawati.

Ascaris lumbricoides — Ascasis lumbricoides is the most common roundworm worldwide, currently infecting nearly 1.5 billion people. It is also the most common to the Yanomamo. Passed through feces, it requires a two-week incubation period in the soil, after which it can be ingested by the eggs are infective. They hatch in the intestinal tract, and the larva enter the venous circulation and pass to the lungs, from which they migrate up the subject's upper respiratory passages and are swallowed. The parasite can cause pneumonia during this stage in its life cycle. Another complication is intestinal obstruction, although most cases are asymptomatic. (http://www.emaainstron.com/Species/Summaries/AscariasLumbricoides).

This infection is quite common among the Yanomami, with prevalence rates ranging from 74 to 99 percent in four villages (Lawrence et al. 1980; Holmes 1984). Only Condalidore et al. (1989, cited in Condalidore et al. 1991) found a range of 6.6 to 14.4 percent, for which the specific villages were not named.

Strongyloides stercoralis This parasite, like the hookworm, is contracted through the skin. The larval form travels to the lungs, from whence they may be swallowed, to take up residence in the intestine and that nature: it may be symptomatic during the pulmonary stage of infection but is frequently asymptomatic. Unlike some other helminth species, Strongyloides stercoralis does not require an incubation period in the soil, autoinfection is possible, and in some individuals, particularly those who are immunosuppressed, fever and abdominal pain may occur.

Holmes (1984) found from 0 to 1 percent in two villages, while Lawrence et al. (1980) observed from 3 to 11 percent in two others. Condalidore et al. (1989) found in Condalidore et al. (1991) observed a rate of 0.0 to 3.3 percent in several unidentified villages.

Capillaria — Three species of roundworm of the genus Capillaria are infect humans, one of which, C. philippinensis, is most common, and two of which, C. ficarii and C. aculeus, are rare. C. ficarii, hepatitis causes liver capillariasis which may result in hepatitis and capillaria caniculi causes pulmonary capillariasis, which may result in asthma and pneumonia. Both of these illnesses may be fatal.

According to the Centers for Disease Control (http://www.dpd.cdc.gov/dpdx/HTML/Capillaria.htm), the geographic distribution of Capillaria is limited primarily to the Philippines and Thailand with rare cases reported in the Middle East and Colombia. Condalidore et al. (1991) cited in Condalidore et al. (1991) report a prevalence of unspecified Capillaria species of 2.8 to 8 percent among the Yanomamo, a finding that illustrates the extent to which even remote peoples may be exposed to parasites thought to be locally specific to distant areas.

Hymenolepis nana — Hymenolepis nana, a tapeworm that completes its life cycle within its host, is common worldwide. It is most often asymptomatic, although, in the case of heavy infection, it can cause abdominal pain and diarrhea, and can potentially result in anemia. Its life cycle was studied by Hurst and Gibson (1987), which were found early in the Venezuelan village of Guayoxil, with an overall prevalence of 5.5 percent.

Mesocestoides lineatus — Mesocestoides lineatus, a flarial nematode similar to Dracunculus medinensis, is transmitted by black flies and midges. Symptoms of this infection include hepatomegaly and anemia. Torres et al. (1988) found a low prevalence, 1.8 percent in 110 individuals, of this parasite in the Venezuelan villages of Omo and Mavaca.

Fasciola hepatica — Fasciola hepatica is a frequently asymptomatic nematode, although in some cases and especially in small children it may cause pain, diarrhea, or rectal prolapse. There seem to be considerable variation in the prevalence of this parasite. Holmes (1984) found only 9.5 percent in Fattinas, but Yaranqui had a prevalence of 51.1 percent. Lawrence et al. (1980) found a prevalence ranging from 68 to 92 percent.

Meclizinae — Entamoeba histolytica This parasite, the only member of the genus Entamoeba that is pathogenic, is responsible for amebic dysentery and tropical liver abscesses. It seems to be common among the Yanomamo, but not...
in all locations. Lawrence et al. (1984), for example, found rates as low as 26 percent in one village and as high as 77 percent in another. Centrarchid et al. (1991) found rates far higher (from 28.5 to 40 percent).

T. gondii infections in several areas can cause severe symptoms, such as diarrhea, vomiting, and weight loss that generally lasts for one to three weeks but may last longer. In two Yomambo villages it was present, respectively, in 4 percent and 5 percent of individuals. Lawrence et al. (1980), but Holmes (1984) found a prevalence of 20 percent in both Paruma B and Orinoco.

Nonpathogenic Parastites

Several studies have also tested for the presence of parasites that are nonpathogenic, normal denizens of the human intestine. The effects of these infections on the general health of the host are minimal, except in those with the most severely compromised immune systems. However, while specific symptoms may not appear, chronic or severe infection may result in the draining of energy resources from the host. Of these, Entamoeba histolytica had a prevalence of 0 percent in one Yomambo village and of 10 percent in the other. Chabosia meioli was prevalent in about 10 percent of individuals in one village but was found in more than half of another (Lawrence et al. 1984). Endolimax nana infected a quarter of the people in one of the Yomambo villages and of 10 percent of the other. Blastocystis hominis was found in almost every individual in the Yomambo villages, with 91 percent and 100 percent prevalence. Holmes (1984), however, found somewhat lower rates (70 to 84 percent) in several villages.

The Effects of Acculturation

It is clear that virtually all Yomambo studied bear a heavy parasitic burden. Figures 7.2 and 7.4 display the variety of diseases carried by individ-

![Figure 7.1: Disease profile in the Yomambo villages of Mavara and Ocmo](image1)

![Figure 7.4: Number of species of parasites per person in the Yomambo villages of Orinoco and Paruma B](image2)
volved this tribe. Figure 7.4—compiled from Grillet et al. 2001, Lawrence et al. 1980, Peres-Mato 1988, and Torres et Monti-Doh 1991, Torres et al. 2000—shows the incidence of debilitating and life-threatening parasitic and viral diseases at the mission villages of Mara I and Omo in Ven-

Figure 7.4: For example, they found that hookworm infection (not identified by species) was very common in both Yanomamo villages, with in-
fection rates of about 70 percent in one and above 80 percent in the other. At 93 percent, it was even more common in the acculturating villages, however, suggesting that Yanomamo groups might be at increased risk in the already high rates of hookworm infection. These researchers also found that malaria (including P. knowlesi common in acculturating villages than in Yanomamo villages, although, again, even in the Yanomamo villages, disease rates were fairly high at 68 to 70 percent in one village and 90 to 92 percent in another. Dengue fever, believed to have originated in the Maroni region, was found in acculturating villages but not at all among the Yanomamo. Chagas disease, which is less common in Yanomamo villages, was found in 4 percent and 5 percent in two villages than in acculturating villages, in which about a quarter of the people were infected. However, another study found rates of around 20 percent in the Yanomamo villages of’anima B and Omoququ (see Holmes 1984).

On the other hand, Encarnaçao de Abravé, responsible for arbus-
dendritic and topolical liver abscess has had a much higher prevalence among the Yanomamo, from 42 percent in one village to 78 percent in another, than in the acculturating villages, where prevalence ranged from 0 to 30 percent. Whereas Ascaris lumbricoides was common in both Yanomamo and acculturating villages, in the Yanomamo villages, with prevalence of 90 percent and 100 percent, infection rates did not diminish in adulthood. In the acculturating villages, infection rates of 100 percent were found in children but declined to less than 10 percent in adults. Little difference was found between rates of infection with Strongyloides stercoralis in the acculturating villages and the Yanomamo villages.

These results are difficult to interpret. No, simple structural segregation can be made about whether the acculturation process leads to a heavier or lighter parasite burden. There was no apparent pattern depend-
ent on the mechanism by which parasites are spread, such as those that build up in the soil versus those that are autoinfective.

It is also difficult to interpret differences in overall parasitic load and age-related changes in parasite load. In the Yanomamo villages, a higher average number of species were found per adult person, ranging from 4 to 6, compared with 3 to 4.5 in the acculturating non-Yanomamo comm-
unities. This range is nearly identical to what Holmes (1984) found in highland Yanomamo populations (see figure 7.4). In one Yanomamo vil-
lage, the average number of parasites decreases with age among adults, whereas in the other the average was fairly constant across age groups.
In acclimatizing communities, the average number of species per person was lower, from 1.3 to 5.5, with no PMI trend across groups. Finally, in acclimatizing villages, fourteen different species of intestinal parasites were found, while only twelve were found in Yanomami villages.

Another study allows us to compare the Yanomami to Venezuelan natives who live in the same area. In this case, the Yanomami are compared with poor Venezuelan natives who are more or less fully integrated into the state economy and social setting but who live in the same area. Holmes (1984: 389, her table 6) was able to compare helminths Carlsbadia humuviades, Triakis, and Ancylostoma duodenale, Strongyloides stercoralis and guinea worm (Diamphitoxa colubridae) infection rates in two highland Patina Yanomami groups with those among the Spanish-speaking residents of San Carlos de Rio Negro. San Carlos has been visited for decades; its residents have access to medical care and schools, and they purchase most of the food they consume. The comparison is useful because both groups occupy the same general area of the Upper Orinoco, although the Yanomami are at a significantly higher altitude. Except for the fact that the Yanomami have a larger fraction of the population infected by Ancylostoma duodenale and both kinds of Enterobius, there are no striking differences. However, the number of parasites per person is much greater among the Yanomami than it is for the residents of San Carlos. For example, in San Carlos only 5 percent of the population is infected by four or more parasites; in the Patina villages, 30 percent of the population is infected by four or more parasites (Holmes 1984: 389, her table 6). It may also be useful to compare Yanomami villages at different stages in the acclimatization process. One of us (Hames), based on research visits to nearly all the villages surveyed, has rated the villages studied by Lawrence et al. (1980), Holmes (1984), and others summarized in Hurtado et al. (1997) from most to least acclimatized. This rating informs our discussion below.

The results of such a comparison are inconclusive (see figure 7.5, which compares the lightly contacted village with one of the most acclimatized mission villages). The lightly contacted village, Patamativi (Lawrence et al. 1980), was an exception in extremes. For almost every species tested, Patamativi had either the highest prevalence (Ancylostoma sp., H. lumbricoides, T. trichura, E. coli, and P. pyrolitica) or the lowest (G. lambia), and nearly the lowest rate of Strongyloides sp.1. In the case of Ancylostoma sp. and E. coli, the margin by which they exceeded their neighbors is insignificant, 1.5 percent and 1.5 percent, respectively.

The prevalence of A. lumbricoides was at 8 percent in the lightly contacted village. The prevalence of T. trichura, however, was higher by 11 percent. The prevalence of E. histolytica was higher by a margin of 17.5 percent. Coyuweteri, an intermediate village, exhibited no such trend (Hurtado et al. 1997), nor did the acclimatized mission villages of Patina B, Ocarno, and Mavaca.

The results of these comparisons are not revealing, but one may still draw certain conclusions. For example, in both comparisons, rates of G. lambia were lower in the lightly contacted villages, suggesting that it is as well other infections contracted through the water supply may be of greater concern for the Yanomami in the future. For parasites that travel through the soil, results are not at all certain. This may be true to differences in sanitation in more missionized villages, or perhaps the buildup of parasites in the soil is mitigated by having better and timely access to vermicidal medications. The differences may also reflect dissimilarity in sampling techniques from one study to another. Perhaps a more controlled study of a similar nature could provide a more accurate comparison, and thus prescriptive value for treatment programs among the Yanomami.

Our comparisons of lightly contacted and mission Yanomami villages on one hand and heavily acclimatized non-Yanomami Amerindian and Venezuelan peasants living in the Upper Orinoco show few clear patterns.
Nevertheless, it seems that the variety of parasites and the mean number of parasites per person may be slightly greater in lightly contacted and mission Yumamamo villages than in more isolated peasant villages. Over the short term, it seems that increased settlement around missions will have little effect on the Yanomamo health even though the potential for infection may be greater. We must stress that this will be true only if missionaries and governmental agencies continue to provide care and closely monitor epidemiological trends.

**Yanomamo Demography**

Mortality statistics provide critical information on the role that diseases play in a population. In tribal populations, as in most others, age-specific mortality rates commonly present themselves in a U-shaped or J-shaped distribution. In relation to age, rates start high in the early years, decline slightly to the teen years, and then begin a slow but accelerating climb thereafter. Excellent demographic studies (McLanahan 1982; Early and Peters 2000) provide important information on mortality rates, life expectancy at various ages, and causes of death among the Yanomamo.

Understanding the causes of death will enable government health authorities, missionaries, and anthropologists to be in a better position to monitor health problems, design preventive programs, and treat the ill. Both of the demographic studies mentioned here tabulate causes of death, but some obvious problems are common to most ethnographic and retrospective investigations in establishing actual causes even within broad categories. The ethnographers had to rely on an informant's recollections of causes of death and then transtate these causes to a Western typology. Infectious diseases such as malaria, influenza, and measles are probably reliably diagnosed by the Yanomamo, who are quite familiar with the symptoms. However, an illness that began as influenza could have led to pneumonia, which was the actual cause of death. More problematically, when the cause of death is unknown, this seriously distorts rates of reliably identified causes of death. In some studies (McLanahan 1982: 42, his table 3.1), the percent of deaths due to unknown causes is 6 percent (figure 7.6), whereas in others (Early and Peters 2000: 291), this percent can vary between 10 to 50 percent (figure 7.7) of all deaths, depending on the era studied. The difference largely reflects the recent four-year time span of McLanahan's investigation compared with the sixty-six-year period covered by Early and Peters.

Aside from these differences in unknown causes of death, comparing the two studies is problematic for two other reasons. McLanahan does not list infantilicide as a cause of death, not because it was absent in his area of study but because he did not classify such births as live births. This is not unreasonable, since the decision to commit infantilicide is almost always made before an infant is born (unless the infant is born with a congenital anomaly), and therefore one can regard it as a kind of postpartum abortion. In contrast, Early and Peters count infantilicide as a cause of death, and it constitutes from 5 to 20 percent of all deaths. Second,
although both studies use the category "infectious disease." Melanoma has a category called "degenerative disease," and Early and Peters have a corresponding "non-infectious disease" category. Nevertheless, there is probable considerable overlap between these two categories. With these caveats in mind, we compare the two studies in the following.

Both studies indicate that infectious disease is the primary cause of death among the Yanomamo, although it is much higher for the Mâvacara Yanomamo, and the rates of death from noninfectious and degenerative diseases are about the same. For the Mâvacara Yanomamo, deaths from infectious diseases are 80 to 70 percent. Eighty-five percent of deaths for adults (Melancon 1982: 47, his table 3.2). The higher rate of infectious disease for the Mâvacara Yanomamo (Sperlich 1967) when compared to 50 percent to some extent is an artifact of Early and Peters classifying pneumonia as a cause of death. If pneumonia is removed as a cause of death, infectious disease is a cause of death for the Xikrin increases to 55 percent. And if the large number of unknown causes were known, death rates from infectious disease would be very similar for both populations.

Early and Peters' study spans a sixty-six-year period from 1930 to 1996, with their investigation divided into a time series based on degree and kind of contact with outsiders. Consequently, it is more than any other demographic study of which we are aware, allows us to understand how contact affects patterns of mortality and disease patterns in a previously uncontacted tribal population. They divide the demographic history of the Xikrin into precontact (1930-1957), contact (1958-1960), linkage (1961-1981), and Brazil (1982-1996) stages, which measure the degree to which interaction with Brazilians has increased through time. Causes of mortality through these periods are displayed in Figure 7.8. Bearing in mind that "unknown" as a cause of death looms large in every period (especially precontact), the immediately recognizable trend is that death from infectious diseases increases dramatically from precontact to contact and changes little thereafter. During the contact period and thereafter, Early and Peters (2000) note, malaria and tuberculosis introduced by miners with whom the main contact for the increased force of infectious diseases as a cause of Yanomamo mortality.

These results for little difference in survivorship between the two populations. Life expectancy at birth ranges between twenty-nine and forty-six years, depending on contact type, among the Xikrin (Early and Peters 2000: 199), their table 19.31 and is thirty-seven years for the Mâvacara Yanomamo (Melancon 1982: 65, his table 3.6). Significantly, the lowest life expectancy for the Xikrin is at first contact; life expectancy reaches the high point immediately after contact, during the initial phase, and declines to thirty-five years during the Brazil stage of sustained contact.

Cradle birth and mortality rates and their relationship are fundamentally measures of how well a population is adapted to the environment. If a population increases through time, then by definition it is able to overcome various sources of environmental resistance (disease and resource insufficiency) and has not reached carrying capacity where fertility equals mortality; and the population cannot grow. Cradle death rates for the Xikrin Yanomamo (Early and Peters 2000: 194, their table 19.2a) range from 17 to 56 per thousand, and for Melancon's xikrin (1982: 89), 46 per thousand, which places them in the moderate to high range (Early and Peters 2000: 96) by world standards. Cradle birth rates range from 28 to 52 per thousand for the Xikrin (Early and Peters 2000: 194, their table 19.2a) and 59 per thousand for the Mâvacara Yanomamo (Melancon 1982: 89). The natural rate of increase is estimated to be 1.25 percent for the Mâvacara Yanomamo and 1.12 percent for the Xikrin (obtained from Early and Peters 2000: their table 19.2c; for all periods). These figures accord well with early estimates by Niel and Weis (1975: 38). It is important to realize that these demonstrations of Yanomamo population increase are probably not characteristic of growth patterns elsewhere among the Yanomamo tribal distribution, as explained in the following discussion.

Where the Yanomamo come into chronic contact with outsiders and where medical intervention is absent or ineffective, there is evidence of population decline. In Brazil, military takeover of the Surinam area
Epidemiological Contexts

There seems to be sufficient evidence among Yanomamo in regard to stature and weight differences to allow scholars to attempt to untangle the relationship between disease, diet, and growth. For example, some lowland groups are approximately eight centimeters taller (Table 7.3). In the Yanomamo villages than highland groups. If we were to compare the tallest Yanomamo lowland groups with other Amazonian villages in Table 7.1, we find that they are of average height for Amazonian peoples. Our review of the literature on parasite load and disease incidence in highland and lowland groups did not indicate any clear differences. Even if such differences were noted, could they still not be explained without additional data on infection, age, and sex distributions, and season in which the measures were made? We would also need to know the degree to which a disease is likely to cause growth and how their intake is affected in this process.

Dietary differences between highland and lowland groups may also be implicated, as indicated by anthropometric and economic research. As discussed earlier, research by Hager et al. (2001) showed that skinfolds of children in a lowland group at the village of Cejál were similar to those found by Holmes (1980) in her highland research, but they preserved lower skinfold measurements than those taken in other lowland villages studied in 1987. The lowland village of Cejál had just suffered food shortages as a consequence of an El Niño-related weather condition. Other lowland villages where skinfold measurements were made in 1987 operated under normal economic and dietary conditions (Hager et al., 2001), but their skinfold measurements were significantly greater than those of food-stressed Cejál or the highland measurements made by Holmes (1980). A reasonable interpretation of these findings suggests that highland groups are food-stressed. Comparative ecological and economic research on highland and lowland groups elaborates on this possible dietary connection. Hames (1995) summarizes important contrasts between highland and lowland groups. Highland groups rely much more heavily on cultivated crops, whereas lowland groups rely more heavily on food resources foraged through hunting, gathering, and fishing. In fact, lowland groups expend twice as much labor time in foraging activities as they do in both husbandry, plantations, and manioc. Staples of the Yanomamo diet are notoriously deficient in protein and micronutrients (Gross, 1974), even though they provide adequate calories. It may be the case that lowland groups have a superior diet, especially protein and fatty acid intake, which may account for their greater stature. There are at least two ways in which dietary factors may affect growth; on one hand, it may simply be that a better diet leads directly to enhanced growth; more complex, it may be that a better diet may counteract the stunting effects of chronic illness.

Regardless of the possible role of dietary differences in Yanomamo growth, we believe that these dietary differences are a major problem that affects all Yanomamo. Many of the most malnutrition and debilitating illnesses are spread as a consequence of contact with non-Yanomamo people. Some diseases such as measles and influenza periodically sweep through the Yanomamo and then disappear. Clearly, regulation of outside contact and health monitoring can deter these diseases. But extremely serious diseases such as hepatitis, tuberculosis, and malaria are now embedded in the Yanomamo. Their persistence as a chronic feature of Yanomamo life no longer depends on reintroduction from outside sources. It is clear that the governments of Brazil and Venezuela, along with nongovernmental organizations, face a daunting task. Many of the parasitic drives are treated simply with ivermectin, but without environmental sanitation practices, reinfection is guaranteed. Although there is a vaccine against hepatitis B virus infection, there is no cure for those already infected, and treatment to reduce its effects is expensive. At the same time, embedded cultural practices such as long-term betel chewing, pretreatment of food, and the sharing of body parts not objects enhance its spread. The World Health Organization has taken steps to eradicate this disease, and many others, in attempts to develop appropriate campaigns to reduce disease among the Yanomamo must be accomplished by scientific biomedical and anthropological research to provide health-care workers with accurate knowledge to apply the most effective treatments and interventions possible.

Notes

1. In this comparison we ignore Sipiman, da Rocha, and Wittkamp's (1974) eighteen-village study because it contains a mixture of highland and lowland groups. Nevertheless, this study's mean stature measures are greater than those of any of the highland groups.

2. Heroin is a medication that kills the microflora eating the host. As it does so, however, the allergic response elicited by the dead parasites can be extreme; many persons receiving treatment may experience extreme itching and discomfort. In a few cases, anaphylaxis can result.

3. Melancon (1985), using a stable population model, arrives at a life expectancy at birth of 20.5 years for males and 22.9 years for females. We
REFERENCES


