LOST PARADISES AND THE ETHICS OF RESEARCH AND PUBLICATION

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THE NEXUS OF YANOMAMÖ GROWTH, HEALTH, AND DEMOGRAPHY

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Our goal in this chapter is to provide a synthetic overview of studies on Yanomamö health from an ecological perspective, with a special emphasis on emerging medical problems that are primarily a consequence of recent contact with non-Yanomamö. As we shall document, throughout most of their recent history the Yanomamö 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 Yanomamö population growth. Our goal is to begin an assessment of the degree to which diet and disease affect Yanomamö growth and development and morbidity and mortality rates. Just as important, we hope to document the consequences of the introduction of novel diseases on an 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 Yanomamö anthropometrics and diet. The Yanomamö are one of the smallest people in all of Amazonia. The cause of their short stature as well as some interesting variation among Yanomamö populations is unknown. In the 1970s a number of anthropologists (e.g., Gross 1974; Harris 1977) suggested that the Yanomamö

were suffering from an inadequate protein intake, which may account for their short stature. Research by Lizot (1977) and Chagnon and Hames (1979) demonstrated that protein intake was more than adequate, and Lizot (1977) 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 afflict the Yanomamö. Throughout human history such diseases have had an enormous impact on human population structure, and the Yanomamö are no exception. As we shall demonstrate, the Yanomamö are afflicted 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 predate 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 Yanomamö 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 Yanomamö (Melancon 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 Yanomamö contact with outsiders who habitually introduce diseases. Regulation of outside contact and effective monitoring and treatment are critical dimensions for enhancing Yanomamö health.

Yanomamö Growth

By Amazonian and world standards the Yanomamö are of small stature. The general literature on growth has consistently demonstrated a negative correlation between socioeconomic status and adult stature and weight (Huss-Ashmore and Johnston 1985; Bogin 1999). The implication is that poverty leads to reduced dietary quality, an increase in disease, or both (Garn 1980). It is particularly difficult to untangle the role of nutritional intake and disease and their synergistic relationship. One attempt to document this relationship (Martorell et al., 1980, cited in Huss-Ashmore 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 Hodge and Dufour (1991) for Shipibo Indians.

A consistent finding of the several studies of Yanomamö growth is that the Yanomamö 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 Yanomamö groups (Parima and Coyoweteri). To this we have added other Yanomamö studies (Spielman et al. 1972; Coco 1973; Hames, field data 1987; Crews and Mancilha-Carvalho 1991) and data reported by Santos and Coimbra (1996) on the Surui. Table 7.1 clearly indicates that of the sixteen tropical and subtropical native South Americans surveyed, Parima Yanomamö men and women are the second smallest and lightest in the sample. Notably, the two villages surveyed by Holmes contain the lightest and shortest Yanomamö ever documented. We will return to this finding later.

Dietary insufficiency is an obvious hypothesis for small stature. Basing her assessment on weight-for-height curves and arm and fatfold measures, Holmes (1985) notes that children from ages one through twelve are moderately to severely malnourished, whereas older 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 the same 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 Hagen et al. (2001) on fatfold thickness in the lowland village of Cejal undergoing short-term food scarcity may provide a

TABLE 7.1 Anthropometric Statistics for the Yanomamö and Other Populations

Group[1]	Male Stature (cm)	Female Stature (cm)	Male Weight (kg)	Female Weight (kg)	Male BMI	Female BMI
Motilon[1]	146.2	138.1	nd	nd	nd	nd
Parima Yanomamö[1]	146.9	136.9	43.7	37.9	20.22	20.22
Yanomamö Surucucu[2]	151 1	142.0	46.9	43.0	20.40	21.30
Yanomamö: Coyoweteri[1]	152.3	139.6	44.4	38 2	19.22	19.60
Yanomamö (18 highland and lowland villages)[3]	153.2	142.4	nd	nd	nd	nd
Auca[1]	154.0	144.0	nd	nd	nd	nd
Apalai-Waiana[1]	154.2	142.8	nd	nd	nd	nd
Bari[1]	154.5	nd	nd	nd	nd	nd
Guahibo[1]	155.4	nd	54.1	nd	22.52	nd
Mundurucu[1]	155.6	145.4	nd	nd	nd	nd
Ye'kwana[1]	156.0	146.0	62.0	53.0	25.48	24.86
Tucano[1]	156.0	146.0	nd	nd	nd	nd
Yanomamö: Ocamo[4]	156.0	148.0	nd	nd	nd	nd
Yanomamö Kedi-Washawa[5]	156.5	145.1	51.8	44.4	21.01	21.09
Surui[6]	156.5	147.0	53.3	49.9	nd	nd
Karina[1]	156.6	146.7	56.6	nd	23.26	nd
Warao[1]	157.3	nd	50.8	nd	19.60	nd
Curripaco[1]	157.3	144.4	59.2	50.2	24.02	24.08
Pemon[1]	159.0	146.7	nd	nd	nd	nd
Guajiro[1]	159.2	nd	60.5	nd	23.93	nd
Yaruro[1]	165.6	nd	58.8	nd	21.34	nd
Mekranoti[1]	166.4	153.1	66.6	56.4	24.17	24.06
Xirkin[1]	168.7	155.9	63.6	56.0	22.53	23.04
Venezuela Peasant[1]	166	157	65	57	23	23.1
United States[1]	172	159	75	65	25.4	25.5
Caracas Elite[1]	172.9	161.1	61.4	52.8	20.75	20.34

Communities in boldface are Yanomamo communities.

Sources: [1]Holmes (1995); [2]Crews and Mancilha-Carvalho (1991); [3]Spielman et al. (1972); [4]Coco (1973); [5]Hames, field data (1987); [6]Santos and Coimbra (1996).

context for interpreting Holmes's results. The village of Cejal, located near the mouth of the Casiquiare Canal on the Orinoco, suffered a shortage of horticultural crops as a consequence of garden flooding brought on by the El Niño weather phenomenon in 1998. Children (ages four to sixteen years) had triceps skinfolds in the range of three to eight millimeters (boys) and three to sixteen millimeters (girls). 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 measures are presented). Data collected earlier in two non-food-

stressed lowland villages by one of us (Hames) indicates that boys in these villages had significantly greater skinfolds ($p < .001$) than those of the food-stressed village of Cejal (Hagen et al. 2001: 14). The difference between the girls in the two villages was not statistically significant ($p = .59$), although they were greater in the nonstressed 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 village of Cejal are similar to those found by Holmes in her highland groups, and the skinfolds of children in non-food-stressed lowland villages are greater than either. This suggests that food may be scarcer in highland villages and is reflected in the skinfold measures of children.

Interestingly, Holmes (1984: 388, her figure 3) 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, Dufour observes for the Yanomamö: "Indeed, they are the shortest people in Amazonia" (Dufour 1994: 156). In reference to the small stature of Yanomamö adults, Tierney (2000: 60) quotes Dufour 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." The quotation is accurate but misleading, since Dufour 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 Yanomamö 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 1979) report that the Yanomamö are well nourished and healthy, and the main dietary study we have (Lizot 1977) suggests that the Yanomamö diet meets or exceeds international dietary standards? Research on two exceptionally small

populations, the Pygmies and the Mountain Ok of New Guinea (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 Yanomamö villages with smallest statures come from highland areas (Parima and Coyoweteri in Venezuela and Surucucu in Brazil, both at about 1,000 meters), whereas those with the tallest statures (Kedi-Washawa and Ocamo) are in the Mavaca lowlands (see table 7.1). The men in lowland villages are seven to ten centimeters taller than Holmes's Parima population.[1] This implies a negative altitude gradient that may be correlated with dietary and disease patterns. There is suggestive evidence that lowland villages (Chagnon 1997) may have better access to food resources. Other than onchocerciasis, which seems more prevalent at high altitudes, our review of epidemiological 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 Yanomamö. In her most recent assessment of their stature, weight, and growth, she argues that the Yanomamö 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 (e.g., Martorell 1989). Holmes also believes that there also may be a genetic component to Yanomamö stature (Holmes 1995: 132, 138).

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

with their geographic position in South America. Consequently, it is uncertain what roles disease, nutrition, and genetics play separately or jointly in determining Yanomamö stature in comparison to that of other Amazonian peoples or within the Yanomamö. 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 Yanomamö health and quality of life is the presence of infectious diseases, the most threatening of which are those of European and African origin. Some of these diseases have spread to the Yanomamö through recent 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), 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-Indians appears to lead to the introduction of new strains that have a devastating effect on the Yanomamö.

The presence of infectious agents among the Yanomamö 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 each infection. 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 Yanomamö 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 patterns of disease and pathogen dispersion as the Yanomamö become more sedentary and have greater exposure to Western diet and lifestyle. For this purpose, acculturated native Amerindian peoples of the same region may provide a model for the effects on health of the acculturation process; indeed, some Yanomamö 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 Yanomamö are the hepatitis viruses. Both hepatitis B (HBV) and hepatitis delta (HDV) have been identified among the Yanomamö. 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/ncidod/diseases/hepatitis/b/fact.htm) 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 chronically infected, and up to 6 percent of adult infections may become chronic. In 15 to 25 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 concomitant HBV infection will become chronic. However, it also causes a more acute infection. Of cases of 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 Yanomamö generally do not have immediate access to the type of emergency care necessary 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 Mavaca villages, HBV was first introduced in 1968 by an American missionary who had reused needles in administering multivitamin complexes to himself and to the Yanomamö in the village (Torres and Mondolfi 1991). It is unlikely that the viruses were present prior to this time. By the time of a 1986 study in these villages (Torres and Mondolfi 1991), 84 percent of eighty Yanomamö 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 7.1 that the number of active infections (either chronic or new) does not decrease appreciably with

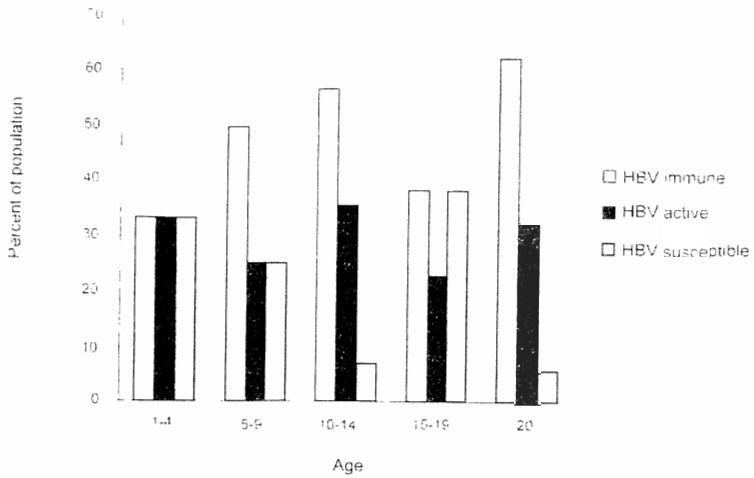

FIGURE 7.1 Hepatitis B virus prevalences in the Yanomamö village of Mavaca (Torres and Mondolfi 1991).

age, which one 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 HDV. As noted previously, those with HBV infection who otherwise showed no symptoms can develop liver damage associated with HDV.

Torres and Mondolfi (1991) 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 HDV infections in this group is likely to be higher than among the general population. Of these individuals, 97 percent had been exposed to HBV, and 53 percent had active infection at the time the samples were collected. After the test for HBV, enough serum remained to test for HDV in only six of the samples. These were tested for the presence of anti-delta antigens, which were present in all six (this prior even to its description in the medical literature in 1977).

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

Intimate contact among the Yanomamö includes the universality of breast feeding, premastication of 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 Yanomamö 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. Tubercles, which form when macrophages attempt to engulf the *Mycobacterium tuberculosis* bacilli, may heal through fibrosis and calcification, and in this state, the infection can remain arrested 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 strains is preventable if proper care is taken with the administration of treatment.

For some groups of Yanomamö, particularly those in Brazil, the disease is likely being contracted through contacts with Brazilians, although some suspect that tuberculosis was first introduced among some Yanomamö through contacts with other Yanomamö from the Apiau and Ajarani region (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-Yanomamö, its prevalence is high. Sousa et al. (1997) found a prevalence of 6.4 percent (40 cases out of 625 people) in a study of five Yanomamö villages in Brazil, which is 100 times higher than the average for Amazonas State, Brazil. Peters (1980) found that among 280 Yanomamö, 3.6 percent had active disease (1980: 276). In addition, he noted there were "40–50 [of 280 Yanomamö examined] suspect cases, either of the pulmonary or intestinal variety" (Peters 1980: 276), or about 16 percent of the population. Apparently these diagnoses were made by "a doctor from the National Division of Tuberculosis" (Peters, 1980: 246)

Measles

Measles and other introduced viral infections can present severe health risk to the Yanomamö. The historical record clearly shows that New World peoples experienced massive population reductions when infected by many Old World diseases. This is certainly due to the fact that, unlike the Europeans, they did not have prior experience with the infections. Whether this is the result of a genetic immunity that is present in Europeans and lacking in Amerindians (see Black et al. 1982) or a consequence of lack of acquired immunity in the community (Neel et al. 1977) is still debated. According to Neel (1979), the high rate of mortality among Amerindians is mostly likely a consequence of their inexperience with the illness that causes nearly all residents of a village to become ill. This leads to a breakdown in the economic and health systems: there is scarcely anyone available to provide food and water to enable the afflicted to fight the illness. Tropical forest horticulturalists have a fundamentally different economic system than temperate land agriculturalists. In temperate environments food is stored in the home for most of the year. Consequently, if an epidemic strikes, the ill can easily procure food from stores within their dwellings. In contrast, tropical forest horticulturalists rely on root crops and plantains which cannot be processed to store for any length of time. In a sense, food is stored in the garden. To acquire food, adults must travel to gardens, harvest the food, transport it home, and prepare it. In addition, on a daily basis they tend to spend even more time hunting, gathering, and fishing than they do gardening (Hames, 1989). The successful acquisition of these foraged resources is beyond the abilities of someone who is ill. In this sort of economic system, villagewide illness is much more likely to prevent the ill from "curing" themselves through adequate caloric consumption and hydration. In experienced populations, however, large numbers of adults have gained some measure of immunity through previous contact with the illness, and they are able to care for those who lack such immunity. Also in modern populations, easy availability of water, food, and medications mitigates the symptoms of disease and associated complications.

In a specific instance described by Neel et al. (1970), it was suggested that the Yanomamö were unlikely to have been exposed to measles in the past. Lack of previous infection was confirmed in 1966 and 1967 with serological evidence: in only two out of eighteen villages did a significant number of individuals test positive for measles antibodies. One of these villages was located near a mission and had been known to have experienced a measles epidemic; in the other, none of the positive responders was younger than twenty-eight years, suggesting that this village had sustained an epidemic of measles prior to direct contact with non-Indians.

Alarmed by this evidence, Neel obtained measles vaccine so he could vaccinate the Yanomamo in 1968. However, measles was introduced to some of these villages by a Brazilian missionary prior to Neel's expedition. Thus they began a vaccination campaign in the midst of a measles epidemic.

Throughout this epidemic, most villages were visited by a government team or by missionaries, and antibiotics were supplied to help prevent secondary infections. For some, especially distant, villages, these were provided late in the infection, however Neel et al. (1970) estimated that of about 170 cases, 29, or 17.7 percent, proved fatal. Most of these were due to secondary pulmonary infection. This toll would certainly have been far worse had the team not been able to vaccinate so many people and provide antibiotics to those infected. It also shows what a devastating effect such an outbreak could potentially have in the future if health care workers do not maintain constant vigilance.

Onchocerciasis

Onchocerciasis was probably introduced to the Yanomamö in the early 1970s (Salzano and Callegari-Jacques 1988: 97) and is now very common in highland communities, where infection in some villages is widespread (Grillet et al. 2001). It has been present in the Americas since the introduction of immigrants and slaves from Africa, where it is endemic in certain regions. Caused by the filarial parasite *Onchocerca volvulus*, it is rarely fatal. However, it can be disfiguring and debilitating; at its worst, it can lead to blindness and to disorders of the lymphatic system.

Some of the most adverse consequences of this infection are related to the host's immune response to the microfilariae. The symptoms of this disease are often similar to a mild to severe allergic reaction, such as itching, cracking, and thickening of the skin, related bacterial infection, and eventual fibrosis. Hanging groin can also result from inflammation of lymph nodes associated with the infection.

Blindness results when nodules form in the cornea or retina of the host. Because symptoms develop over time, however, uninvasive diagnosis of infection can be difficult. Palpable nodules may not be found in all infected individuals; Rassi et al. (1976), for example, found only seventeen Yanomamö with palpable nodules out of seventy-five Yanomamö subjects who had tested positive for microfilariae in skin biopsies.

Species of black fly of the genus *Simulium* serve as the vector for the parasite, including *S. guianense*, *S. oyapockense*, and *S. incrustatum*, although the role of the latter as a vector is undetermined. The prevalence of onchocerciasis seems to be greater at higher altitudes. In a study of biting rates of these three species of black fly, the biting rates of both *S. guianense* and *S. incrustatum* increased with altitude (Grillet 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 at higher altitudes.

Prevalence of this disease can vary greatly from one village to another. Rassi et al. (1976) found that onchocerciasis had not yet appeared in several villages inhabited by the Yanomamö. In Toototobi, however, prevalence of the disease, as determined by palpation, vision tests, skin biopsy, and reactivity to Hetrazan,[2] was 61 percent. In Auaris, prevalence was 25 percent, and in Surucucu, it was 24 percent.

Onchocerciasis may be on the rise, however. Grillet et al. (2001) measured the prevalence of the disease in several villages as well. Although these were not the same villages as those examined by Rassi et al. (1976), prevalence was much higher. They found high rates of infection in highland villages (24 to 80 percent), although in at least one lowland village (Ocamo), the rate was considerably lower (2.4 percent).

Treatment of onchocerciasis is relatively straightforward; ivermectin can rid an individual of infection. However, the real likelihood of reinfection makes vigilance and repeated treatment necessary to prevent long-term physical damage. For this to occur, health 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 Yanomamö health. In several studies conducted among the Yanomamö, *Plasmodium falciparum* has proven to be the most common malaria pathogen (Perez Mato 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 Mato 1998). Torres et al. (1988) found that the titers of antibody to *P. falciparum* were higher than those to *P. vivax* in all but two cases out of fifty-nine studied.

This contrasts with the species distribution common elsewhere, even in Venezuela itself: the average Venezuelan distribution of infections in 1992 was 76 percent *P. vivax* and only 24 percent *P. falciparum*. This is significant to the Yanomamö because, although *P. vivax*, unlike *P. falciparum*, can remain dormant in the liver and thus relapse, the infection caused by *P. falciparum* is often much more acute, sometimes fatally so.

Among some Yanomamö groups, virtually everyone has been infected with malaria at some point. Torres et al. (1988; see also Torres et al. 1997 for additional details) found that of 59 serum samples taken from individuals in Ocamo and Mavaca, all had antibodies to both *P. falciparum* and *P. vivax*. The presence of active infection (determined by the detection of *Plasmodium* species in thick blood smears) 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 (perhaps frequent) periodic epidemics.

Indeed, Perez Mato (1998) found higher levels of *P. falciparum* and *P. vivax* in younger age-groups than in adults in Ocamo and Mavaca in 1992 (figure 7.2). Out of 35 individuals between age six months and ten years of age, 17.1 percent had active *P. falciparum* infection, and 14.3 percent had active *P. vivax* infection. Of twelve individuals between the ages of ten and fifteen years, none were infected with either species. Of those over fifteen years of age, 3.6 percent had *P. falciparum* infection, and only 1.8 percent had *P. vivax* infection. This suggests, though not with certainty,

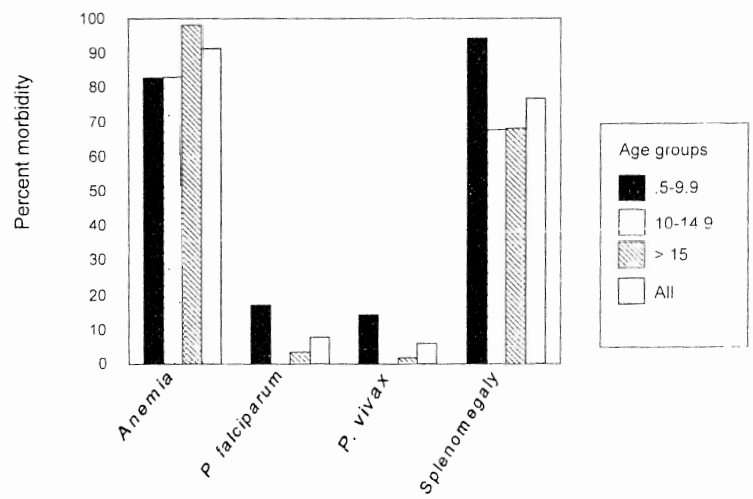

FIGURE 7.2 Malaria and malaria-related morbidity in the Yanomamö village of Mavaca (Source of data, Perez Mato 1998)

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, 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 Ocamo and Mavaca.

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 Coyoweteri and Matoweteri, Laserson 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 14 cases of active *P. falciparum* infections were found in 320 (4.4 percent) samples from both villages. After severe outbreaks in October and November 1994, however, Coyoweteri had a prevalence of active *falciparum* malaria of 45.2 percent (out of 62 individuals) and Matoweteri of 45.7 percent (out of 70 individuals). With this proportion of the population of a village ill, severe economic hardship is a likely result. Ill parents, particularly nursing 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 extreme febrile state reached 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 in turn to hypertension of the portal vein, which conducts blood from digestive organs to the liver, and potentially cirrhosis, a disease in which the tissue of the liver becomes fibrous, resulting in a loss of normal function. Torres et al. (1988) found that 44 percent of individuals in the villages of Ocamo and Mavaca suffered some degree of splenomegaly. An estimated 23 percent of all malaria cases resulted in hyperreactive malarial 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 550 inhabitants (7 percent) of Ocamo and Mavaca had required evacuation for emergency transfusion, due to severe hemolytic anemia.

Perez Mato (1998) found that anemia was ubiquitous in Mavaca in 1992. Of the total population of 103 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 33 individuals in the age range, to suffer from splenomegaly than were adults, at 68 percent of 38 individuals. The presence of splenomegaly in this population was strikingly high, at 77 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

One of the most ubiquitous and persistent health problems facing the Yanomamö 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 reach an equilibrium 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 helminth, such as *Ancylostoma duodenale* and *Ascaris lumbricoides*, as well as a variety of roundworms, flatworms, tapeworms, and filarial worms and protozoans.

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 import in determining the severity and prevalence of infection. The Yanomamö, 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 Yanomamö become more sedentary, unless concomitant measures are taken to ensure proper sanitation such as pit latrines, these infections are likely to increase.

Macroparasites

Ancylostoma duodenale The genus *Ancylostoma* includes the hookworms, of which *A. duodenale* is one of the most common. Hookworm is contracted

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 Yanomamö Venezuelan villages the rates of infection were, respectively, 39 percent and 67 percent, somewhat lower than the rates of 76 percent and 80 percent found by Lawrence et al. (1980) in Mavaca and Patanowateri.

Ascaris lumbricoides *Ascaris lumbricoides* is the most common roundworm worldwide, currently infecting nearly 1.5 billion people. It is also the most common to the Yanomamö. Passed through feces, it requires a two-week incubation period in the soil, after which, if ingested, the eggs are infective. They hatch in the intestinal tract, and the larvae 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.nematode.net/Species.Summaries/Ascaris.lumbricoides/).

This infection is quite common among the Yanomamö; prevalence rates ranged from 73 to 99 percent in four villages (Lawrence et al. 1980; Holmes 1984). Only Confalonieri et al. (1989; cited in Confalonieri et al. 1991) found a range of 6.6 to 14.3 percent, for which the specific villages were not named.

Strongyloides stercoralis This parasite, like the hookworm, is contracted through the skin. The filariform larvae travel to the lungs, from whence they may be swallowed, to take up residence in the intestine and there mature. 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. Confalonieri et al. (1989; cited in Confalonieri et al. 1991) observed a rate of 0 to 3.3 percent in several unidentified villages.

Capillaria Three species of roundworm of the genus *Capillaria* can infect humans, one of which, *C. phillipinensis*, is most common, and two of which, *C. hepatica* and *C. aerophila*, are rare. *C. hepatica* causes hepatic capillariasis, which may result in hepatitis and eosinophilia; *C. aerophila* 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/Capillariasis.htm), the geographic distribution of *Capillaria* species is limited primarily to the Philippines and Thailand, with rare cases reported in the Middle East and Colombia. Confalonieri et al. (1989; cited in Confalonieri et al. 1991) report a prevalence of unspecified *Capillaria* species of 2.8 to 6.6 percent among the Yanomamö, a finding that illustrates the extent to which even very remote peoples may be exposed to diseases and 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 possibly sap nutrients from its host. Of three villages studied (Hurtado et al. 1997), it was found only in the Venezuelan village of Coyoweteri, with an overall prevalence of 5.3 percent.

Mansonella ozzardi *Mansonella ozzardi*, a filarial nematode similar to *Onchocerca volvulus*, is transmitted by black flies and midges. Symptoms of this infection can include hepatomegaly and adenopathy. Torres et al. (1988) found a low prevalence, 1.8 percent in 110 individuals, of this parasite in the Venezuelan villages of Ocamo and Mavaca.

Trichuris trichiura *Trichuris trichiura* is a frequently asymptomatic nemathelminth, although in some cases and especially in small children it may cause pain, diarrhea, or rectal prolapse. There seems to be considerable variation in the prevalence of this parasite. Holmes (1984) found only 9.5 percent in Parima B, but Orinoquito had a prevalence of 53.3 percent. Lawrence et al. (1980) found a prevalence ranging from 68 to 92 percent.

Microparasites

Entamoeba histolytica This parasite, the only member of the genus *Entamoeba* that is pathogenic, is responsible for amebic dysentery and tropical liver abscess. It seems to be common among the Yanomamo, but not

in all locations. Lawrence et al. (1980), for example, found rates as low as 28 percent in one village and as high as 77 percent in another. Confalonieri et al. (1991) found rates ranging from 28.5 to 40 percent.

Giardia lamblia *Giardia lamblia* infection 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 Yanomamö 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 Parima B and Orinoquito.

Toxoplasma gondii *Toxoplasma gondii* is a fairly common infection worldwide that most often is asymptomatic in adults, although it may produce blindness in severe cases. If contracted by a pregnant woman, it can cause congenital damage to the heart, brain, or lungs of the fetus. The only study (Sousa et al. 1997) that has tested for the presence of *Toxoplasma gondii* among the Yanomamö found it in 39 percent of 202 individuals examined.

Nonpathogenic Parasites

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 hartmanni* had a prevalence of 0 percent in one Yanomamö village and of 19 percent in the other. *Chilomastix mesnili* was prevalent in about 10 percent of individuals in one village but was found in more than half of another (Lawrence et al. 1980). *Endolimax nana* infected a quarter to a third of the Yanomamö tested for it (Lawrence et al. 1980). *Balantidium coli* was not found among the Yanomamö (Lawrence et al. 1980); these authors found *Entamoeba coli* to be nearly ubiquitous in two Yanomamö 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 Yanomamö studied bear a heavy parasite burden. Figures 7.3 and 7.4 display the variety of diseases carried by indi-

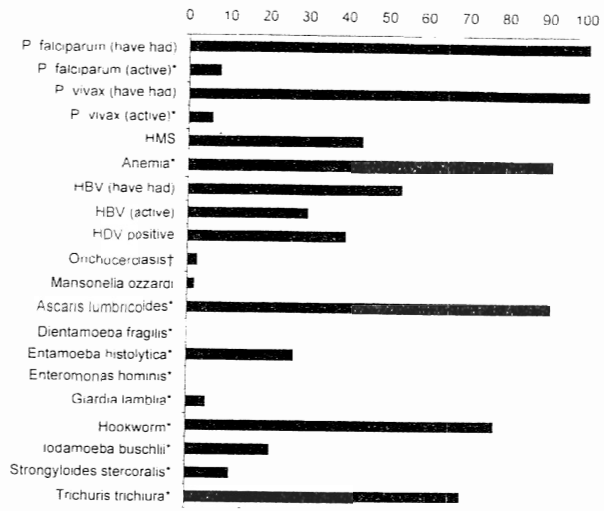

FIGURE 7.3 Disease profile in the Yanomamö villages of Mavaca and Ocamo (Sources of data: Grillet et al. 2001, Lawrence et al. 1980; Perez Mato 1988; Torres and Mandolfi 1991, Torres et al. 2000). Note: diseases without* or † indicate combined mean incidence for Mavaca and Ocamo.

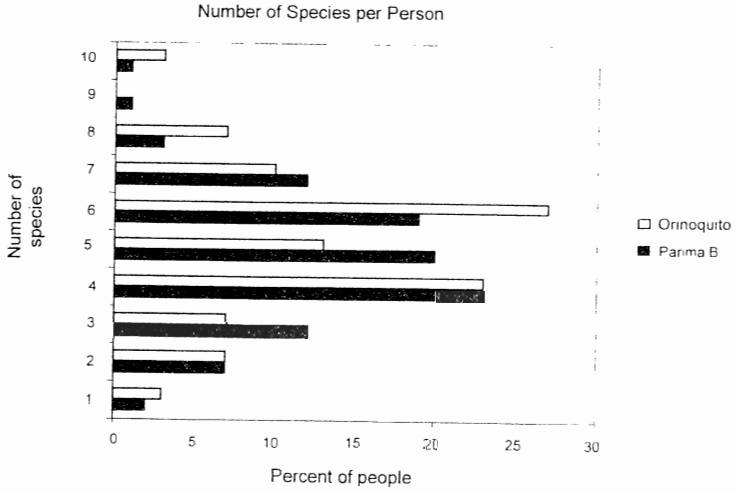

FIGURE 7.4 Number of species of parasites per person in the Yanomamö villages of Orinoquito and Parima B (Source of data: Holmes 1981)

viduals of this tribe. Figure 7.3, compiled from Grillet et al. 2001, Lawrence et al. 1980, Perez-Mato 1988, and Torres and Mondolfi 1991, Torres et al. 2000, shows the incidence of debilitating and life-threatening parasitic and viral diseases at the mission villages of Mavaca and Ocamo in Venezuela. As indicated, everyone sampled had contracted both types of malaria, even though only 5 to 10 percent had active cases. The consequences of malaria, such as anemia (90 percent) and hyperreactive malarial splenomegaly (42 percent, indicated as HMS in Figure 7.3), were common. In addition to malaria and associated conditions, about half of those sampled had hepatitis, and about 40 percent had HDV active cases. The load of intestinal parasites can also be quite high. Figure 7.4, derived from Holmes (1984), shows that members of the highland mission villages of Parima B and Orinoquito carry from one to ten intestinal parasites, with a median range of four to six.

Comparative health data on the Yanomamö at missions and in villages some distance from missions, as well as health data on acculturated native people who are neighbors to the Yanomamö in Venezuela, may allow us to detect changes in health profiles as the Yanomamö become more acculturated. Many of the parasites that afflict the Yanomamö require an incubation period in the soil and are spread through oral-fecal contact or through contact between bare skin and fecal material. As villages undergo acculturation and their inhabitants become more sedentary, it is possible that parasites build up in the soil and water sources, and rates of infection may increase. In addition, population density around missions tends to be much higher than in nonmission areas. For example, one of us (Hames) noted that the Yanomamö population around Mavaca in the mid-1970s was no more than 150 people. By 1986 there were more than 525 scattered in small settlements around the mission (see also Chagnon 1997: 228–229). At the same time, acculturation may lead to the development of sanitation facilities (e.g., latrines) and the availability of vermicides and other medications from missions or governmental health outposts that may moderate any increase in infection that occurs as a consequence of a more sedentary life. Yet it is undoubtedly the case that greater sedentariness and higher population density increase the potential for the spread of infectious and parasitic diseases. How missions or governmental health workers mitigate these effects is key to Yanomamö well-being.

Lawrence et al. (1980) were able to compare parasite infection in two Yanomamö villages with that in three non-Yanomamö (but native) acculturated villages in the same region of the Upper Orinoco Basin of Venezuela. The results are somewhat mixed (Lawrence et al. 1980: 534, their figure 2). For example, they found that hookworm infection (not identified by species) was very common in both Yanomamö villages, with infection rates of about 76 percent in one and about 80 percent in the other. At 93 percent, it was even more common in the acculturating villages, however, suggesting that Yanomamö groups may incur an increase in the already high rates of hookworm infection. These researchers also found *Trichuris trichiura* to be more common in acculturating villages than in Yanomamö villages, although, again, even in the Yanomamö villages, rates were fairly high, at 68 to 70 percent in one village and 90 to 92 percent in another. *Dientamoeba fragilis*, believed to cause vomiting and diarrhea, was found in acculturating villages but not at all among the Yanomamö. *Giardia lamblia* was also less common in Yanomamö villages, at 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 Yanomamö villages of Parima B and Orinoquito (see Holmes 1984).

On the other hand, *Entamoeba histolytica*, responsible for amebic dysentery and tropical liver abscess, had a much higher prevalence among the Yanomamö, from 28 percent in one village to 78 percent in another, than it did in the acculturating villages, where prevalence ranged from 0 to 30 percent. Whereas *Ascaris lumbricoides* was common in both Yanomamö and acculturating villages, in the Yanomamö 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 Yanomamö villages.

These results are difficult to interpret. No straightforward generalization can be made about whether the acculturation process leads to a heavier or lighter parasite burden. There was no apparent pattern dependent 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 parasite load and age-related changes in parasite load. In the Yanomamö villages, a higher average number of species were found per adult person, ranging from 4.2 to 6.8, compared with 3.0 to 4.5 in the acculturated non-Yanomamö communities. This range is nearly identical to what Holmes (1984) found in highland Yanomamö populations (see figure 7.4). In one Yanomamö village, the average number of parasites decreased with age among adults, whereas in the other the average was fairly constant across age-groups.

In acculturating communities, the average number of species per person was lower, from 1.3 to 6.0, with no real trend across age-groups. Finally, in acculturating villages, fourteen different species of intestinal parasites were found, while only twelve species were found in Yanomamö villages.

Another study allows us to compare the Yanomamö to Venezuelan nationals who live in the same area. In this case, the Yanomamö are compared with poor Venezuelan nationals who are more or less fully integrated into the state economy and social system but who live in the same area. Holmes (1984: 389, her table II) was able to compare helminth (*Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Strongyloides stercoralis*) and protozoan (*Entamoeba coli* and *Giardia lamblia*) infection rates in two highland Parima Yanomamö groups with those among the Spanish-speaking residents of San Carlos de Rio Negro. San Carlos has been settled 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 Yanomamö are at a significantly higher altitude. Except for the fact that the Yanomamö have a larger fraction of the population infected by *Ancylostoma duodenale* and both kinds of *Entamoeba*, there are no striking differences. However, the number of parasites per person is much greater among the Yanomamö 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 Parima villages, more than 50 percent of the population is infected by four or more parasites (Holmes 1984: 389, her table I).

It may also be useful to compare Yanomamö villages at different stages in the acculturation 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 acculturated. 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 acculturated mission villages). The lightly contacted village, Patanowäteri (Lawrence et al. 1980), was an exercise in extremes. For almost every species tested, Patanowäteri had either the highest prevalence (*Ancylostoma* sp., *A. lumbricoides*, *T. trichiura*, *E. coli*, and *E. hystolitica*) or the lowest (*G. lamblia*, and nearly the lowest rate of *Strongyloides* sp.). In the case of *Ancylostoma* sp. and *E. coli*, the margin by which they exceeded their neighbors is insignificant, 1.5 percent and 4.5 percent, respectively.

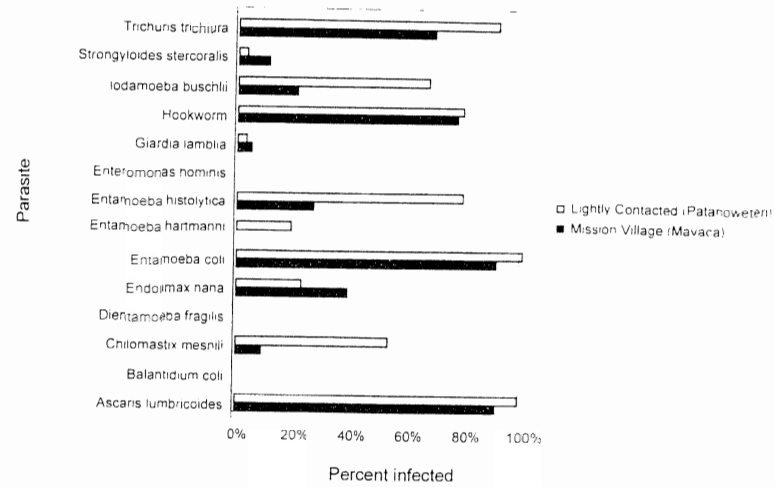

FIGURE 7.5 Parasite loads in two Yanomamö villages with different degrees of acculturation (Source of data: Lawrence et al. 1980).

The prevalence of *A. lumbricoides* was higher by 8 percent in the lightly contacted village. The prevalence of *T. trichiura*, however, was higher by 11 percent. The prevalence of *E. histolytica* was higher by a margin of 17.5 percent. Coyoweteri, an intermediate village, exhibited no such trend (Hurtado et al. 1997), nor did the acculturated mission villages of Parima B, Ocamo, 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. lamblia* were lower in the lightly contacted villages, suggesting that it (as well other infections contracted through the water supply) may be of greater concern for the Yanomamö in the future. For parasites that travel through the soil, results are not at all certain. This may be due to differences in sanitation in more missionized villages, or perhaps the buildup of parasites in the soil is mitigated by having greater and timelier 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 Yanomamö.

Our comparisons of lightly contacted and mission Yanomamö villages on one hand and heavily acculturated non-Yanomamö 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 highly contacted and mission Yanomamö villages than in Venezuelan peasant villages. Over the short term, it seems that increased settlement around missions will have little effect on 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.

Yanomamö 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 steadily to the teen years, and then begin a slow but accelerating climb thereafter. Two excellent demographic studies (Melancon 1982; Early and Peters 2000) provide important information on mortality rates, life expectancy at various ages, and causes of death among the Yanomamö.

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 translate these causes to a Western typology. Infectious diseases such as malaria, influenza, and measles are probably reliably diagnosed by the Yanomamö, 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 (Melancon 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: 201), this percent can vary between 18 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 Melancon's investigation compared with the sixty-six-year period covered by Early and Peters.

Aside from a large difference in unknown causes of death, comparing the two studies is problematic for two other reasons. Melancon does not

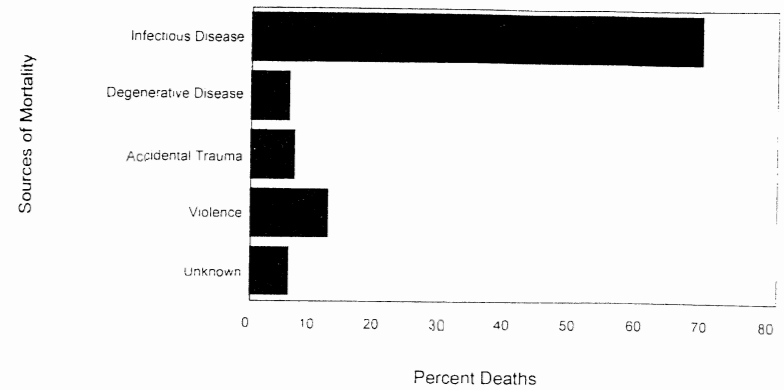

FIGURE 7.6 Causes of mortality among the Mavaca Yanomamo (Source of data: Melancon 1982).

list infanticide as a cause of death, not because it was absent in his area of study but because he decided not to classify such births as live births. This is not unreasonable, since the decision to commit infanticide 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 infanticide as a cause of death, and it constitutes from 5 to 20 percent of all deaths. Second,

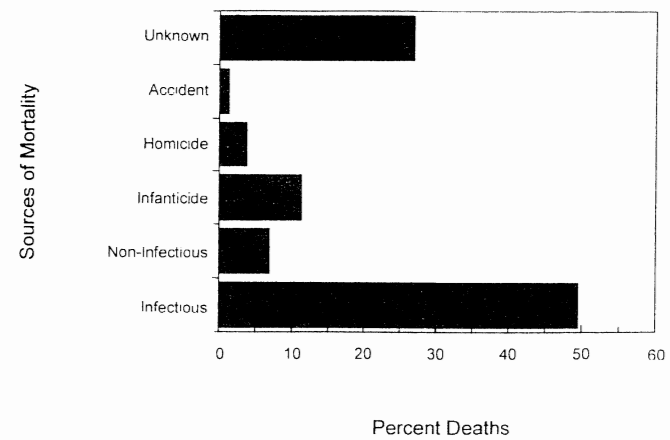

FIGURE 7.7 Causes of mortality among the Xiliana Yanomamö (Source of data: Early and Peters 2000)

although both studies use the category "infectious disease," Melancon has a category called "degenerative disease," and Early and Peters have a corresponding "non-infectious disease" category. Nevertheless, there is probably 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 Yanomamö (although it is much higher for the Mavaca Yanomamö), and the rates of death from noninfectious and degenerative diseases are about the same. For the Mavaca Yanomamö, deaths from infectious diseases are 60 to 70 percent higher for children than for adults (Melancon 1982: 47, his table 3.2). The higher rate of infectious disease for the Mavaca Yanomamo (70 percent compared to 50 percent) to some extent is an artifact of Early and Peters classifying infanticide as a cause of death. If infanticide is removed as a cause of death, infectious disease as a cause of death for the Xiliana increases to 56 percent. And if the large number of unknown causes were known, death related to infectious diseases would be very similar for both populations.

Early and Peters's 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, 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 Xiliana 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 where the main causes for the increased force of infectious diseases as a source of Yanomamö mortality.

There seems to be little difference in survivorship between the two populations. Life expectancy at birth ranges between twenty-nine and forty-six years, depending on contact period, among the Xiliana (Early and Peters 2000: 199, their table 19.5) and is thirty-seven years for the Mavaca Yanomamö (Melancon 1982: 65, his table 3.6).[3] Significantly, the lowest life expectancy for the Xiliana is at first contact; life expectancy

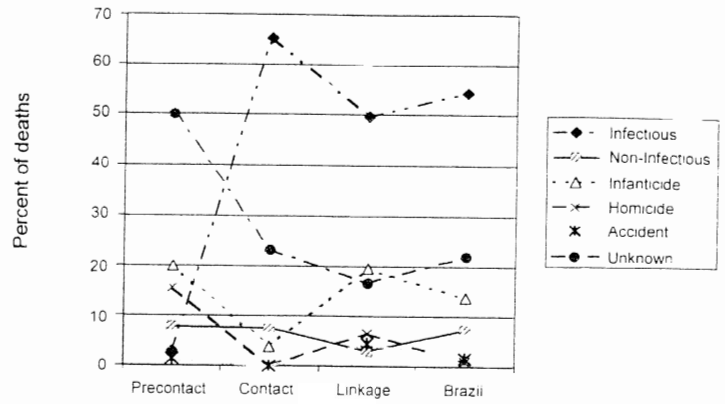

FIGURE 7.8 Variability in causes of mortality among the Xiliana Yanomamo in four periods of their history (Source of data: Early and Peters 2000).

reaches the high point immediately after contact, during the linkage phase, and declines to thirty-five years during the Brazil stage of sustained contact.

Crude birth and mortality rates and their relationship are fundamental 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 (when fertility equals mortality, and the population ceases to grow). Crude death rates for the Xiliana Yanomamö (Early and Peters 2000: 194, their table 19.2a) range from 17 to 56 per thousand, and for Melancon's study (1982: 89), 46 per thousand, which places them in the moderate to high range (Early and Peters 2000: 96) by world standards. Crude birth rates range from 28 to 52 per thousand for the Xiliana (Early and Peters 2000: 194, their table 19.2a) and 59 per thousand for the Mavaca (Melancon 1982: 89). The natural rate of increase is estimated to be 1.25 percent for the Mavaca Yanomamö and 1.12 percent for the Xiliana (derived from Early and Peters 2000: their table 19.2c for all periods). These figures accord well with early estimates by Neel and Weiss (1975: 38). It is important to realize that these demonstrations of Yanomamö population increase are probably not characteristic of growth patterns elsewhere among the Yanomamö tribal distribution, as explained in the following discussion.

Where the Yanomamö 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 Surucucu area

through the Calha Norte initiative and the construction of the BR 210 road provide dramatic examples of this process. In 1987, the Brazilian military took control of the Surucucu and Paapiú regions as part of the infamous Calha Norte project. They then permitted tens of thousands of gold miners to enter the area and expelled missionaries, health officials, and researchers. In 1989 it was estimated that "23 percent of the Yanomami had been killed by malaria or by *garimpeiro* bullets," (Ramos 1995: 277). Ramos also presents data on infectious disease in the area that show astounding increases (400 percent and more) in malaria, malaria-related illnesses (e.g., anemia), respiratory infections, tuberculosis, and malnutrition (Ramos 1995: 278, her figure 11.1). There is no indication of how many individuals or villages these figure applies to.

Earlier, in 1974, the construction of BR 210, a spur of the Transamazon Highway, in Brazil had a devastating impact on the Yanomamö living nearby. Ramos and Taylor (1979) report that medical treatments by local Catholic missionaries (Consolata Order) for viral diseases and their complications, diarrhea, skin diseases, and malaria, increased from 2,485 three years prior to the beginning of road construction to 12,529 three years after the road was completed. It is difficult to know whether this is a consequence of greater access to medical care, a real increase in disease, or a combination of both. A detailed investigation on the mortal consequences of road construction on three villages located within a few days' walk from BR 210 is particularly disturbing. Many Yanomamö died as a result of a measles epidemic that occurred from February to March 1977: in Iropitheri, 35 of the 69 inhabitants died (51 percent); in Uxiutheri, 15 of the 32 inhabitants died (46 percent); in Maxikopiutheri, 10 of the 33 inhabitants died (30 percent) (Saffirio and Hames, 1983: 12).

Colchester (1985: 29) claims that in Venezuela and Brazil, although some Yanomamö populations are holding steady or increasing, other groups are losing population. Citing Migliazza (1982), Colchester (1985: 64–65) suggests that the Ninam (a small ethnolinguistic division of the Yanomamö) in Venezuela and Brazil lost about 25 percent of their population (from a base of 125) as a consequence of introduced diseases from 1963 to 1978. In 1981 this same group was struck by a measles epidemic (Colchester 1985: 65) that caused the death of forty-one persons.

Finally Chagnon (1997) describes mortality rates (actually, percent of people who died from 1987 to 1991) in three types of villages and concludes that health practices of the Mavaca Salesian mission and Yanomamö visiting patterns to missions are responsible for a dramatic spike in mortality rates in villages that have intermediate contact.

Chagnon classified seventeen villages as belonging to one of three categories: mission villages that had "maximum" contact with missionaries, "intermediate" villages that had irregular contact with missions, and "minimum" or distant villages that had little or no contact with missions. Over that period, Chagnon shows, mission villages and distant villages suffered death rates of 5 percent and 6.5 percent, respectively but the intermediate villages suffered a rate of 20 percent. In addition, he compares age distribution data in distant and intermediate villages and finds a severe constriction in the one- to ten-year age cohort among the intermediate villages. This elevated rate for intermediate villages is attributed to an active campaign by Salesian missionaries to draw Yanomamö villages nearer to the mission and to inadequate health monitoring and treatment by missionaries in the context of an unnamed epidemic (or epidemics, Chagnon 1997: 249) that swept through the area. Although this demonstration is superficially persuasive, it presents several problems. There are no statistical tests of significance to demonstrate that the death rate differences are other than random. As mentioned, the epidemic is not named or even characterized, its source is unknown, and what fraction such deaths contributed to the differences between death rates is not mentioned. Finally, the locations of the villages are not specified, nor is the factor of degree of contact clearly operationalized.

Independently of these problems, the study demonstrates, at least in microcosm, the devastating effects of epidemics caused by direct or indirect contact by outsiders and is consistent with findings elsewhere on the Yanomamö, such as Neel et al.'s (1970) account of the 1968 measles epidemic. It also demonstrates the inherent dangers of attracting native peoples to the outposts of civilization even if it is believed to be in their best interests (Cowell 1973).

Conclusion

The Yanomamö suffer from extraordinary high disease loads as demonstrated by high mortality rates and short stature. This leads us to suspect that there is a synergetic relationship between high parasite loads (e.g., malaria) and chronic infections (e.g., hepatitis) that slows growth and ultimately reduces stature in adults. Short adults produce short children who are unable to mount adequate immune responses without compromising growth. It is also possible that chronic illness reduces adult economic productivity, leading to lowered nutritional intake, which increases mortality and slows growth.

There seems to be sufficient variation among Yanomamo in regard to stature and weight differences to allow researchers to attempt to untangle the relationship between disease, diet, and growth. For example, some lowland groups are approximately eight centimeters taller (see table 7.1, Kedi-Washawa Yanomamo villages) than highland groups. If we were to compare the tallest Yanomamö lowland groups with other Amazonian ethnic groups 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 does not indicate any clear differences. Even if such differences were detected, they might not be revealing without additional data on intensity of 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 reduce growth and how diseases interact 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 Hagen et al. (2001) showed that skinfolds of children in a lowland group at the village of Cejal were similar to those found by Holmes (1985) in her highland research, but they presented lower skinfold measurements than those taken in other lowland villages studied in 1987. The lowland village of Cejal 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 (Hagen et al. 2001), but their skinfold measurements were significantly greater than those of food-stressed Cejal or the highland measurements made by Holmes (1985). 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 (1993) 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 horticulture. Plantains and manioc, staples of the Yanomamö 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 complexly, it may be that a better diet may counteract the stunting effects of chronic illness.

Regardless of the possible role of dietary differences in Yanomamö growth, we believe we have amply documented that disease is a major problem that affects all Yanomamö. Many of the most mortal and debilitating illnesses are spread as a consequence of contact with non-Yanomamö people. Some diseases such as measles and influenza periodically sweep through the Yanomamö 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 Yanomamö. Their persistence as a chronic feature of Yanomamö 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 illness can be 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 a long-term breast-feeding, premastication of food, and the sharing of body piercing objects enhance its spread. The widely used BCG vaccine for tuberculosis, for unknown reasons, appears to have limited efficacy for the Yanomamö. For these reasons and many others, any attempt to develop appropriate campaigns to reduce disease among the Yanomamö must be accompanied 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 Spielman, da Rocha, and Weitkamp's (1972) 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. Hetrazan is a medication that kills the microfilariae infecting 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 (1982), 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

use his empirical life expectancy at birth to make it consistent with that of Early and Peters (2000), who do not use stable population models.

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