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Global Environmental Change: The Health and Environmental Implications in Brazil and the Amazon Basin

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An epidemiological transition characterizes Brazil today. Infectious disease rates have declined in the past four decades, and the prevalence of chronic diseases such as cardiovascular diseases has increased. The poor in cities experience both chronic and infectious diseases. Previously controlled endemic diseases, such as Chagas' disease, have been reintroduced to urban areas by the poor leaving rural areas. In the Amazon, arbovirus infections and malaria show increasing incidence. Indigenous people suffer from introduced diseases on contact with new settlers to the region and from chronic undernutrition. Gold mining has been associated with the release of thousands of tons of mercury and mercury levels in humans is approaching dangerous (Minamata) levels.

1. Introduction

Like many other rapidly developing countries, Brazil is increasingly characterized by the epidemiologic transition typical of industrialized societies. Between 1940 and 1980 mortality declined from 18 per 1000 to 6 per 1000 people and life expectancy at birth has increased by twenty years during the same period. Whereas infectious diseases caused 39 to 60% of all deaths depending on the region of the country in 1940, by 1980 infectious diseases accounted for only 3 to 16% of deaths.[1] The reverse trend is shown by cardiovascular diseases which accounted for only 9 to 13% of mortality in 1940 but 20 to 38% in 1980.[1] During this epidemiological transition, however, there is evidence that the poor suffer from a double jeopardy. They experience the chronic diseases typical of urban-industrial society, but also continue to suffer from infectious diseases which are re-introduced into areas where disease vectors were previously controlled; factors which are further exacerbated by conditions of poverty.[2]

Brazil's gross national product makes it the eighth largest economy in the world, but its income distribution is one of the most uneven. Land concentration and use of violence against small landholders has made land access increasingly tenuous for many rural people. In addition, prices of agricultural commodities have often been used to gain the favor of urban populations rather than to ensure the viability of the small family farm. All these trends foster a precarious health situation for much of Brazil's population.[3]

In this article we review the range of health and environmental threats experienced by Brazilians today. We propose that the traditional dichotomy between health conditions in underdeveloped/rural areas and urban health infrastructure and improvements is changing as the rural poor migrate to cities, and previously controlled diseases are re-introduced into urban areas This change presents a new challenge to public health not only in Brazil but throughout the developing world.

2. Environmental and Health Changes in the Amazon

The forces of modernizing society have reached deep into the remote Amazon. Beginning in the 1960's Brazil's government sought to politically and economically integrate the vast Amazon Basin with the rest of the country.[4] To do so, Brazil has built roads, towns, and other infrastructure in the Amazon to attract settlers and promote economic activities that would link this relatively isolated region to the developed regions of the south of Brazil.

The roads have attracted significant numbers of people to this area and land distribution schemes have accelerated the process further. In the state of Rondonia, for example, the population increased by 16% per year during the 1970's, as a result of in-migration. These explosive rates of population growth may be found in every state of the Amazon region.[5]

Many of the changes that have negatively affected the health of Amazonian residents have followed environmental changes brought about by economic development schemes. For example, the bulk of the land cleared by migrants is not devoted to permanent agriculture, but degenerates to low quality pastures or returns to secondary succession or becomes fallow.[6] The clearing of forests has a number of effects. First, new settlers are brought into direct contact with arboviruses which previously had affected only nonhuman sylvatic vertebrates.[7] Second, it leads to increased ground temperatures. Moreover, roads disrupt the natural flow of streams, and stagnant lakes that harbor malaria-carrying mosquitoes form throughout the region. Cases of malaria occur along these new roads which open up the forest to settlement. The prevalence of malaria increased by 24% per year during the early Transamazon colonization period of the 1970's.[8] Today the WHO estimates that over 90% of the malaria cases in the Americas occur in Brazil.[9]

Indigenous people have suffered recent decimation due to viral diseases to which they have little resistance, such as the common cold, measles, influenza, and chickenpox. These diseases are responsible for the 40 to 90% mortality among these people.[10] As in the case of the first historical contact of Native Americans with Europeans, the pattern has been repeated in the past three decades as roads penetrate deep into the Amazon interior. This pattern has been repeated several times among Amerindian groups. For example, the Suruí Indians of Rondonia experienced 50% mortality in the first decade of contact with Brazilians, resulting in an age/sex population distribution in 1974 that clearly showed the high mortality of 0–4 year olds and the elderly, and notable increases in mortality among those over 45 years of age (Fig. 1(a)). Like other indigenous groups with access to health care, the Suruí are now reproducing and surviving, as seen from the population figures for 1984 (Fig. 1(b)). Coimbra estimates that Amerindian deaths on the initial contact with settlers can be reduced by as much as 50% by providing vaccination and in situ health care at that time.[11]

(a)

(b)

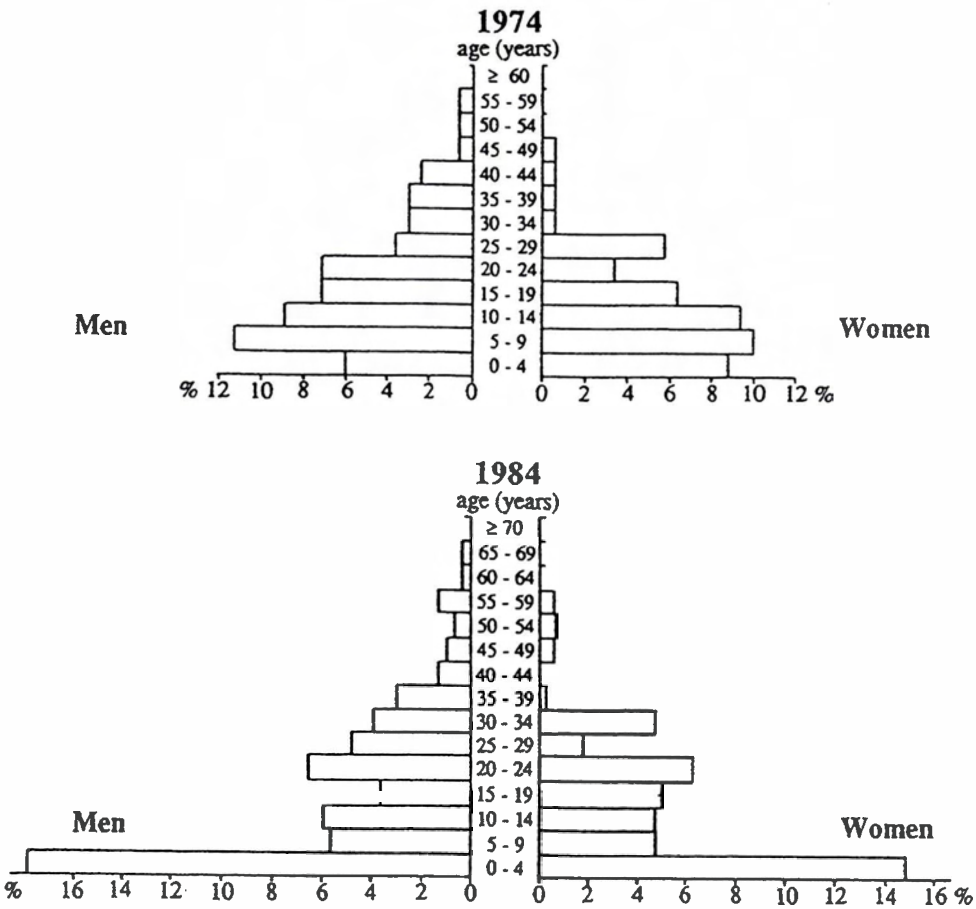

Fig. 1. (a) The impact of epidemics among elderly and 0–4 year old Suruí Indians is evident in the age/sex pyramid for 1974. (b) Once the initial decimation period is past, catch-up fertility occurs as evidenced by the 0–4 year olds among the Suruí Indians in 1984.

However, adoption of Western eating habits, agricultural practices and markets often leads to deterioration in the subsistence activities and nutritional status of native Amazonians.[11–13] Indigenous children today tend to be short and light for their age, although they maintain appropriate body proportionality, as determined using accepted weight-for-height standards.[12] This suggests a certain degree of stunting due to chronic undernutrition. In addition, changes to less nomadic residence patterns and reliance on impure water sources mean that the Suruí, like other rural Brazilians, find that malaria and gastrointestinal infections have become an ever-present threat to health and nutritional status.[11]

Roads have provided access not only to migrant farmers but also to gold miners. Wood and Carvalho[5] estimate that one million people moved to the Amazon during the 1970's. The great flow of migrants into the Amazon in search of gold took place in the 1980's following the discovery of gold in Serra Pelada in 1979 when the peak price of gold reached US$850/ounce. Gold mining has touched most regions of Amazonia and is greatly responsible for the uncontrolled increase in the prevalence of malaria in the Basin. While malaria in the Amazon had been brought under control by 1960, it has re-emerged due to the use of mining pits and dredges to pump bottom river sediment or upland forest soils into sluices where the particles of gold accumulate. When miners leave the area, they also reintroduce malaria and yellow fever into areas of Brazil once free of these diseases.

In addition, there are potentially serious health effects from high levels of metallic mercury exposure during gold mining. Mercury is used to bind the gold, which is then separated from gold, using a blow torch to volatilize the mercury. This volatilized mercury gradually accumulates in the aquatic food chain. Unlike in the now famous case of mercury poisoning in Minamata, Japan, where a single industrial source polluted one local fishing area, in the Amazon region thousands of mercury sources pollute the waters. Brazilian mining agencies estimate that 300,000 miners were distributed among 1800 gold fields in the Amazon in the early 1990's. To date, some 3,000 tons of mercury have been released into the environment, compared to the 200 to 600 tons dumped into Minamata Bay.[14]

Because miners in the Amazon are spatially dispersed, non-industrial and virtually unregulated entrepreneurs, there is no clear way to mobilize local public opinion to stop mercury input into the food chain. In a study in the Rio Madeira, 51% of people in a population *not* engaged in gold mining had total mercury concentrations in their hair of above 10 parts per million (ppm). This bioconcentration of mercury is due to the high level of consumption of fish caught downstream of gold mining sites. More significantly, among women of reproductive age, 24% had total concentrations of above 15 ppm. Only 2% of those included in the study had in hair mercury concentrations of below 2 ppm, but 3% had ones of above 50 ppm.[15] These levels are approaching those associated with the neurological symptoms described as "Minimata disease", but given the isolation of the region, potential cases are unlikely to receive medical attention. Only recently have field surveys been undertaken in limited areas in an attempt to identify clinical effects of this exposure.

Another source of mercury is related to the process of deforestation and burning of biomass in Amazonia Between 1975 and 1988 an estimated 10% of the forested regions of the Amazon were cleared and burned (approximately 588,000 square kilometers). In these few years Brazil became the fourth largest contributor of atmospheric carbon, after the USA, Russia and China, principally through deforestation activities. In areas with good roads and attractive natural resources, up to 50% of the forests have been cut in the past twenty years.[6] About 90 tons of organic mercury are conservatively estimated to be emitted into the atmosphere and precipitated in aquatic ecosystems annually.[16] The actual amounts may be more than six times this value.

3. Chagas' Disease

Man-made changes in the environment also result in other cases of shifting disease patterns. The control of Brazil's most common endemic diseases, Chagas' disease, malaria, and yellow fever, has been promoted by the Brazilian government since the early decades of this century. This is not only a matter of public health interest, but is also viewed as part of a larger effort toward national and rural frontier development.

Brazil has the largest territory in which Chagas' disease is endemic in all of Latin America. An estimated one-third of its population is at risk. Prevalence is estimated at 16% for urban areas, and between 20 and 84% in highly endemic rural areas.[17] Brazil has an estimated 6.3 million cases of Chagas' infection, and 200,000 new cases are identified each year. Of those infected, 1.5 million show overt clinical symptoms[18] and one-third exhibit abnormal electrocardiograms of significant heart disease.

In terms of morbidity and mortality, Chagas' disease is estimated to cause 10% of deaths in adults aged 45–65, and is the leading cause of death due to infectious disease in this age group. It is the third leading cause of people retiring due to disability in Brazil (*e.g.* 10% of all disabled).[19] With annual direct medical costs of US$ 250 million,[20] and US$ 5 billion in work-related losses, it is the second most costly endemic disease after malaria.

The etiologic relationship between *Trypanosoma cruzi*, the disease agent, and vector-host *Triatoma* species insects, particularly *T. infestans*, was identified at the turn of the century. The focal habitat of *T. infestans* is the walls of the adobe houses of the rural poor. However, appropriate insecticide control did not become readily available until after World War II. Given other emergent public health crises in Brazil, the national program for Chagas' Disease control was not implemented until the early 1970's by Brazil's Superintendencia de Controle da Malaria (SUCAM), and was modeled on the malaria eradication campaign which was so successful during the 1940's and 50's.

By the mid 1980's vector-human transmission by *T. infestans* had been virtually halted due to intensive coverage of households in endemic regions of the country, at a cost of $US 15–20 million/year.[18] Today, *T. infestans* is present in fewer than 10% of counties in Brazil's endemic regions, and one-third of the original endemic counties are now under surveillance only.[21] The SUCAM Chagas' disease control program has been proclaimed an exemplary success by supporting organizations such as the World Bank and WHO, and has been introduced in six other Southern Cone countries.[22]

As for most endemic diseases, however, this is not the end of the story. *T. infestans* is only one of approximately thirty known important vector species in Latin America, of which 16 species present a significant public health threat. Secondary vectors, besides *T. infestans*, have now begun to infest Brazilian households, as shown by the increase in *T. sordida* of a study site in Minas Gerais (Fig. 2).[23] Re-emergence of other vector species is really only one piece of this complex picture of human-environment change. Today 75% of *T. cruzi* infected insect specimens are not captured in houses, but are found in the immediate environs: in storage areas, wood piles, barns, or chicken coops. It has been suggested that the gradual "domestication" of secondary triatomine species has evolved as humans gradually invade and destroy the insects' natural habitats. The secondary vectors are notoriously difficult to control because they thrive equally well in houses (which are easy to treat with insecticides) and outbuildings (which are not easy to treat with insecticides).[21]

Historical data also suggest that the early control of Chagas' disease in São Paulo state is partly explained by the decrease in population in rural areas when coffee plantations replaced small farms, and industrialization attracted workers to the cities.[23] We found similar shifts in population in the Triangulo Mineiro region of the state of Minas Gerais in the three years following the inception of the control program (1976). Remarkable success was achieved in reducing the number of *T. infestans*-infested households per community from 12% of domiciles in 1978 to 5.5% in 1985.[24] However, between 1976 and 1979, mean household size decreased from 4 persons per household to 3.5, and there was a net reduction of about 4% in the total number of houses per community each year, for that period[24] These data are supported by the results of longitudinal community studies. In a Goiás site annual decreases in population are estimated at 10–15%.[25] Fewer dwellings and residents mean loss of human blood sources in rural communities to support *Triatomine* populations.

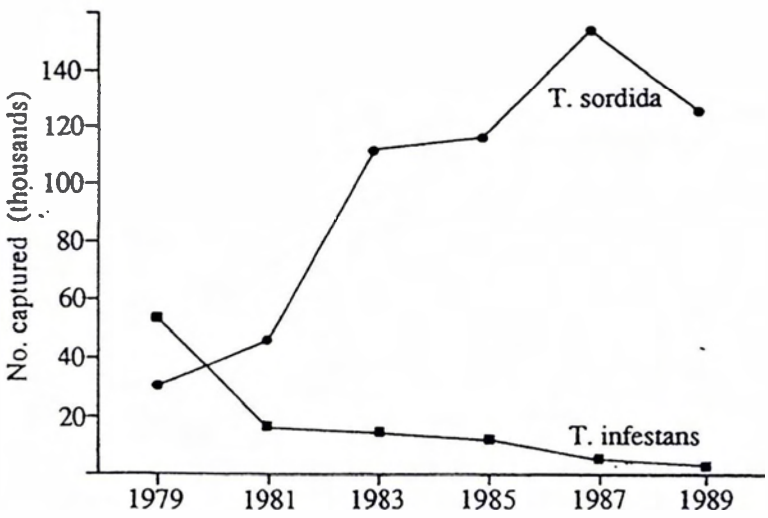

Fig. 2 Numbers of *T. infestans* and *T. sordida* triatomines captured in Minas Gerais under the National Health Foundation's Chagas' Disease Control Program (CDCP), 1979–1989.

Interestingly, while the overall regional prevalence of *T. infestans* infestation was greatly reduced, we identified four factors which promoted recurrent community and household infestation, even in cases which continual spraying and surveillance activities were carried out. These are the presence of secondary vectors,[19] crowded living conditions, the rate at which a community demolished old homes (but did not replace them), and living next to an infested house. A subsample of house infestation reports for an eight year period for one county in the Triangulo Mineiro region were taken from the end of the phase of all-household spraying, to a phase of surveillance only (1978–85). Approximately half the 700 cases had but a single reported infestation while the rest averaged two or more infestations. *Triatomine* infestation remains predominantly a "rural" problem—that is, 74% of all infestation cases occur in communities with less than 50 households and recurrent house infestation is five times more likely to occur in a rural household. In rural settings, long-term house infestation is three times more likely to result from infestation in an adjacent neighbors' houses, or where the household has multiple outbuildings to shelter vector insects, than homes without these characteristics.

In urban residences, recurrent infestation is associated with crowded living conditions, but in rural households it is not. Crowding obviously increases the risk of disease transmission. The association between crowded living conditions and long-term vector insect infestation may simply reflect greater poverty or behavioral differences of long-term infested urban households. A similar association between crowding and infestation has been reported for a rural community in northeastern Brazil.[26]

Homes made of concrete blocks, were also more likely to be infested recurrently than those made of adobe or wood. Both crowding and concrete construction were more common in urban than rural areas during the late 1980's in our study sample. In time, concrete or wood construction may replace adobe in both rural and urban settings. Infestation may appear to be more difficult to control simply because these sturdier houses are more likely to be continually inhabited, and to fall under surveillance for a longer period. As rural migrants replace their housing with modern concrete block homes, they also may import vector insects or insect-promoting habits.[26]

Rural migration to crowded shanty-town urban areas has changed not only the demographic, but also the endemic disease map of Brazil (Fig. 3). While the focus of the control program remains control of secondary vectors in the rural environment, the increased potential for Chagas' disease in urban population has been suggested by Dias *et al.*[19] and by outbreaks along major human migration routes.[27] The prevalence of Chagas' disease is increasing, not decreasing in these areas. For example, an estimated 3–5% of the unskilled urban labor force is believed to be infected, and this figure could reach 12%, depending on the workforce surveyed,[28,29,19] and is thought to be the result of in-migration of infected persons from rural areas. However, the relationship between vector presence and prevalence of infection in the fast-growing shanty areas of Brazil has not been well studied. The potential for new foci of Chagas' disease infestation has been suggested by the re-introduction of other vector-borne endemic diseases to Brazil's urban south.

In Brazil's political climate there is a movement to eliminate "disease-specific" and "vertically integrated" endemic disease control programs, like its malaria and Chagas' disease control programs. National shifts in control priorities may be difficult to achieve,

Fig. 3. Endemic disease map of Brazil.

while a community and household level program may provide greater flexibility in meeting local changes in human and environmental conditions. Recent experiments in monitoring by "community guards" revealed that over 60% of infestation cases can be accurately reported by the householders themselves.[30,31] Such involvement not only promotes community health education and disease reduction, but is also cost effective. One WHO researcher notes that while rural residents generally recognize the threat of Chagas' disease and its insect vectors, a recent survey of urban residents of inspected houses revealed that four-fifths of respondents did not recognize the vectors in their midst.[30] What may not be obvious, however, is the need for centralized surveillance for monitoring disease outbreaks, shifts in local vector species and identifying communities at risk.

4. Conclusions

The population of Brazil is already over three-quarters urban, and is expected to be 90% urban by the year 2000. In São Paulo, Brazil's industrial production center, with over 85% of total industrial output, the prevalence of chronic respiratory diseases is rapidly increasing.[32] Health problems of the contemporary world—urban violence, AIDS, hunger, cancer, occupation-related disabilities, and cardiovascular disease—are major causes of poor health among urban populations of all socio-economic classes.

With Brazil's economic growth it might be expected that the epidemiological transition is complete. Instead, we see the spread of diseases previously restricted to rural areas, such as the spread of dengue fever and malaria, in major urban areas. In 1991, for example, 51,695 cases of dengue fever were diagnosed in Rio de Janeiro.[33] As municipal authorities fail to keep pace with explosive urban settlement, inadequate sewage disposal and potable water supplies make cholera and other gastrointestinal infections a persistent threat. Poor drainage and lack of sanitation and other public health services mean growing threats from vector-borne diseases. Outside of the urbanized Southeast of Brazil, for example, sewage facilities are available to only 8–30% of the population.[34] Low quality housing also encourages malaria and Chagas' disease vectors. These conditions, prevalent in underdeveloped rural areas, are now combined with the threat of diseases of industrial societies.

In conclusion, Brazil is experiencing major environmental and health transitions as we approach the end of the millennium. The 1980's were a disastrous decade for the poor of Latin America and were known as "the decade of destruction." This was the period when much Amazonian deforestation took place, and Amazonian environmental change began to have measurable consequences for the global environment and human health. Habitat degradation provides new opportunities for a large number of endemic diseases. The burning of fossil fuels and tropical deforestation are contributing to global changes in the earth's climate that will result in the extinction of some species while others might thrive. Global warming and changes in drainage and forest cover may allow malaria and other vector-borne diseases to spread further into the temperate world and into urban areas.[35] These threats, while serious for countries with ample economic means, are even more threatening to countries with fewer resources where even reallocation of national funds will be insufficient for meeting the new threats brought by global environmental change. The last four years of this century need to be dedicated to addressing these health and environmental needs which will be with us well into the next millennium.

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