HEALTH IMPACT OF DRAINAGE AND SEWERAGE IN POOR URBAN AREAS IN SALVADOR, BRAZIL

By

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"Of all preposterous assumptions of humanity over humanity, nothing exceeds most of the criticisms made on the habits of the poor by the well-housed, well-warmed, and well-fed."

HERMAN MELVILLE,

Poor Man's Pudding and Rich Man's Crumbs, 1854.

Abstract

The lack of environmental sanitation measures is a world wide problem, especially in developing countries, and greatly facilitates the spread of disease.

This thesis aims to contribute towards a better understanding of the effect on diarrhoea, nutritional status and intestinal nematode infections of drainage and sewerage in an impoverished urban environment. After an extensive literature review of some relevant aspects of the health impact of environmental sanitation, field research was designed and conducted in nine poor urban areas of the city of Salvador (pop. approximately 2.3 million), capital of Bahia State, in northeast Brazil.

The study was targeted to a sample of children under 15 years old living in the poor urban areas of the city at the time of the field work (August/89-November/90). An extensive questionnaire was applied to collect information on each child and on the conditions of the family and the household, three stool examinations of the children 5-14 years old were performed (to measure nematode infection and reinfection), diarrhoea was monitored fortnightly, in children under 5 years old for one year, and anthropometric measurements taken every two months.

The results showed that among children in neighbourhoods with unimproved community sanitation the incidence of diarrhoea was consistently higher and the nutritional status, expressed by the mean height-for-age z-score, was significantly lower throughout the study period as compared to those with improved sanitation. Regarding intestinal nematode infections, as the level of community sanitation improves, the following trends were noted: prevalence and intensity of infection and reinfection declined, risk factors for infection became more numerous and more significant, clustering of cases by household became more significant, predisposition of individuals to reinfection and to heavy infection became more marked, and infections with different species were increasingly aggregated in the same individuals.

These results suggest that sewerage and drainage can have a significant effect on diarrhoea, nutritional status and intestinal nematode infections and that the evidence of the health impact was strongest for intestinal nematode infections.

The interpretation of these epidemiological findings in the light of the Brazilian health, urban and social policies contributes to a comprehensive framework for the control of nematode infections, diarrhoea and malnutrition in poor urban areas of Salvador and elsewhere.

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CHAPTER 1

Introduction

1.1. Introduction

Few studies have investigated the health impact of community environmental sanitation, and few epidemiological studies have investigated impact on diarrhoeal diseases, nutritional status and intestinal nematode infections, as facets of the same phenomenon and focused on urban areas. However, this present study, following a prospective design, was centred on aspects of health impact of environmental sanitation in poor urban areas using as indicators diarrhoeal diseases, nutritional status and intestinal nematode infections.

There are a number of direct and indirect benefits which environmental sanitary improvements are likely to provide (CVJETANOVIC, 1986; OKUN, 1987,1988). Direct benefits by preventing the spread of excreta- and water-related diseases, including reductions in morbidity or mortality from several diseases, an easing of the physical burdens of daily life and increased time for parents - mainly the women - to engage in child care and other activities. The secondary or indirect benefits are potentially more numerous and diverse, although they may be difficult to document or quantify. They include mobilization of the community for other activities once an organization for environmental sanitation has come together, satisfaction from living in a healthy environment, improvements in nutritional status, reduced costs for health care, freeing of health service for attention to other problems, improved school attendance and enhanced agriculture and commerce. Thus, environmental sanitation improvements are potentially so far-reaching, that their full benefits might best be described as an improved quality of life in the community.

In this thesis, "sanitation" refers to community excreta and sullage disposal.

1.2. Urbanization, health and environmental sanitation

1.2.1. Urban growth and the urban poor

During the past 30 years, significant increases have taken place in both world population and in urbanization. In 1950, out of a total world population of 2.5 billion, 28% were living in urban areas; by 1975 this proportion had reached 39% and by the year 2000, if present trends continue, nearly half the world's expected population of over six billion will be residing in urban areas (UNITED NATIONS, 1985).

The direct result of this urban population explosion has been a tremendous increase in the number of squatter settlements in urban areas and the growth of cities which are unserved and underserved by infrastructure and public services.

According to HARPHAM and STEPHENS (1991), about a third of the population of the cities in developing countries live in slums and shanty towns and, by the year 2000, perhaps as many as 2200 million people will inhabit these cities.

Urban population growth in Latin America and the Caribbean is proceeding at an average annual rate of 3.6%, with a total urban population in 1985 of 279 million. The total population is growing at only 2.4% (UNITED NATIONS, 1987a). This implies that the rural population is stabilizing at around 126 million and the demographic increase is being absorbed mainly by the cities.

According to the World Health Organization's 1985 estimates (WHO, 1987a), only 41% of this burgeoning Latin American and Caribbean population has access to sewer systems and over 90% of the waste water collected is discharged directly to receiving waters, often in or near squatter settlements, without treatment of any kind. Another 38% of the urban population is served by on-site sanitation options. This leaves 59 million urban dwellers without access to acceptable sanitation services, most of whom inhabit low-income communities that typically surround the urban centres. Urban growth by the year 2000 means that there will be 141 million additional persons requiring this service. Needless to say, sewerage and excreta disposal is and will remain a leading public health and environmental problem (BARTONE, 1990).

Estimates are that, at present, an average of 50% of the world urban population live at the level of extreme poverty, in slums and squatter settlements, with this figure rising as high as 79% in some cities (HARPHAM *et al.*, 1988). By the end of the twentieth century, the urban poor may represent a quarter of humanity.

"The poor living in the slums and shanty towns of most cities of the world have inadequate housing, sanitation, clothing, and food; have limited information, education, and voice; are systematically prevented from exercising the rights that other people take for granted. From the economic point of view they are considered a burden, and from the health point of view, a danger" (WHO, 1988).

The low-income population in the developing world, however, are not "poor" in terms of skill, ingenuity, social identity, traditions, culture or personal dignity (and other attributes of human "richness"); they are poor in the sense that, in the context of rapidly-evolving social values, based on monetary values and on exchange of material goods, they cannot meet their own needs.

1.2.2. Urbanization in Brazil

In Brazil, the proportion of the population living in urban areas increased from approximately one-third in 1940 to more than two-thirds in 1980, and to three-fourths nowadays.

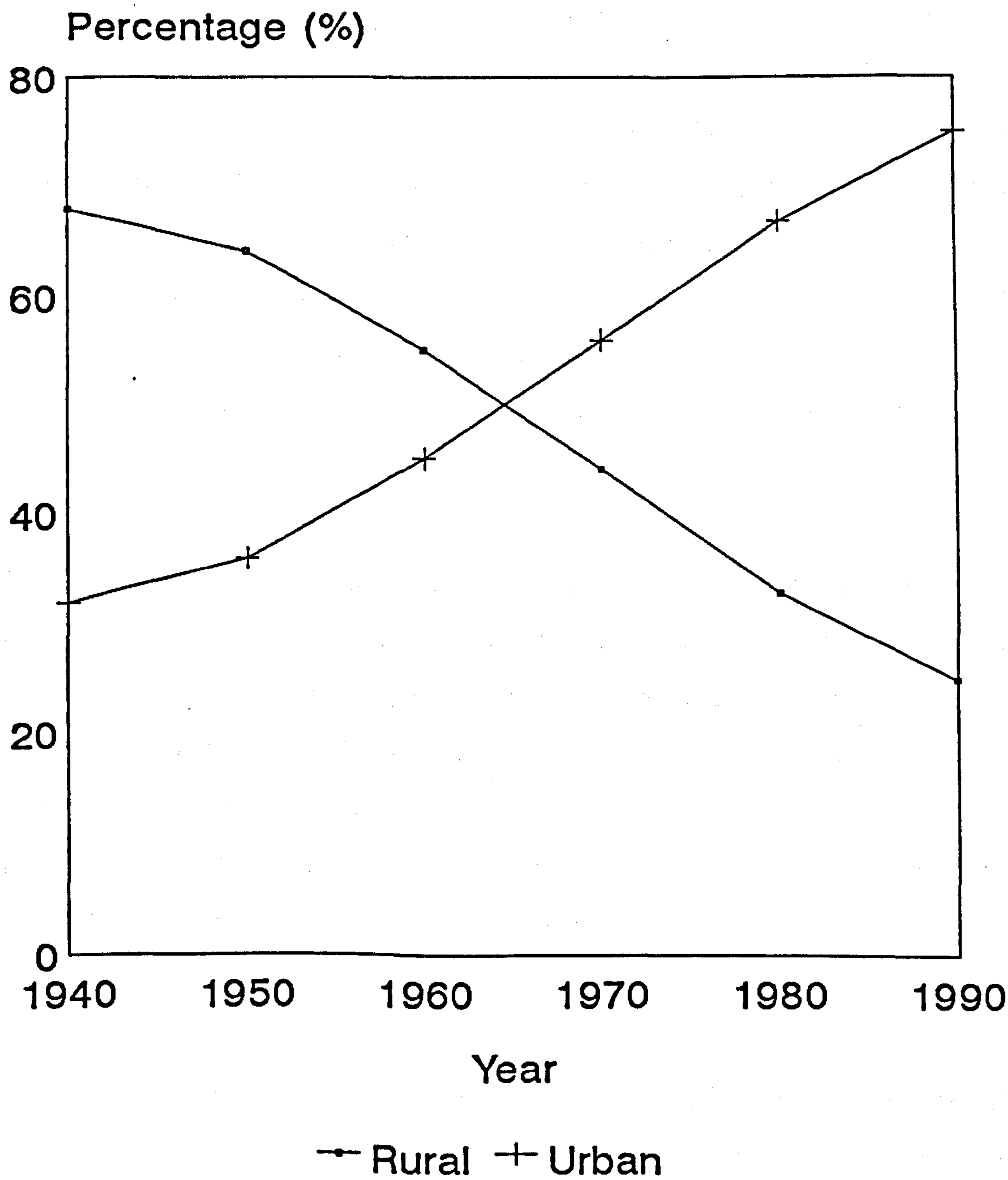
The percentage of the total population living in cities with more than 1 million inhabitants doubled between 1960 and 1980.

In 1990, 75% of the Brazilian population lived in cities (Fig. 1.1) and if current trends of demographic growth continue, in the year 2000 about 80% of the population, more than 120 million people, will live in cities.

1.2.2.1. Environmental sanitation in Brazil

The rapid urbanization, due to the urban industrialization and the change of agrarian profile in Brazil, that led to the shift of the distribution of the population between the rural areas and the cities in the middle of 1960s, brought the appearance of squatter settlements ("invasões" or "favelas"), a growing urban population density and an urgent need for infrastructure to prevent a deterioration of the quality of life in the cities. Thus, a National Plan for Sanitation and Water Supply (PLANASA) was formulated in 1971, directed to the solution of these problems in urban areas and at a national level. Its philosophy of economic and financial viability led to a complete separation between the sanitation measures

Fig. 1.1. Rural and urban population in Brazil, 1940-1990



(water supply and excreta disposal) and the public health (FREITAS *et al.*, 1990). The main orientation of the sector changed from the health perspective which envisaged sanitation as one of the basic actions necessary for the population's health, to a view of sanitation as a consumer good. Considerable progress has been made with water supply and moderate success with excreta and sullage disposal. The percentage of the urban population supplied with water increased from 45% in 1970 to 88% in 1990. During the same period, the percentage of the urban population connected to a sewer increased from 22% to 35%. It is estimated that around 10% of the sewage collected is subject to treatment and adequate disposal (CIMA, 1991).

The lack of basic sanitation services is concentrated in the low-income areas. Of 5.9 million urban households not connected to the water supply system and without adequate indoor sanitary facilities in 1980, 72% (more than 21 million people) earned less than three minimum salaries per month (CIMA, 1991). Depending on the inflation and exchange policy, the Brazilian minimum wage (BMW) varies between 50 and 80 US$ dollars.

Access to adequate environmental sanitation services in Brazil is unequally distributed between regions and social groups. While 54% of urban Brazilian families have water supply and excreta disposal, in the Northeast region this proportion falls to 27%.

Under PLANASA, the drainage and solid waste collection systems were maintained as responsibility of the municipalities, and investments in these services have not had the same importance as water supply and sanitation, because they have historically been given less priority.

Less than 50% of the urban population is served with solid waste collection. The low-income areas usually suffer most, because they have no service to collect rubbish or very inadequate levels of service provision. Only 3% of the urban solid waste has an adequate final disposal. 63% is thrown in water courses and 34% is dumped on open sites (CIMA, 1991).

1.2.3. Impact of urbanization on health

The impact of the urban environment on health is complex and conditioned by a wide range of characteristics and behaviours. The health of a city's people is strongly determined by physical, social, economic and cultural factors in the urban environment, which may vary with climate, terrain, population density, housing stock, type of industrial base, income distribution etc. The impact of urban processes on health is not just the sum of the effects of the various factors taken individually, since they interact with one another (WHO, 1991).

1.2.3.1. Physical factors

Factors in the physical environment that affect health include water supply, domestic and community sanitation, standing water, rubbish, vector populations, pollution from domestic and industrial wastes, housing quality and availability, food and food safety, noise, working conditions, use of chemicals, radiation, and the extent of open space and access to recreation.

Urban housing, including patterns of settlement, embraces a cluster of factors potentially harmful to health. Apart from the psychosocial question of whether a house truly serves as a home, dwellings may either increase the risk of, or protect against, the hazards of communicable and noncommunicable diseases and injuries.

1.2.3.2. Socioeconomic, cultural and political factors

The physical environment conditions, and is conditioned by, the social environment. Social and cultural factors that affect health include low income, limited education, inadequate diet, overcrowding, poor hygienic practices, and social instability and insecurity.

Health is affected by educational levels and by the character and accessibility of education, which can help people to deal better with their environment - to increase their incomes, to protect themselves better against hazards, and to modify their behaviour so as to promote health.

1.2.3.3. Causes of disease

Several factors contribute as causes of disease in urban environments. Communicable and noncommunicable diseases, injuries, and psychosocial health problems can occur for different reasons, and affect the health of the urban population in different ways. Those that cause communicable diseases are presented below.

Environmental conditions that favour the spread of communicable disease are as follows:

a) Lack of an adequate water supply can be associated with typhoid fever, cholera, hepatitis, diarrhoeal diseases and intestinal parasites, trachoma and skin infections;

b) Insanitary disposal of excreta can also be a major cause of diarrhoeal diseases and intestinal parasites, including ascariasis, trichuriasis and hookworm infections;

c) Inadequate disposal of solid wastes can be another potential factor in the spread of gastrointestinal diseases, and also of leptospirosis, primarily as a result of the proliferation of insect and rodent vectors;

d) The absence or inadequacy of surface water drainage, can cause flooding, wastewater accumulation or poor run-off of heavy rain, and so encourage vector breeding and infections due to contact with contaminated water or soil. It can also make the soil humid favouring the development of hookworm larvae and survival of other pathogens;

e) Inadequate personal and domestic hygiene can increase the risks of faecal-oral, skin, eye and vector-borne infections (due to mechanical vectors such as flies), and poor food safety practices increase those of faecal-oral infections;

f) Structurally inadequate housing can contribute to the incidence of several diseases as tuberculosis, pneumonia, measles, and gastrointestinal and meningococcal infections (WHO, 1991).

1.2.3.4. Present situation in Brazil and in Northeast region

70% of the public hospitalizations are due to diseases caused by lack of environmental sanitation measures (CIMA, 1991).

Intestinal infectious diseases are the first cause of death in the Northeast region with 11% of all deaths. The risk of death due to intestinal infectious diseases is nearly 6.5 times greater in the Northern and Northeastern regions than in the Southern and West-Central regions, showing the great internal heterogeneity in conditions of living and health. The children born in Northeastern region are 50% more likely to be classifiable as stunted than those born in South region (INAN, 1990). Life expectancy at birth and infant mortality in urban areas of Northeast region are 58.1 years and 96 per thousand, respectively, where there are adequate water supply and sanitation services, but 45.5 years and 146 per thousand where these services are inadequate (IPEA, 1989). Certainly, these figures also reflect socioeconomic differences.

1.3. Objectives and hypothesis of the study

The main objective of this study was to contribute towards a better understanding and increased awareness of the health effects of environmental factors, particularly sanitation (human excreta and sullage disposal) in poor urban environments in Northeast Brazil. More specifically, the monitoring of diarrhoeal disease incidence had the following detailed objectives: 1) the impact of community environmental sanitation on diarrhoea morbidity; 2) the age-specific impact; and 3) seasonal variations. In addition, the collection and analysis of anthropometric measurements aimed to study the impact of community environmental sanitation on the nutritional status. Finally, the objectives of the component of the study relating to intestinal nematode infections were the following: 1) the impact of community environmental sanitation on the prevalence and intensities of nematode infections; 2) the age- and sex-specific impact; 3) the contribution of other risk factors on the prevalence of nematode infections; 4) household clustering of nematode infections in groups of neighbourhoods with different types of community sanitation; 5) the prevalence and intensity of reinfection after chemotherapy in the groups with varying community sanitation; 6) the effect of environmental sanitation on predisposition to reinfection; and 7) the effect of environmental sanitation on predisposition to multiple species.

The central hypothesis to be evaluated was that "inadequate excreta and sullage disposal in the community as a whole (or the lack of neighbourhood sanitation) is an important risk factor for diarrhoeal diseases, poor nutritional status and intestinal nematode infections and its contribution to inter-household transmission is at least as important as that of domestic conditions to intra-household transmission of intestinal nematode infections".

Another objective, following from the first one, but no less important, was to provide indicators and information to support the development of public health policy for poor urban areas, using epidemiologic methods, with regard to environmental interventions to prevent diseases and to improve health. The fulfilment of such an objective can contribute to give more priority to environmental sanitation as a public health measure.

A research project in a poor urban area of Salvador city was devised to test the central hypothesis and achieve the defined objectives.

1.4. Structure of the Thesis

This thesis reports the results of a study carried out between August 1989 and November 1990 in the city of Salvador, Bahia, Brazil. This chapter sets out the study questions and presents the general background to their formulation. Chapter 2 presents the background on health effects of inadequate urban sanitation, mainly on health impact measurement problems.

Chapter 3 describes the study area and population and Chapter 4 the study methodology used for the study design, data collection and analysis. The analysis of the results is presented in chapters 5 to 8. Each chapter presents a specific set of objectives, the relevant part of the studies and a discussion of the relevant results. Chapter 5 is concerned with the different characteristics of the three study groups and with their implications for the health impact study. Chapters 6, 7 and 8 are concerned with the impact of environmental sanitation on diarrhoeal diseases, on nutritional status and on the prevalence and intensity of nematode infections, respectively.

In the final chapter, a discussion of the main results is presented in order to interpret their importance and contribution to the definition of a basic framework towards the development of sanitation measures in poor urban areas in Brazil.

CHAPTER 2

Health effects of inadequate urban sanitation

2.1. Introduction

According to WOLMAN (1975) the environmental determinants of the enteric diseases seem clear. A host of specific organisms can produce enteric disease. Which ones, precisely, are involved will vary with time and place, the age of susceptible persons, and other factors. Nevertheless, epidemiologic studies make it abundantly clear that all these infections generally have a common source: namely, human excreta in the wrong place- in water, in food, on the hands, and frequently on household utensils and equipment and in the neighbourhood environment.

Some environmental measures are most likely to interrupt the vicious cycle of disease. First, excreta must be removed from direct contact with people (WOLMAN, 1975). In poor urban areas of developing countries, people literally live among and frequently ingest these human discharges. Water of good quality and of sufficient quantity should be made conveniently available for people to wash, so that personal hygiene can be practised. Food preparation and handling must be carried out in sanitary surroundings. Rubbish should be collected and disposed off adequately. And finally, public comprehension of these elementary essentials must be achieved.

The health benefits of improved sanitation and water supply interventions have been well established and documented (MCJUNKIN, 1982; ESREY *et al.*, 1985; CVJETANOVIC, 1986; ESREY and HABICHT, 1986; CAIRNCROSS, 1990; ESREY *et al.*, 1990; HUTTLY, 1990; WIBOWO and TISDELL, 1993; VANDERSLICE *et al.*, 1994; VANDERSLICE and BRISCOE, 1995), although most studies have been conducted in rural areas and may not apply to urban settings (ESREY and SOMMERFELT, 1991). Evidence accumulated during the International Drinking Water Supply and Sanitation Decade also supports the conclusion that sanitation and water supply improvements can benefit child health (HUTTLY, 1990). Specific health benefits of environmental sanitation interventions include decreased morbidity and mortality due to diarrhoeal disease, decreased morbidity due to intestinal helminths, improved nutritional status of children, decreased prevalence of schistosomiasis, trachoma and guinea worm disease, as well as improved child survival (ESREY *et al.*, 1990).

Most studies of the health impact of water supply and sanitation have related to water supply improvements. Some include the impact of excreta disposal on health, but by comparing individuals and households with differing access to improved excreta disposal, and only very few of them are about the impact of excreta and sullage disposal as a community intervention.

The importance of sanitation in preventing disease is often underestimated and understated. In fact, if a perfect system of sanitation and control of faecal contamination were possible, a great part of the morbidity due to water-related diseases, mainly faecal-oral diseases, would be eliminated. In addition there are some excreta-related diseases, such as hookworm and strongyloidiasis, where improved water supplies are unlikely to reduce disease transmission, but where sanitation can be expected to do so (FEACHEM *et al.*, 1983a).

It is clear that improved environmental sanitation can promote health in situations where inadequate services exist. Recognizing resource constraints, the next logical step, always in a monetary logic, is to determine the health benefits of specific types and levels of environmental sanitation services in order to inform decision makers.

Where environmental faecal contamination is high as in peri-urban slums, childhood diarrhoea rates also tend to be very high (LOPEZ de ROMANA *et al.*, 1989; SCHORLING *et al.*, 1990; KAMINSKY, 1991) and intestinal helminth infection rates are also almost always very high (KAKANDE, 1971; SOH *et al.*, 1973; SILVA and JAYATILLEKA, 1981; BUNDY *et al.*, 1988; FORRESTER *et al.*, 1988; HETTIARACHCHI *et al.*, 1989; FERREIRA *et al.*,1991;

HAGEL *et al.*, 1993; HALL and NAHAR, 1994). This finding is based on few studies, but it is not surprising since adequate sanitation (excreta disposal), that is adequate disposal of faeces, is the primary barrier to faecal transmitted diseases (WAGNER and LANOIX, 1958; KAWATA, 1978; BATEMAN, 1991). Nonetheless, access to adequate excreta disposal lags far behind access to adequate water supplies in practically all developing countries. From the point of view of health benefits and the environment, it appears that more emphasis, not less, should be given to domestic and community sanitation compared to water supply (ESREY *et al.*, 1985).

The overall community level of excreta disposal may be more important than individual access to sanitation. For the transmission of disease, the faeces of an individual are not necessarily dangerous to that same individual. It is the infected neighbour who may transmit disease to an uninfected person. In practical terms, the critical measure of sanitation from the point the view of the health of an individual is the level of sanitation of all of the other individuals in their community. If the community level of sanitation is the key measure of sanitation service for achieving health benefits, then the appropriate measure of sanitation service for programme design and evaluation purposes may not be the number or proportion of individuals with access to improved sanitation but, rather, the number or proportion of communities with a high level of improved sanitation service and appropriate usage of those services.

2.2. A classification of excreta-related disease

It is important to understand the mechanisms by which excreta-related diseases are transmitted in order to evaluate the effect of poor sanitary conditions on health and the likely impact of improved interventions. A conceptual framework that links various groups of water and excreta-related infections to the design and implementation of a disposal system was proposed by FEACHEM *et al.* (1983a), and provided an important advance in this respect. It has two major limitations. First, there is a lack of knowledge about the transmission of several infections, particularly the numbers of micro-organisms needed to infect susceptible people. Second, the excreted viruses, bacteria, and protozoa differ quantitatively rather than qualitatively in their transmission characteristics, making it easy to end up with a large, relatively uninformative category containing the majority of infections. Nevertheless, it meets an important need for an environmental classification to group infections in such a way that the efficacy of different preventive measures is made clear.

FEACHEM *et al.* (1983a) categorised excreta-related diseases as follows:

(a) <u>faecal-oral diseases (non-bacterial)</u> - for example polio, hepatitis A and amoebic dysentery; these diseases are transmitted by the faecal-oral route; the pathogen is present in faeces of infected people, and can infect other people when they swallow it due to contamination of water, food, hands, etc.; they are non-latent (they do not require time between excretion and infectivity) and require a relatively low infective dose; these infections, caused by viruses, protozoa, and parasitic worms, can spread very easily from person to person whenever personal and domestic hygiene is not ideal, and changes in excreta disposal methods are unlikely to have much effect on them unless accompanied by sweeping changes in personal cleanliness, requiring substantial improvements in water supply and housing, as well as major efforts in health education;

(b) faecal-oral diseases (bacterial) - for example diarrhoea, dysenteries and typhoid fever; for these diseases caused by bacteria, person-to-person transmission routes are important but so too are other routes with longer transmission via contamination of foods, crops, or water sources with faecal material; disposal of human excreta alone is not enough to control them; they are non-latent, moderately persistent, able to multiply and require a medium or high infective dose;

(c) soil-transmitted helminths - for example ascariasis, trichuriasis, hookworm and strongyloidiasis; this category contains several species of parasitic worm whose eggs are passed in faeces; they are not immediately infective, but first require a period of development in favourable conditions, usually in moist soil. Under suitable conditions, they can survive for months and then reach their next human host by being swallowed or by penetrating the soles of the feet, or on contaminated vegetables. Thus, they are latent and persistent; since the eggs are not immediately infective, personal cleanliness has little effect on their transmission, but excreta or sewage disposal which helps to avoid faecal contamination of the floor, alleys or streets will limit transmission;

(d) beef and pork tapeworms - require a period in the body of an animal before re-infecting man when the meat is eaten; any system which prevents untreated excreta or fresh sludge being eaten by pigs and cattle will control the transmission of these parasites;

(e) water-based helminths - for example schistosomiasis; these diseases are caused by worms which are passed in excreta and then develop in the body of an aquatic creature;

(f) excreta-related insect vectors - for example filariasis and those above which may be transmitted by flies and cockroaches; filariasis is transmitted by the *Culex quinquefasciatus* mosquitoes that breed in highly polluted water.

The diarrhoea agents are transmitted via the faecal-oral route and do not require an intermediate host. This cycle involves defecation of pathogens -bacterial, viral or protozoal- which are then ingested by consuming pathogen-laden food or water or by oral contact with dirty hands or other contaminated objects. This means that there are several routes for the faecal-oral transmission of diarrhoea-causing pathogens. If host factors allow infection to occur in a child, then diarrhoea may strike, weakening and possibly killing her through dehydration and loss of electrolytes (ESREY *et al.*, 1990). In addition, fever, malabsorption of nutrients, and anorexia result in slower growth. Most studies assessing the impact of water and sanitation on child health have, thus, focused on one or more of three major indicators of health, all of which are related: diarrhoea incidence, nutritional status, and mortality.

2.3. Measurement problems

SHUVAL *et al.* (1981) have suggested that improvements in sanitation and water supply facilities would realize relatively little health benefit in populations at either very low or very high socioeconomic levels, an appreciable impact only being seen in middle-level communities. KAWATA (1978) also argued for a minimum level of sanitary improvement before any health benefit can be expected.

On the other hand, BRISCOE (1987) has pointed out several flaws in the analytic methods used to assign low priority to sanitation and water supply improvements, including misleading cost-effectiveness analyses that fail to take account of the multiple health benefits, direct and indirect, of sanitary improvements. He also concluded that long-term effects on child survival are probably substantial, in addition to the more immediate impacts on morbidity.

However precise one's measurements of diseases and nutritional status might be, they cannot give a total picture of the health benefits of sanitation and water supply. The studies providing wider information are limited and scattered, and the indicators used are frequently insufficient to give an overall assessment of the health effects in the broadest sense.

WAXLER *et al.* (1985) studying infant mortality in Sri Lanka, developed a path model showing cultural, socioeconomic, environmental and medical predictors of infant deaths and found that among the most proximate group of factors the availability to the family of a sanitary latrine was the most significant. They also stated that the lack of sanitary facilities was associated with poverty.

While economic factors affect the availability or lack of sanitary facilities, their provision, especially from external resources, does not guarantee that they will be used nor that they will generate health benefits. Behavioural patterns, cultural, social and economic factors are complementary and play an important role. Therefore some planners consider that sanitation programmes must go hand in hand with activities designed to stimulate the local economy in order to have any impact on health (GREENLAND *et al.*, 1981). This can bring the problem of health into the area of general planning for development.

The impact of excreta disposal facilities is also subject to difficulties of interpretation for two reasons. First, because of the association between socioeconomic factors and both the diseases studied and latrine ownership, it is difficult to disentangle the effect on disease solely due to latrine use. Second, in many parts of the developing world, latrines are often not used by infants and young children so that interventions to improve excreta disposal practices often fail to reach this age group despite the fact that they are a major source of enteric pathogens (ESREY *et al.*, 1985).

Detecting the health impact of sanitation and water supply programmes seems problematic. In 1976, before the declaration of the International Drinking Water Supply and Sanitation Decade, an expert panel convened by the World Bank concluded that longitudinal studies were probably the only way to detecting the health benefits arising from such projects (WORLD BANK, 1976). The panel also concluded that the costs of such studies were likely to outweigh any benefits and recommended that they should not be undertaken. Furthermore, in 1983, a review of studies of the health impact of water and sanitation projects, all of them following a prospective design, pinpointed a number of serious methodological problems possibly invalidating any conclusions from their results (BLUM and FEACHEM, 1983).

BLUM and FEACHEM in 1983, pointed to numerous weaknesses in such studies due to (a) lack of adequate control, (b) comparison of a single experimental community with a single control, (c) confounding, (d) failure to recall health indicators reliably during surveys, (e) failure to analyze data by age, and (f) lack of records pertaining to the utilization of the facilities.

The realisation of the methodological problems facing health impact evaluations of sanitation and water interventions led to a workshop held in Cox's Bazaar, Bangladesh in 1983, to review the information and experience accumulated to date and to define a way forward (BRISCOE *et al.*, 1986). The main product of this workshop was a document proposing the use of the case-control method for evaluating the impact on diarrhoea of such interventions (BRISCOE *et al.*, 1985) and another outcome was the recognition that measures of child growth represented alternative indicators of health impact, which were potentially of great importance, and which merited further research (BRISCOE *et al.*, 1986).

BRISCOE *et al.* (1986), in discussing possible outcome measures, recommended that more research on the use of anthropometric indicators as a potential indicator of health impact was justified, both because of the public health significance of malnutrition and because such indicators offer the promise of being both valid and responsive.

2.4. Impact of environmental sanitation on diseases

As mentioned above, there is a wide range of excreta-related diseases. Those which constitute the major health burden or are often the focus of health impact evaluations of environmental sanitation interventions are reviewed here.

2.4.1. Diarrhoeal diseases

Diarrhoeal disease is one of the leading killers of children in the world (ESREY *et al.*, 1990). SNYDER and MERSON (1982), estimated that there were more than 875 million cases of diarrhoea and 4.6 million deaths annually in Africa, Asia, and Latin America, but in 1985, nearly 3 billion of episodes of diarrhoea were estimated to have occurred in the developing countries, leading to the death of 5 million persons, 80 percent of them under five years of age (MARTINES *et al.*, 1991). Morbidity rates are generally higher in older infants (6-11 months) and children 12-23 months, while mortality peaks in children under 2. Early childhood mortality in Northeastern Brazil is among the highest in the world, exceeding 140 per thousand during the first five years of life. For more than 52% of all such deaths recorded, diarrhoea is listed as either the primary or an associated cause of death (GUERRANT *et al.*, 1983).

Measurement of diarrhoeal morbidity is difficult, due partly to the lack of a satisfactory definition of diarrhoea (SNYDER and MERSON, 1982). Several studies on diarrhoeal morbidity have been reported but there are major differences in the terms used to define a diarrhoeal episode. The definitions have varied from the relatively simple ones such as "more than two watery or loose motions in 24 hours", as used in a Bangladesh study (RAHAMAN *et al.*, 1979), to a more complex one in Guatemala, "under 1 year of age: 5 or more liquid stools per 24 hours; over 1 year: 3 or more liquid or semi-liquid stools preceded by 2 weeks of normal stools" (SCRIMSHAW *et al.*, 1967). In recent years, most community-based studies have used the mother's definition (MOORE *et al.*, 1966; LEEWENBURG *et al.*, 1978; PICKERING *et al.*, 1987; SCHORLING *et al.*, 1990).

WEIR *et al.* (1952) questioned the efficacy of latrine construction in Egyptian villages for control of diarrhoeal diseases while housing remained unchanged and economic conditions confined people to unhygienic environments. The latrines were used by the people only when it was convenient to do so. It is not surprising that opportunities for transmission of pathogens were not reduced by the measures employed. Similarly, KOURANY *et al.* (1971) pointed out that access to flush toilets for the disposal of excreta had no benefit with respect to frequency of infection among the Panamanian children, since the facilities available were notoriously inadequate and were shared communally.

KOOPMAN (1980) studying sewage disposal, water supply and endemic diarrhoea in an urban slum of Cali, Colombia, found that although diarrhoea incidence rates varied markedly by age group, the relationship of these rates to household sewage disposal did not vary significantly by age group. The transient association of increased diarrhoea in surrounding populations and the variation in this increase with exposure to the sewage of the local population led to the conclusion that the community spread of diarrhoea, related to inadequate sewage disposal, was even more important than household spread. Houses with no provision for the removal of excreta had 60% more cases of diarrhoea than those with a latrine, and 127% more than those with a sewer.

ESREY *et al.* (1990) added 17 more studies to their review of 67 studies from 28 countries (ESREY *et al.*, 1985) and concluded that, taken as a whole, they provided strong evidence that improvements in water supplies, sanitation facilities and hygiene practices may have a significant impact on diarrhoeal diseases. Improvements in water quantity and excreta disposal facilities appeared to have a greater impact than improvements in water quality although, in most cases, it was difficult to separate clearly the effect of water quantity and quality. They found that improved water supplies and sanitation interventions demonstrated a median reduction of 22% in diarrhoeal morbidity rates of children under 5 years of age. If only the studies of better quality were considered, the median reduction was 26%. The impact of sanitation alone also was examined in 30 studies, of which 21 reported health improvements. Calculations showed a median percent reduction of 22%. Of the better studies the median was 36%. The increasing effect associated with an upgrading of interventions may be related to the number of family or community members using the facility or the number of times in which it is used by each individual.

VANDERSLICE and BRISCOE (1995) studying the effects of environmental interventions on diarrhoeal disease in Cebu, Philippines, found that the effects of water quality, household sanitation, and community sanitation were strong, consistent, and statistically significant on diarrhoea in children from birth to 2 years of age. For households without in-house connections, providing such a connection would result in a mean reduction in the predicted probability of diarrhoea in children of 12%. For households without private or well-maintained excreta disposal facilities, the provision of such facilities was estimated to reduce childhood diarrhoea by 42%, and for households with excreta around the house, eliminating the excreta would result in 30% less diarrhoea among affected children. Improving drinking water quality would have no effect in neighbourhoods with very poor environmental sanitation, but for households with good quality drinking water, improving the level of community sanitation would reduce diarrhoeal prevalence by 25%. They conclude, raising the issue of conceptual and empirical difficulties to conduct studies that take into account the interactions between environmental interventions.

2.4.2. Nutritional status

Malnutrition is widely prevalent in the developing world, and is related to various interrelated factors such as morbidity, diet, environmental conditions and socioeconomic levels (HAAGA *et al.*, 1985). In addition it is a common cause or associated cause of death in children. Improvements in environmental sanitation interventions may have an impact on nutritional status in rural areas not only via the well-documented malnutrition/morbidity relationship, but also through more time available for child care (TOMKINS *et al.*, 1978) and greater agricultural production (EDUNGBOLA *et al.*, 1988). Indeed, ESREY and HABICHT (1983) have suggested that anthropometric indicators of nutritional status are equally as appropriate as diarrhoea incidence for assessing the impact of environmental sanitary improvements, and can be measured more precisely.

Nutritional status is probably the single most informative indicator of the overall health of a population (MOSLEY and CHEN, 1984), and, in cross-sectional surveys, anthropometric measures may be more valid and reliable than some measures of diarrhoea morbidity, particularly those which rely on the recall of the mother. But, the responsiveness of anthropometric status to improvements in environmental sanitation and hygiene practices, compared with that of diarrhoeal diseases, remains unclear.

ESREY *et al.* (1985) reviewed six studies which analyzed the impact of sanitation and water supply on nutritional anthropometry and all of them showed a positive association, although not always significant. HUTTLY *et al.* (1990) reported a significant impact on acute but not chronic malnutrition in young children after a water and sanitation intervention in Nigeria. DANIELS *et al.* (1990) evaluating a latrine programme in Lesotho, showed that children from households with a latrine had better height-for-age. As no impact was found on diarrhoea incidence, and as the prevalence of intestinal helminth infections in Lesotho is extremely low, socioeconomic confounding would seem at least as plausible as infection, as an explanation for the associations found. In Bangladesh, where nutritional status is particularly poor, HASAN *et al.* (1989) found no nutritional impact from improved sanitation and water facilities despite a significant reduction in diarrhoeal diseases. TOMKINS *et al.* (1978), HEBERT (1985), ESREY *et al.* (1988), and BERTRAND *et al.* (1988) have showed associations between sanitation- and water-related factors and nutritional status. It appears likely that the potential impact of improved sanitary conditions on nutritional status depends on many other factors, as is the case for diarrhoeal diseases (HUTTLY, 1990).

BATEMAN and SMITH (1991) using data from the 1987 Demographic and Health Survey (DHS) in Guatemala, conclude that both improved water supplies and improved sanitation services were associated with improved child health, where child health was measured as longitudinal growth. There was an apparent, though not statistically significant, greater risk of poor growth associated with inadequate sanitation than with inadequate water supply. The most important finding in their analysis was that the community level of sanitation appeared to be as important or more important than individual access to sanitary services for reducing the risk of stunting (more than two standard deviations below the NCHS/WHO reference median) in children between 6 and 36 months of age. The problem of confounding by socioeconomic status in observational studies is particularly acute with nutritional status as the outcome measure.

2.4.3. Intestinal helminth infections

Intestinal helminth infections constitute some of the most common in human beings throughout the world, the most prevalent being the soil-transmitted nematode infections (category (c) in Section 2.2) that are also a major cause of morbidity in school-age children in developing countries (SAVIOLI *et al.*, 1992; WORLD BANK, 1993). The policies and strategies to control them are based mainly on chemotherapy. Although safe and effective drugs are available for treatment (BUNDY *et al.*, 1985), the best way to use these drugs for the benefit of the community is yet to be determined. On the other hand, environmental sanitation plays an important role in the reduction of exposure to infection. Its importance as a measure to control helminthic infections is public knowledge, since the lack of sanitation can also provide for easy transmission via the faecal-oral route. However, little is known of the impact of environmental sanitation interventions on the prevalence and intensity of helminthic infections (HENRY, 1988).

According to BRADLEY *et al.* (1991), many surveys have demonstrated a high prevalence of intestinal parasitic infections in children of slums, shanty towns and squatter settlements. In many communities the majority of children aged between 5 and 15 years are not only infected with at least one species of worm but they also tend to harbour the heaviest burdens (BUNDY *et al.*, 1992). The environment of low-income urban communities is often heavily contaminated by eggs and larvae of intestinal parasites, largely due to inadequate excreta disposal. There are theoretical grounds for supposing that infections by intestinal helminths are more sensitive to differences in excreta disposal than viral, bacterial or protozoal infections (FEACHEM *et al.*, 1983a). Inadequate sanitation measures and poor hygienic practices provide for easy transmission via the faecal-oral route.

The most widespread soil-transmitted nematodes are *Ascaris lumbricoides*, the hookworms and *Trichuris trichiura*. The global number of people afflicted with these three infections has been estimated as 1000 million, 900 million and 800 million respectively (WHO, 1987b; CROMPTON and SAVIOLI, 1993). Half the Latin American population is infected by intestinal worms, including 18% by hookworms (APT, 1987). The principal public health significance of the helminthiasis resides, not in their impact on mortality, but, rather, in their consequences for impaired growth and development in children, chronic disability and long-term impairments of function (WARREN *et al.*, 1990). The morbidity caused by intestinal helminths in Latin America involves 5-15% of the population (APT, 1987). Data from a number of geographical areas have shown that infection with *T. trichiura* occurs as frequently as that of *A. lumbricoides* (BUNDY, 1986) and that both of them appear to be the most frequently encountered in urban communities (CROMPTON and SAVIOLI, 1993). Frequently, children harbour several types of parasite at the same time.

Actual prevalence and intensity rates of these nematode infections differ widely both between and within countries, partly depending on environmental and socioeconomic conditions. In Brazil, the Ministry of Health carried out 2.5 million examinations of stool samples and found the prevalence of *A. lumbricoides* to be 59.5%, although the prevalence rates in the different states ranged from 26.7 to 97.6%. According to the same source, in 1969 the national prevalence of hookworm infection (mainly *N. americanus*) was 26.5% (WHO, 1987b).

Epidemiological studies from many different geographical areas, have shown common trends (ANDERSON, 1986). Prevalence of infection rises rapidly in the first years of life, and then levels out in adulthood. Intensity, on the other hand, tends to peak in school-age children for *A. lumbricoides* and *T. trichiura* and in young adults for hookworm infections (COOPER and BUNDY, 1987; HUTTLY, 1990; BUNDY and KEYMER, 1991).

It seems that there is growing recognition that the health impact of these infections has been underestimated, and that geohelminthiasis may be a highly prevalent source of chronic disease, with particularly important implications for child health and development (GILMAN *et al.*, 1983; STEPHENSON, 1987; HOLLAND, 1987a,b; BUNDY and COOPER, 1988a; CROMPTON, 1989; STEPHENSON *et al.*, 1989; POLLITT, 1990; STEPHENSON *et al.*, 1990; KVALSVIG *et al.*, 1991; NOKES *et al.*, 1991, 1992a,b; CALLENDER *et al.*, 1993).

Despite the acknowledged role of poor sanitary conditions in the transmission of these nematode infections since the early part of this century (BROWN, 1927; CORT and OTTO, 1933; OTTO and CORT, 1934), the impact of community sanitation interventions on them, has not been well studied (FEACHEM *et al.*, 1983a; HENRY, 1988; HUTTLY, 1990).

Intestinal nematode worm burdens have a highly aggregated distribution in human populations. The majority of hosts are lightly infected, while a few harbour a large number. Even after effective treatment, heavily infected individuals tend to re-acquire intense infections, a phenomenon known as predisposition. Thus the significance of predisposition with respect to helminth epidemiology is enhanced by the fact that helminth parasites are invariably aggregated, even within a given subgroup of the overall population (KEYMER and PAGEL, 1990).

The possibility of a small minority of intensely infected individuals making the greatest contribution to environmental contamination with helminth infective stages and being predisposed to heavy infection (and thus at greatest risk of developing disease) (ANDERSON and MAY, 1982) is of considerable relevance for disease control. The optimal design and implementation of programmes for the control of the helminthiasis is critically dependent upon an understanding of the extent and causes of predisposition. Although much information is currently accumulating (KEYMER and PAGEL, 1990; MCCALLUM, 1990; BUNDY and MEDLEY, 1992), this understanding is still far from complete.

Predisposition may result from genetic, environmental, behavioural, nutritional or combined factors (ANDERSON, 1986) that either cause certain individuals to come in contact with (to be exposed to) large numbers of infective stages or to have a reduced ability to combat the infections once contact has been made. If predisposition is due to differences in susceptibility between individuals, the study of such differences can help to elucidate how people's susceptibility can be reduced, for instance by vaccination. If, on the other hand, predisposition has an environmental or behavioural cause related to exposure, then the implications for control are very different. If genetic differences underlie predisposition, they are unlikely to be affected by environmental interventions. If, however, an environmental intervention alters the degree to which predisposition occurs, it suggests that predisposition has an environmental cause.

In many developing countries, communities often harbour a variety of different species of helminth parasites, mainly for the intestinal nematode infections. It is common for *Ascaris, Trichuris* and hookworm to be present as multiple species infections in an individual (HASWELL-ELKINS *et al.*, 1987; HOLLAND *et al.*, 1989; CHAN *et al.*, 1992). In the context of control programmes, emphasis has been given to chemotherapy with broad-spectrum anthelmintics of great potential value in reducing the total burden of intestinal helminth infection within a community. However, the sustainability of health benefits obtained in this way is open to question, as reinfection will occur in a few months, unless the course of mass chemotherapy is repeated regularly.

The frequent occurrence of multiple species infections raises the question of whether or not those individuals who are predisposed to heavy infection with one species of intestinal nematode are also more likely, on average, to harbour heavy burdens of the other species present in a community. The issue of multiple species predisposition and how environmental sanitation can affect it has received little attention in the epidemiological research and literature (CROLL and GHADIRIAN, 1981).

These issues emphasize the importance and relevance of also studying the contribution of environmental, socioeconomic, demographic, cultural, behavioural and nutritional risk factors to helminth infections in epidemiological investigations related to helminth control, since the majority of them remain unclear (WHO, 1981).

2.4.3.1. Ascariasis

Ascariasis is caused by a parasitic worm which follows the faecal-oral route of transmission. *Ascaris lumbricoides* infection is prevalent in many tropical countries (CROMPTON, 1989); it is endemic in virtually the entire developing world and infects about one-fifth of the world's population (MARKELL *et al.*, 1986). There are an estimated 1000 million cases of infection (WHO, 1987b; CROMPTON and SAVIOLI, 1993) and 20,000 deaths attributable to it annually in Africa, Asia, and Latin America (WALSH, 1984). *Ascaris lumbricoides* is largely specific for man and the infection does not produce a strong protective immunity. For its survival the parasite depends on a reservoir of infective eggs in an environment and thrives in areas where there is a lack of sanitation, particularly where people defecate indiscriminately around or throw their sewage in human settlements. Preschool children are the group at greatest risk to actual or potential deleterious effects (WHO, 1987b).

High prevalence of *Ascaris lumbricoides* is related to inadequate or lack of sanitation often observed in rural communities of the developing countries (CROLL *et al.*, 1982; MARTIN *et al.*, 1983; THEIN-HLAING *et al.*, 1984; STEPHENSON, 1987). However, there have been frequent reports of *Ascaris lumbri-*

coides prevalence in urban areas, similar or even higher than in the contiguous rural areas, in several developing countries (HARPHAM, 1986; CANCRINI *et al.*, 1989; KAN *et al.*, 1989; AUER, 1990; HOLLAND and ASAOLU, 1990; FERREIRA *et al.*, 1991; HAGEL *et al.*, 1993; HALL and NAHAR, 1994). The intensity of *Ascaris lumbricoides* infection seems be affected by the urban area organization. Urban populations without adequate housing and sanitation, in areas of high demographic density, can be exposed to environmental contamination levels higher than those found in indigenous rural communities, where the population dispersion limits the degree of exposure to contaminated material.

Ascariasis can also affect nutritional status. The conclusions from a number of field studies undertaken to assess the influence of *A. lumbricoides* infection on child nutrition have been contradictory: some showed a positive relationship between ascariasis and poor nutritional status (TRIPATHY *et al.*, 1971; GUPTA *et al.*, 1977; WILLETT *et al.*, 1979; STEPHENSON *et al.*, 1980; STEPHENSON *et al.*, 1983; FOO, 1986; GUPTA, 1990; SAWAYA *et al.*, 1990; THEIN-HLAING *et al.*, 1991) while others have been inconclusive (FREIJ *et al.*, 1979; GREENBERG *et al.*, 1981; GUPTA and URRUTIA, 1982; KLOETZEL *et al.*, 1982).

In the United States, SCHLIESSMAN *et al.* (1958) compared the *Ascaris lumbricoides* prevalence among groups with different levels of water and sanitation. Using those with privies and no well as a baseline, he reported reductions in prevalence of

71% for people with flush toilets and indoor plumbing, 37% for privies and indoor plumbing, and 12% for privies and a yard well.

In Mozambique, MULLER *et al.* (1989) evaluated a programme for improved pit latrine construction, but found no association between the type of latrine used and *Ascaris lumbricoides* infection or presence of *A. lumbricoides* eggs in the soil. They concluded, however, that behavioural factors were largely responsible for the apparent lack of impact of the latrines.

ESREY *et al.* (1990) reviewed fourteen studies relating water supply and/or sanitation to *Ascaris lumbricoides* infection. There were five negative studies, all of which looked only at excreta disposal facilities and one study (FEACHEM *et al.*, 1983b) reported both positive and negative findings with significant differences being found in ascariasis among users of different types of excreta disposal facilities. They conclude that water supply and sanitation facilities can reduce *A. lumbricoides* prevalence by about 30% over two or more years (SCHLIESSMANN *et al.*, 1958; ARFAA *et al.*, 1977; HENRY, 1981) and average intensity (measured by egg output) by about 60% (SAHBA and ARFAA, 1967; ARFAA *et al.*, 1977) and that hygiene practices involving water (e.g. food-washing, floor-washing, and hand-washing, although AUNG-MYO-HAN *et al.*, 1988, have reported a negative result from a hand washing intervention study) are probably more important in preventing the transmission of the worm than excreta containment.

2.4.3.2. Hookworm infections

Hookworm is endemic throughout the developing world. There are an estimated 900 million cases of infection (WHO, 1987b) and 60,000 deaths annually in Africa, Asia, and Latin America (WORLD HEALTH, 1984). These figures emphasize the public health importance of hookworm infection as a cause of morbidity and mortality. The infection is a good indicator of life in squalid conditions, where the prevalence is sometimes as high as 80%. There is no direct evidence that man develops protective immunity to hookworm infection, but epidemiological studies suggest that some degree of immunity probably develops with time (WHO, 1987b). Hookworm infection causes chronic blood loss and depletion of the body's iron stores, and must be considered an important factor in the etiology of tropical iron-deficiency anaemia, and this has implications for young children, pregnant women, and the health and productivity of adults whose livelihood and contribution to the economy depend on hard physical work (WARREN and MAHMOUD, 1984). The contribution of hookworm infection to malnutrition is in general not as well established as its role in iron-deficiency anaemia (WHO,1987b). Lack of sanitation, indiscriminate defecation, and high egg production ensure constant exposure to infection, as do the practices of using the same places for defecation and going barefoot.

LACAZ *et al.* (1972) studied the relationship between basic sanitary conditions, socioeconomic status and hookworm infection in São Paulo, Brazil, where 6,835 school pupils were examined and grouped according to the availability of sanitary services. Those living in marginal urban areas without domestic running water and sewerage facilities and those from rural areas living in bad conditions showed hookworm infection much more frequent than those living in urban areas with sanitary services and belonging to comparatively well-off families.

ARFAA *et al.* (1977) found in Iran that villages which received sanitation improvements had a 4% decrease in hookworm prevalence, and a 26% reduction in egg count among those infected. These prevalence and egg count reduction values for the group receiving sanitation and chemotherapy were 69% and 88% respectively, for the chemotherapy only group 73% and 87%, and for the control group, 11% and 12%. The results are confounded because each cohort began with a different hookworm prevalence. The sanitation-only cohort started with 71% infected, while the control group began with 44%. The way in which interventions were assigned to the villages was not stated.

KILLEWO *et al.* (1991) studying the pattern of hookworm in a periurban area in Dar es Salaam, found from the lack of clustering by household that most of the transmission of this parasite in the study area was between households rather than within them, and that the household, and the latrine in particular, was not the primary focus of transmission in the area.

In their review of eleven studies relating hookworm infection to excreta disposal facilities with or without water supplies ESREY *et al.* (1990) found five studies reporting positive findings: two involving water supply and sanitation (CHANDLER, 1954; SCHLIESSMANN *et al.*, 1958) and three involving sanitation only (CORT *et al.*, 1929; SWEET *et al.*, 1929; KHALIL, 1931).

2.4.3.3. Trichuriasis

Trichuriasis is an important worldwide disease, predominantly of children (COOPER and BUNDY, 1988). Considering its worldwide distribution and high prevalence, trichuriasis has been neglected more than most other intestinal parasitic diseases (WARREN and MAHMOUD, 1984). The degree of morbidity is related to the intensity of the infection.

Chronic impairment of the host's nutritional status should be suspected when diarrhoea, hypoalbuminaemia, and iron-deficiency anaemia are observed in association with the presence of the parasite (WHO, 1987b). Children with intense infections of *Trichuris trichiura* have the symptoms and signs associated with any chronic colitis (COOPER, 1991). The severe suppression of height growth of such children (COOPER *et al.*, 1990) and the adverse effect on certain cognitive functions in children with moderate to heavy infections has recently been shown in Jamaica (NOKES *et al.*, 1992b).

High prevalence of *Trichuris trichiura* is found in children living in poor urban areas of the developing countries where the faecal contamination of the environment is high due to inadequate or lack of community sanitation (BUNDY *et al.*, 1988; FORRESTER *et al.*, 1988; AUER, 1990; HOLLAND and ASAOLU, 1990; CHAN *et al.*, 1992; HALL and NAHAR, 1994).

Despite the importance of sanitation as a barrier to the transmission of *Trichuris trichiura* infection, the impact of domestic and community sanitation interventions on it has been little studied (KAKANDE, 1971; HENRY, 1981; FEACHEM *et al.*, 1983b).

HENRY (1981) showed with data from Saint Lucia that the prevalence of infection with *Trichuris trichiura* in young children was significantly lower in areas with improved sanitary conditions. KAKANDE (1971) reported that the prevalence of *Trichuris trichiura* infection in children in a periurban area without sanitation and an urban area with sanitation in Kampala was almost equal, while the findings of the study of FEACHEM *et al.* (1983b) in urban Africa suggested that the provision of sanitation facilities to a small cluster of houses, or to houses scattered through an area, may not protect those families from parasitic infection, including *Trichuris trichiura*, if the over-all level of faecal contamination of the environment is high.

In summary, in this chapter was presented that: several diseases are related to inadequate sanitation; the impact of improved sanitation on child health has been studied, although few studies have been conducted in urban areas; some methodological pitfalls were identified in such studies; sanitation has also been reported to produce a differential health impact depending on the presence or absence of other risk factors; diarrhoea incidence, mortality, prevalence of intestinal helminth infections and, more recently, nutritional status have been utilized as health indicators to evaluate the impact of improved sanitation; difference between neighbourhoods in environmental conditions may be associated with larger differentials in health than differences in household-level facilities (KOOPMAN *et al*, 1981; PICKERING *et al.*, 1987; BATEMAN and SMITH, 1991).

CHAPTER 3

Study area and population

3.1. Relevance of the present study to the Brazilian situation

In the Northeast region of Brazil the following conditions prevail:

a) high diarrhoea incidence, high prevalence of malnutrition and high prevalence of intestinal nematodes;

b) the health measures adopted and control programmes are mostly very narrowly medical in conception, and do not include environmental sanitation;

c) very few studies of the health impact of sanitation measures have been carried out;

d) rapid demographic change, with a continuous process of intra- and inter-regional migration making it an increasingly urban region;

e) the precarious living conditions of huge sections of the population, mainly in the urban areas;

f) a health system highly developed in some areas and completely absent in others, with the basic health needs of the majority of the population not being met;

g) the almost complete lack of collaboration between the health system and the infrastructure/sanitation institutions, resulting in low quality services to the population and in waste of time and financial resources.

In these conditions, four important considerations support the conduct of a health impact study of community excreta and sullage disposal:

i) A common feature of Brazilian cities and towns is their high level of intra-urban differentials. Sets of neighbourhoods or zones are normally distinguishable in terms of physical appearance, population composition and related social characteristics and problems. A situation like that can offer a good opportunity for a health impact study, by comparing communities with different levels of provision of environmental infrastructure in terms of their patterns of occurrence of intestinal nematode infections, diarrhoea and malnutrition. This may offer at the same time applicable and fresh information for improvement of disease control strategies and of health;

ii) The rapid increase in the urban population and the parallel decline of the rural population increase the relative importance of a variety of urban health problems, on which very little information has been collected so far;

iii) Public health measures and disease control programmes are still in development, and so can be adapted more easily to take account of new information which a study might produce;

iv) Such a study would underline the necessity of planning health and sanitation programmes at state or municipal level, and of sanitary and epidemiologic evaluation.

3.2. The place and its population

3.2.1. Salvador

Salvador was the first capital of Brazil and is the capital of the State of Bahia (Fig. 3.1). At present it is the third largest city in Brazil and the largest in the Northeast region. It has unusual topography, located on a succession of ridges which are separated by valleys more than 40 meters in depth. The hillsides are steep, sometimes with slopes greater than 45 degrees. This irregular topography was decisive in the growth of the city. Salvador was built on the ridges and on the hilltops, where the residential areas and the first streets were located.

Salvador's population increased from 290 thousand inhabitants in 1940 to 1.5 million in 1980, and nowadays this figure is 2.3 million (Fig. 3.2). More than 50% of the population growth is due to natural increase and the remainder to migration, mainly from the interior of the State of Bahia.

The land occupation by the population, the human settlement in Salvador, has two distinct and contradictory faces: some consists of ordered occupation (about 30% of the area) endowed with all necessary infrastructure, and the rest is spontaneous, disordered occupation or squatting, lacking most necessary infrastructure and public services. Today more than two-thirds of the population of Salvador are concentrated in

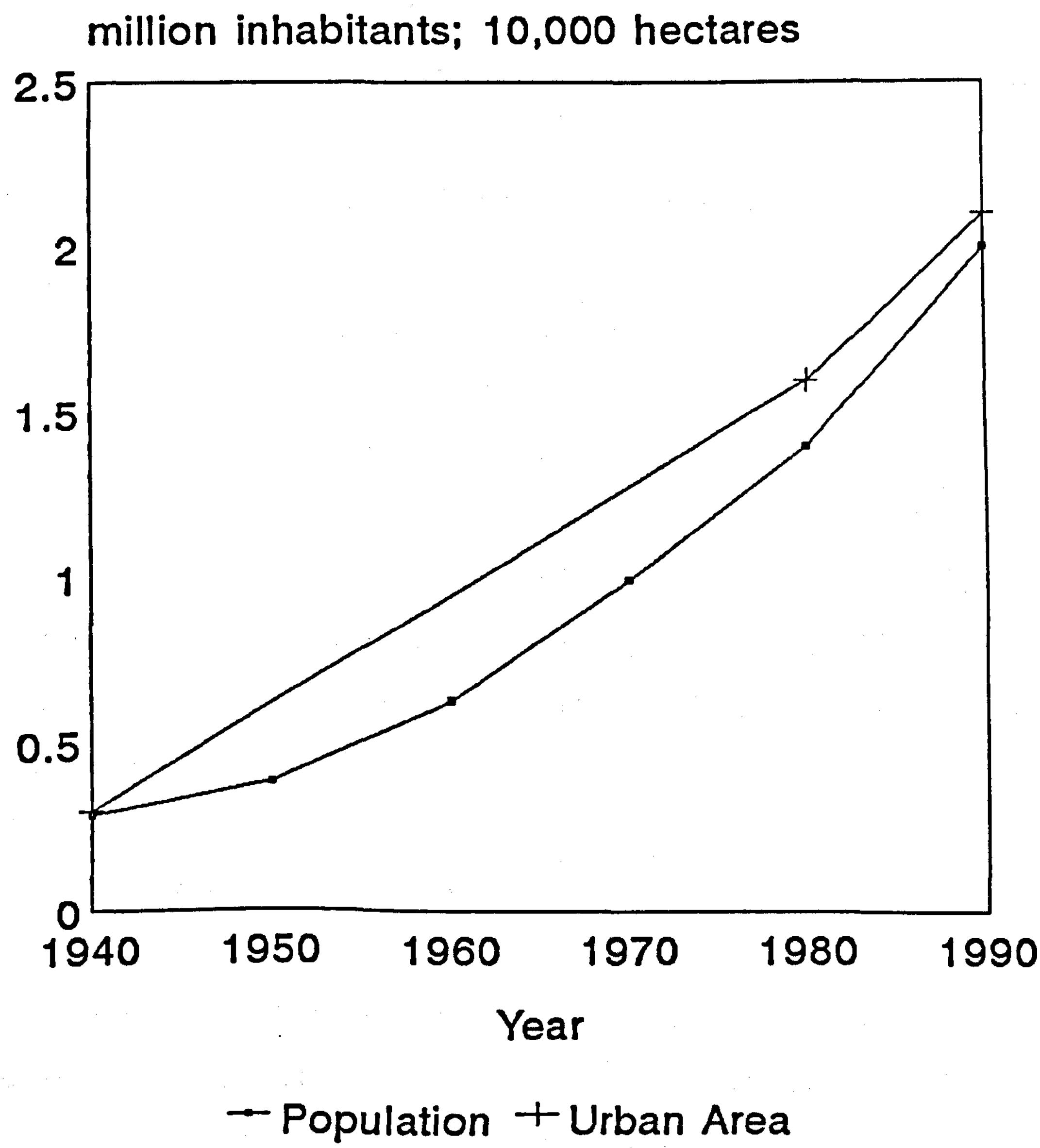
Fig. 3.1. Location of Salvador in the

State of Bahia, Brazil, South America

squatter settlements (called "invasões") and in periurban areas (SOUZA, 1990; ARAÚJO, 1991), located in the valleys and on the slopes of the hills, constructed by the low-income population, with precarious houses of small dimensions, generally without infrastructure and public services, mainly without a sewerage system or other adequate excreta disposal facilities. This lack of environmental sanitation facilitates the direct contact of people with domestic sewage, especially the children that frequently play in the alleys and streets, where open sewage runs past.

COSTA *et al.* (1985), studying the mortality pattern in children aged 1-4 years in Salvador in 1980, estimated a high mortality rate and the main causes as being respiratory diseases, diarrhoeal diseases and parasitic diseases. They conclude that the majority of these deaths could be easily avoided with some basic health measures, such as primary health care, sanitation improvements and vaccinations. They also emphasized that death rates were higher in poor peripheral areas of the city, than in the areas with better socioeconomic conditions, suggesting that the determinant factors of death also have an uneven distribution in Salvador. FARIA (1972) carried out a survey of children aged 7-14 years who attended public schools in the urban area of Salvador, and found that the prevalence of intestinal helminths was very high: *A. lumbricoides* 76.5%, *T. trichiura* 97.8% and hookworm 36.2%.

Fig. 3.2. Demograhic and spatial evolution of Salvador period 1940-1990



After Neves (1985)

Some efforts have been made by the Salvador Municipality, sometimes together with the State and Federal governments, to attend to the needs of the city. Many studies, projects and programmes on housing, public services and infra-structure have been developed and implemented, including the Camarajipe Valley Project described below, but the majority of them are sectorial, and do not tackle the main sanitation problem.

3.2.1.1. The Camarajipe River Basin; a poor urban area

The Camarajipe River, 15 km long, is the largest natural drain in Salvador, with a catchment area of 39 square kilometres inhabited by a mainly low-income population of 800,000 inhabitants distributed in 34 neighbourhoods ("comunidades"). Monthly family income from formal jobs is predominantly in the range of 1 to 3 Brazilian minimum wages (BMW's). The principal source of income lies in the informal job market (various forms of odd jobs).

3.2.1.2. The Camarajipe Valley Project

Having made the decision to intervene on the situation of the low-income populations of Salvador in 1979, the Municipal Government undertook studies with a view to finding solutions. (Municipal Prefecture of Salvador, 1980).

Based on these studies, the Municipal Government concluded that an action programme in the low-income areas would have to follow the following basic order of priorities: legalization of ownership of the land; drainage and basic sanitation of the valleys and hillsides; stabilization of the hillsides with retaining walls; creation of a road system in the valleys, particularly for mass transportation and rubbish collection; installation of water supply, electrical power and other services; and a minimum degree of town planning.

An analysis of the physical area of Salvador was carried out to identify the neighbourhoods and districts with the most serious problems of basic sanitation and greatest deficiencies in urban services. The analysis showed that the Camarajipe River Basin was the area where action was most needed.

Once the solutions for the drainage problems of the Camarajipe Basin had been identified, it was of primary importance to identify the communities within its boundaries which should receive other benefits specified in the action programme for the low-income areas. Based on the priorities set by the municipal administration at that time, the Municipality adopted certain criteria to identify the communities that should benefit from drainage and the other programmes.

These explicit criteria were: ease of access; area occupied and in expansion; consensus within the Municipal Government with relation to the area, characterizing it with reference to services and basic utilities; lack of services and basic utilities; social or community organization; type of housing;

predominant income; natural physical barriers; barriers created by physical intervention; surrounding road system and peculiarities of the area (swampiness, susceptibility to landslides, etc.). In practice, however, considerations of political patronage and economic interest also played a part. No health impact criteria were utilized.

The basic sanitation project installed in this area is characterized by a system of rainwater drainage channels combined with foot paths or stairways, which are connected to macro-drainage channels and then to the Camarajipe River.

The stairways, built from pre-cast reinforced concrete, permit drainage through their hollow interiors of the collected rainfall runoff, and sewage originating from the nearby houses, by means of lateral openings (for runoff) and hook-ups (for sewage) (Fig. 3.3). These stairways function as collectors and channels that take the effluent from the hillsides to the valley. At the same time, the covers serve as a safer walkway for pedestrians than the steep and slippery paths that existed in the area between the hilltops and the valley floors (Municipal Prefecture of Salvador, 1980).

When maintenance is poor, the hollow interiors, lateral openings and hook-ups tend to became blocked with rubbish, causing sewage to overflow.

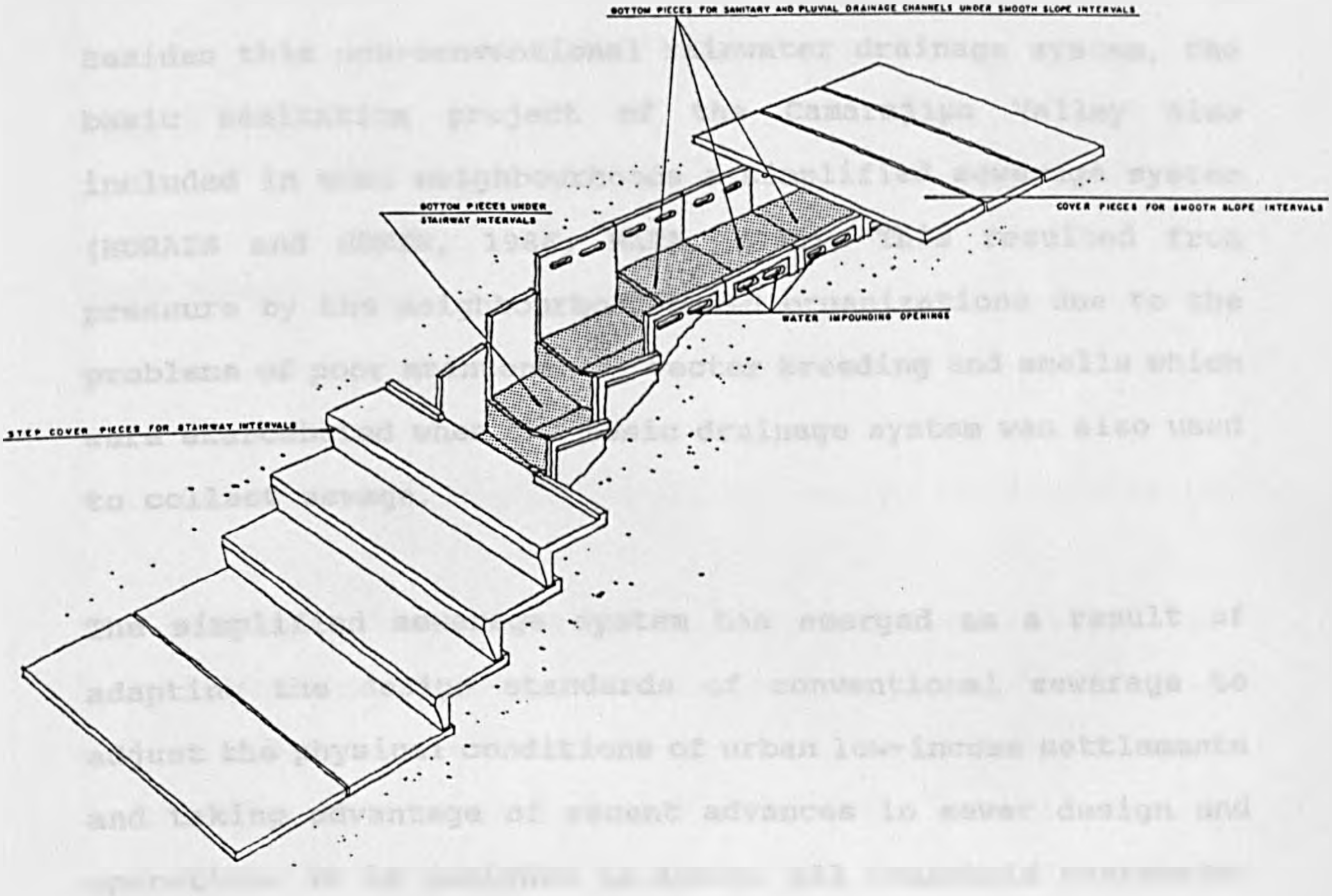


Fig. 3.3. Draining Ramps and Stairways

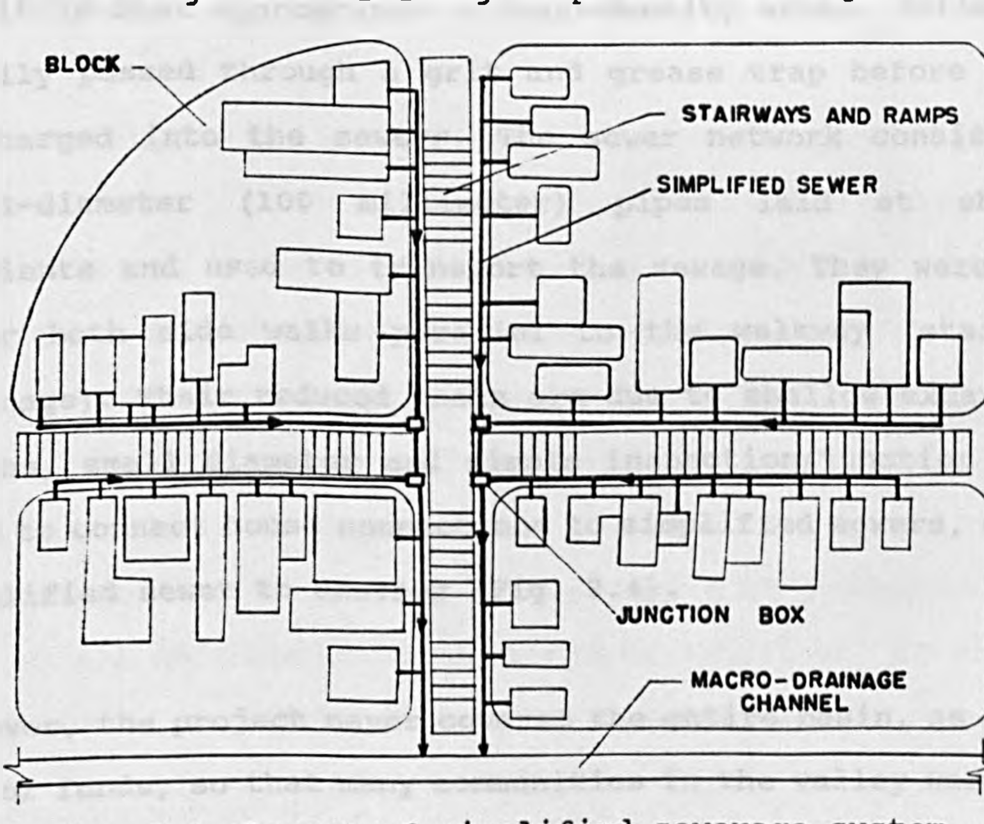


Fig. 3.4. Layout of simplified sewerage system

Besides this non-conventional rainwater drainage system, the basic sanitation project of the Camarajipe Valley also included in some neighbourhoods a simplified sewerage system (MORAES and GOMES, 1986; MARA, 1996). This resulted from pressure by the neighbourhood-based organizations due to the problems of poor maintenance, vector breeding and smells which were exarcebated when the basic drainage system was also used to collect sewage.

The simplified sewerage system has emerged as a result of adapting the design standards of conventional sewerage to adjust the physical conditions of urban low-income settlements and taking advantage of recent advances in sewer design and operation. It is designed to accept all household wastewater and it is most appropriate in high-density areas. Sullage is usually passed through a grit and grease trap before it is discharged into the sewers. The sewer network consists of small-diameter (100 millimeter) pipes laid at shallow gradients and used to transport the sewage. They were laid under both side walks parallel to the walkway (stairways drainage). Their reduced costs are due to shallow excavation depths, small diameter and simple inspection/junction boxes used to connect house connections to simplified sewers, or one simplified sewer to another (Fig. 3.4).

However, the project never covered the entire basin, as it ran out of funds, so that many communities in the valley were left with no sewerage or drainage at all.

CHAPTER 4

Study methodology

4.1. Selection of neighbourhoods for study, and consultation

The Municipal Prefecture of Salvador constructed such non-conventional surface water drainage systems (SWD) (which are used also for sewage disposal) in 17 of the 34 neighbourhoods in the Camarajipe Valley. In 11 others they also constructed shallow sewerage systems (SSS). 6 neighbourhoods were not provided with any of these facilities.

The study population was stratified into three groups according to the level of environmental facilities available: Group 3 consisted of three neighbourhoods which had both rainwater systems and shallow sewerage throughout (Photo 1). Group 2 was another three with rainwater drains used for both purposes (Photos 2 and 3), and Group 1 (the control) consisted of three more with no such intervention (Photos 4 and 5). Three neighbourhoods of each Group were selected at random from the list of all neighbourhoods with appropriate level of sanitation, making a total of 9 study neighbourhoods. They are listed in Table 4.1. and presented in Figure 4.1 below.

Photo 1. Shallow sewerage and stairways drainage system in Boa Vista de S. Caetano neighbourhood

Before the beginning of the study, meetings were held in each district to explain to the population the nature and purpose of the research and to know their opinion and get their agreement to the research. These meetings were organized together with the neighbourhood organizations, mainly Residents' Associations, in each selected neighbourhood.

Photo 2. Stairways and ramps drainage system in the Antônio Balbino neighbourhood

Despite the different forms taken by these organizations and the different names they adopted (they are referred here as Residents' Associations), most of them were created to provide a concrete collective response to a problem affecting a substantial number of the people in a neighbourhood. In

Photo 3. A channel of the stairways drainage system
in the Bom Juá neighbourhood

virtually every instance, these problems were related either to environmental services or to security. In respect to environmental health, neighbourhood organizations were set up in response to the inadequate provision of water supply, sewerage, rain water drainage, collection of solid waste,

Photo 4. Open sewage and children's play area in the Nova Divinéia neighbourhood

access roads and paths, and electricity, or to some special threat to the settlement, such as flooding or land-slides. Since members' houses were built on illegally occupied land, they were also organized to fight eviction or to negotiate with the public authorities and landowners to acquire secure land tenure (KENDALL, 1987; MORAES, 1991). The level of organization of the Residents' Associations varies within and between the neighbourhoods.

During the study a close relationship between the research team and the Residents' Associations was built up, and at the

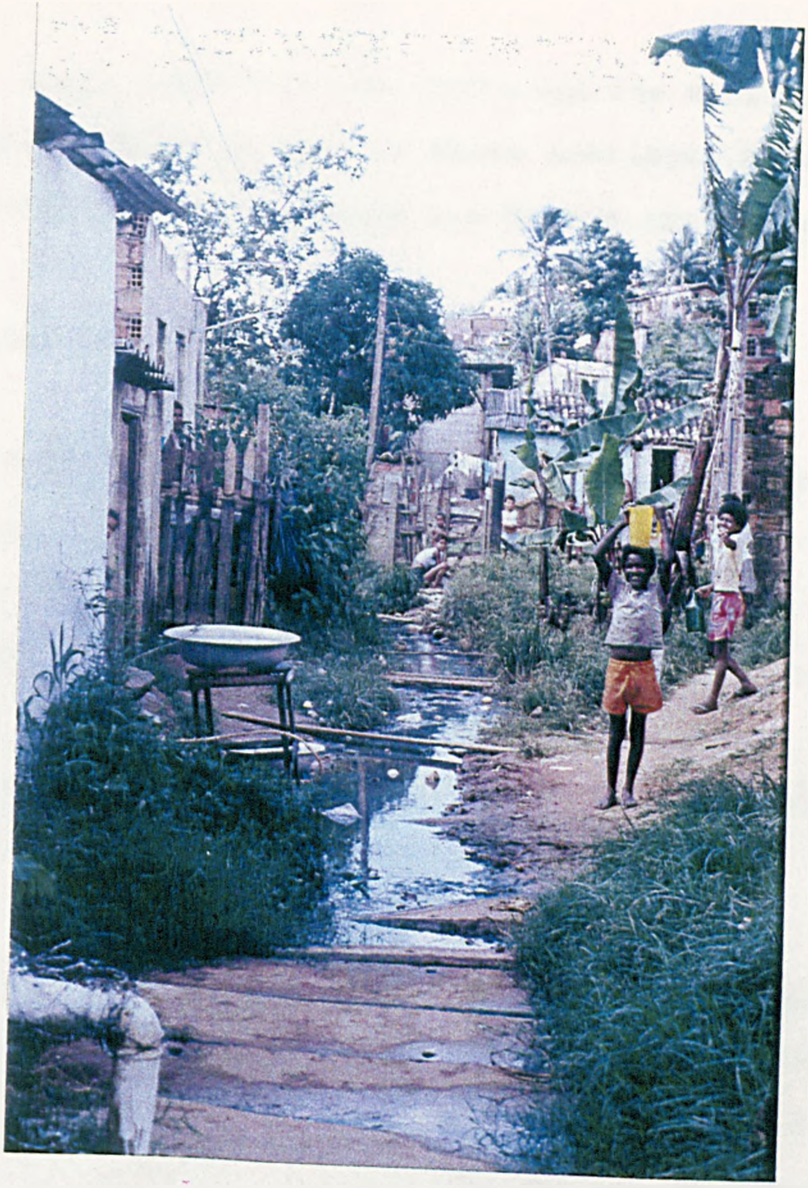


Photo 5. Open sewage and rubbish on the street in the Baixa do Camarajipe neighbourhood

end of the field work, further meetings were held to present and discuss its results with the population. A detailed report of the results was supplied to each Residents' Association, so that they could use the findings to exert pressure on the Municipal Government to provide or to improve the basic services. Local teams from the State and the Municipal Health Office participated in some of these meetings. A total of 66 such meetings were held before and during the study.

4.1.1. Selection of sample

Children under 5 years old (born after 09.10.84) and children between 5-14 years old (born between 10.10.74 and 09.10.84) living in the 9 selected neighbourhoods of the Valley of Camarajipe were studied, with the objective of estimating the incidence of diarrhoea and nutritional status, and the prevalence and intensity of intestinal nematode infections, respectively.

In each selected neighbourhood, about 120 households were randomly selected, with the objective of achieving the sample size required (130 children under 5 years old and 210 children between 5-14 years old as specified below). Households were randomly sampled from a list of all households until the required number of children in each age group had been recruited.

All children born in study households during the study period were incorporated into the study. A household was defined to include all people sharing food and sleeping under the same roof.

4.1.2. Sample size requirements

The sample size calculation was based on the number of children under 5 years of age required in order to detect a 20% difference (90% power at the 5% significance level) in diarrhoea incidence between one group of three exposed (control) and one group of three unexposed (intervention) neighbourhoods following the sanitation intervention, assuming an expected incidence of diarrhoea in the exposed population as 3 episodes/child. year (GUERRANT *et al.*, 1983). The sample size was doubled to adjust for the cluster nature of sampling. The calculations were based on the formula for the comparison of two rates (KIRKWOOD, 1988). This gave a requirement of 314 children per group.

Considering that about 25% of the initial sample might be lost during the study period due to migration and non-response, the sample size was increased to 390 for each group (distributed in three neighbourhoods, 130 for each neighbourhood) resulting in a total sample size of 1,170 children (Table 4.1).

In relation to the study of intestinal nematode infections, the sample size calculated was the required number of children between 5-14 years old to detect a 30% difference in intestinal nematode prevalence between an exposed (control) and an unexposed group of neighbourhoods, also with a 90% power at 5% significance level. It was calculated using the baseline

Table 4.1
Number of households and children selected by study group and neighbourhood

Study Group	Neighbourhood	No. of households selected	No.children selected < 5 yrs	No.children selected 5-14 yrs
Group 1 (Control)	Arraial de Baixo	108	126	210
	Baixa Camarajipe	99	132	211
	Nova Divinéia	115	138	210
Total	3	322	388	631
Group 2 (SWD)	Antônio Balbino	116	125	210
	Bom Juá	105	126	210
	Santa Mônica	124	133	211
Total	3	345	384	631
Group 3 (SSS)	B.Vista S.Caetano	106	126	211
	Jardim Caiçara	118	134	210
	Sertanejo	114	130	210
Total	3	338	390	631
Grand Total	9	1005	1162	1893

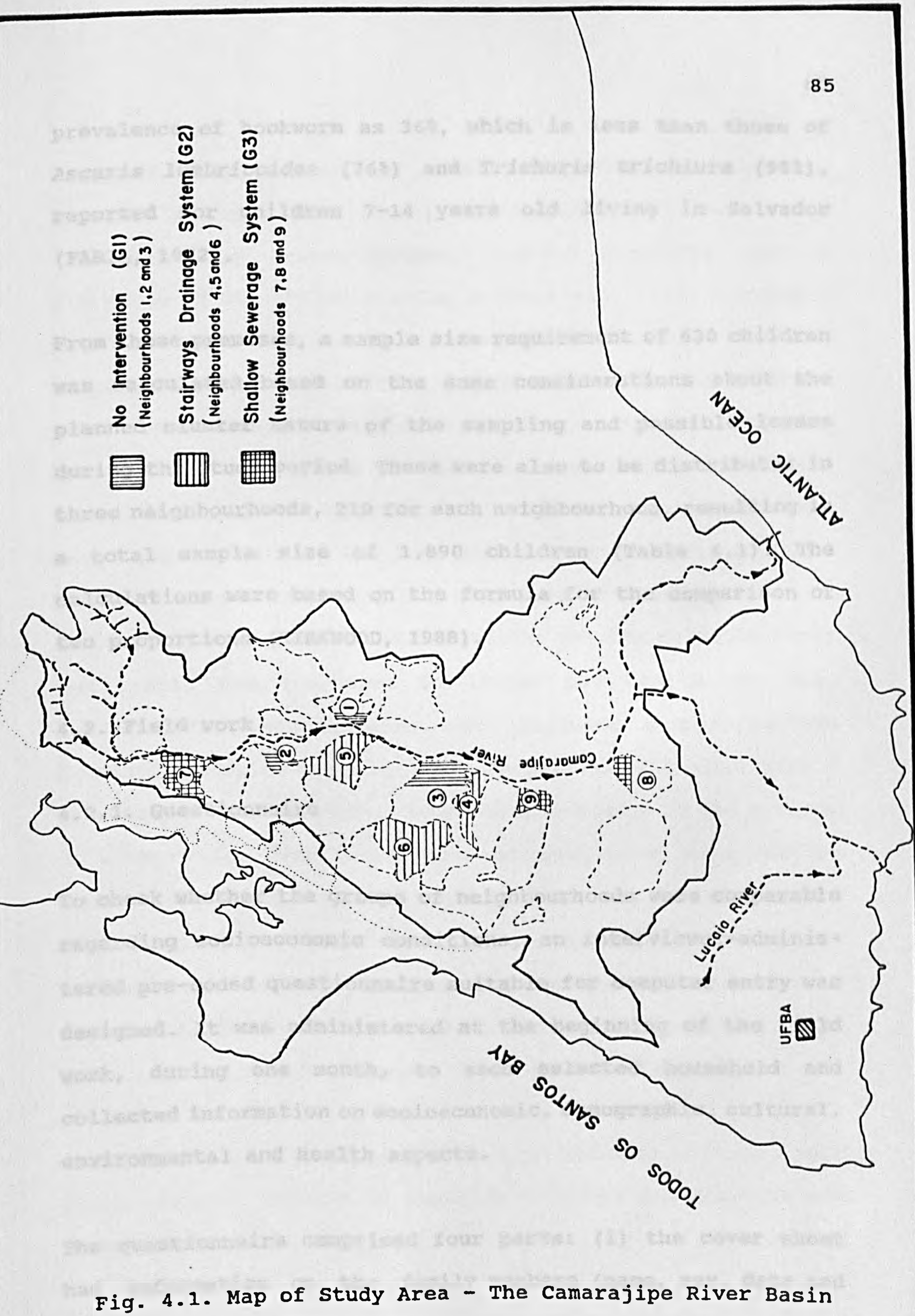


Fig. 4.1. Map of Study Area - The Camarajipe River Basin

prevalence of hookworm as 36%, which is less than those of *Ascaris lumbricoides* (76%) and *Trichuris trichiura* (98%), reported for children 7-14 years old living in Salvador (FARIA, 1972).

From these premises, a sample size requirement of 630 children was calculated based on the same considerations about the planned cluster nature of the sampling and possible losses during the study period. These were also to be distributed in three neighbourhoods, 210 for each neighbourhood, resulting in a total sample size of 1,890 children (Table 4.1). The calculations were based on the formula for the comparison of two proportions (KIRKWOOD, 1988).

4.2. Field work

4.2.1. Questionnaire

To check whether the groups of neighbourhoods were comparable regarding socioeconomic conditions, an interviewer-administered pre-coded questionnaire suitable for computer entry was designed. It was administered at the beginning of the field work, during one month, to each selected household and collected information on socioeconomic, demographic, cultural, environmental and health aspects.

The questionnaire comprised four parts: (i) the cover sheet had information on the family members (name, sex, date and local of birth, educational level, occupation and migration history of each individual), (ii) Section A containing information on breast-feeding, weaning practices and on diarrhoea of the children under 5 years old, (iii) Section B with information on nematode infection of the children under 15 years old and (i) Section C with information on environmental and household sanitation and socioeconomic status. Housing characteristics included: number of rooms, area, floor, walls, roof, electricity, water supply, storage and usage (an estimate of the household's overall water consumption was taken, by asking how many vessels were used on one day, and by measuring the volume of the vessels normally used; the result was expressed in litres per capita per day, l.c.d.). The questionnaire also included excreta/sullage disposal and solid waste disposal facilities; all sites within 10 meters of the house door with visible sewage on the ground, or with sewage overflowing from stairways, or with rubbish were observed and counted; any reported increase of vectors since last year (rats, cockroaches and flies) was noted; income, religion and ownership of goods (a radio, a fridge, a television and the house plot) were also recorded. The questionnaire, in Portuguese, is annexed in Appendix 1.

The questionnaire was administered by the nine trained local field workers. Details of their recruitment and training are given in Section 4.6.

4.2.2. Diarrhoeal morbidity

In this study diarrhoea was defined for all children under 5 years old as looser than usual stool consistency and increased frequency, as noted by their mothers or guardians. Section A of the questionnaire revealed that mothers' definition of diarrhoea always involved a change in stool consistency, with a range in the frequency of bowel movements of two to eight per day.

A daily diarrhoea reporting technique, as used in some other studies (GUERRANT *et al.*, 1983; BLUM and EMEH, 1983; HENRY, 1983; STANTON and CLEMENS, 1987; HUTTLY *et al.*, 1990), was used in this project. The advantage of this method over the usual recall system, is that it does not rely heavily on mother/ guardian's memory. Diarrhoeal histories from children aged under 5 years, were constructed from a daily recall recording system of episodes of diarrhoea by mothers or guardians through a two-week "calendar" designed for use by illiterate adults. A photograph of each child under 5 years old was placed on one card, mothers were encouraged to record daily with a sign "+" or "-" whether or not each of their children had diarrhoea on that day (Photo 6). During the two-week period the field worker returned twice to check if the mother was using the calendar and to encourage her to do so. In addition to this the field worker interviewed the mothers

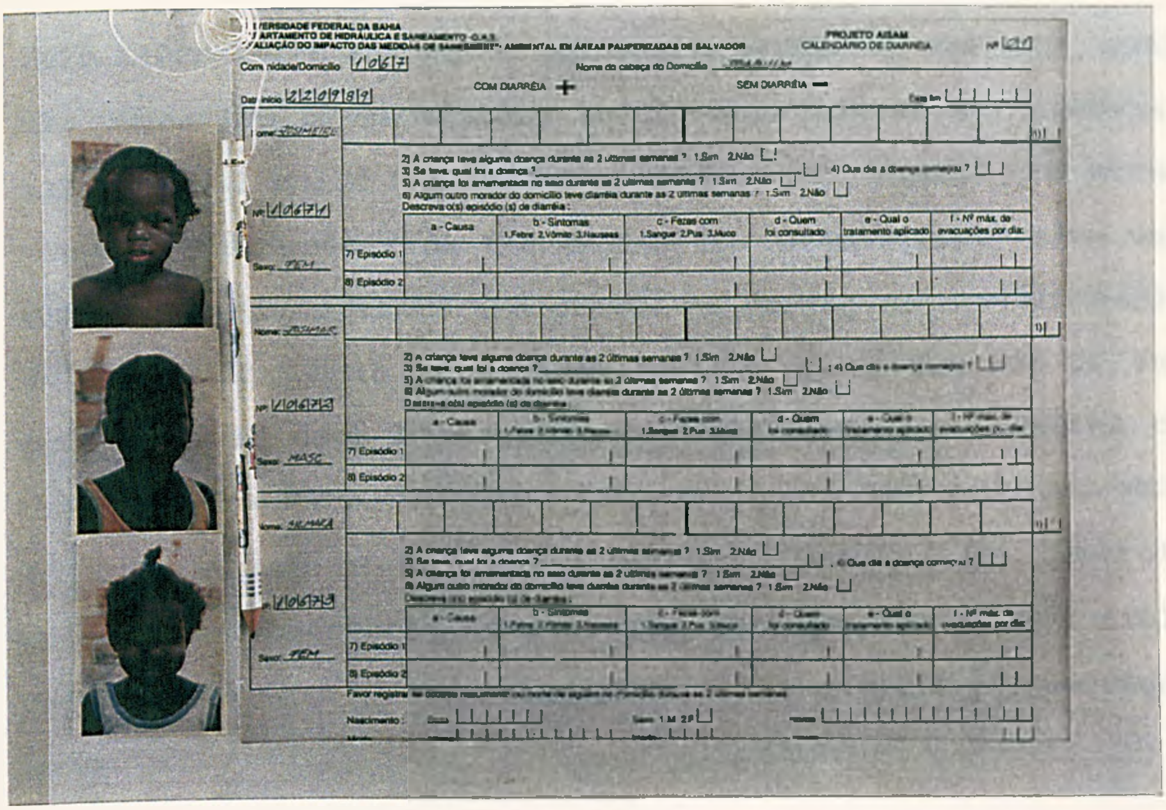


Photo 6. A diarrhoea chart with the photo of each child and the two-week calendar-form

about each episode of diarrhoea in their children (for statistical purposes, an episode was defined as one or more days of diarrhoea separated from any other episode by at least 2 diarrhoea symptom-free days) (AZIZ *et al.*, 1990; MORRIS *et al.*, 1994). The interviews were conducted at two-week intervals, at the end of which the calendar (daily record sheet) was collected and reviewed, and a new one was distributed. Mothers were asked about the cause and symptoms of diarrhoea and treatment. An indication of the severity of the diarrhoea was obtained by asking for the maximum number of stools in a 24-hour period.

This information was collected over a period of one year, with the objective of permitting the observation of any seasonal pattern. All child that reached the age of 60 months or moved away were dropped from the follow up. Considerable time was taken with the mothers and guardians during each visit early in the study, both to explain and to check the use of the calendars in each household. Data on births and deaths of household members, based on information by the mothers, were also collected by the field workers. For quality control, unannounced household visits were carried out by the field supervisors, and by the principal and the auxiliary investigators.

Mothers who asked for advice or treatment were advised how to obtain and prepare oral rehydration solution, as well as on some aspects of health care. They were informed of the location of the nearest health post/centre.

4.2.3. Anthropometric measurements

With the objective of studying the nutritional status of young children in the population, all children under 5 years old in the selected households were weighed monthly and their height measured bimonthly, resulting in seven cross-sectional surveys containing weight and height. At the beginning of the field work the age of each child was carefully recorded. The measurements of weight and height were performed in the children's households, and a specific form was used to record the results.

Body weight was recorded to the nearest 100g using a portable hanging spring balance (CMS, model MP25). Children were weighed wearing light clothes, and without any footwear. The height or length was measured to the nearest 0.5cm with a height measuring board (AHRTAG type) using a cloth tape measure fixed on a wood board, on which a headpiece/footpiece can be moved up and down to the top of the head or the foot of the child. Children under two years old were measured lying down, while children aged two to five years old were measured standing up (JELLIFFE, 1966; UNITED NATIONS, 1987b). Each field worker received a portable weighing scale and a stadiometer. One digital weighing scale with accuracy of 100g and capacity of 130kg was used to weigh the few children over 25kg.

Each child received a weight/age card (donated by the State Health Department) where the field worker recorded his or her weight every month. Mothers kept this card and were encouraged show it to the paediatrician in the health post or centre.

4.2.4. Collection and examination of stool samples

The research examined intestinal nematode infections in the population between 5-14 years old living in the same selected households in each of the nine neighbourhoods. Data regarding infection were collected to determine prevalence rates and intensities of intestinal infections (as indicated by faecal nematode egg counts per gram of faeces). A single parasitological stool examination (GYORKOS *et al.*, 1989) was carried out with particular attention to *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm egg counts although *Schistosoma mansoni*, *Enterobius vermicularis*, *Hymenolepis nana* and *Hymenolepis diminuta* were also identified and noted. The hookworm species *Necator americanus* and *Ancylostoma duodenale* were not distinguished although *Necator americanus* be predominant in Salvador.

Worm fecundity is related to worm density in a non-linear manner (ANDERSON and MAY, 1982) and thus the absolute determination of worm burdens, by expulsion, is a more reliable method for measuring infection intensity than faecal egg counts (CROLL *et al.*, 1982). However, due to the large sample size and the logistical difficulty of expulsion studies, the indicator of intensity of infection used in the present study was the egg count per gram of faeces, which provides only a crude indication of the actual worm burden. Some studies have concluded than the faecal egg-count is a satisfactory measure of parasite number per person (ELKINS *et al.*, 1986) while other studies have found a highly significant correlation between the worm count and faecal egg-count (CHAN *et al.*, 1992) and thus, faecal egg-count has been considered as an acceptable proxy measure of parasite intensity for the purpose of separating intense infections from light ones with reasonable reliability. "Intensity" in this thesis therefore refers to egg counts.

In each selected neighbourhood, on the afternoon of preselected days, the local field worker distributed appropriate containers for collecting stool samples, labelled with the identification of each individual, and collected them in the morning of the following day. The field worker matched the information of the mother and child to prevent mistakes.

Immediately after being collected, the stool samples were sent by the principal investigator to the laboratory for examination on the same day. If that sample was not ready the field worker returned the next day.

Stool samples were examined in the research laboratory of parasitology of the Department of Bioaggression of the Federal University of Bahia, located twenty minutes' drive from the study areas. Intensity of infection with intestinal nematodes was assessed by Kato's thick smear technique with a commercial kit (AK Indústria e Comércio Ltda. of Belo Horizonte). The method is identical to that described by KATZ *et al.* (1972) except that cardboard templates are replaced by plastic ones with a slightly smaller hole. This delivers a mean weight of 41.7 mg of faeces per slide. The stainless screens are replaced by nylon screens. The egg count per gram was obtained by multiplying the slide count by 24. Four microscopists (blinded to the intervention status of the community from whom the samples had been collected) and one laboratory auxiliary involved in the examination were coordinated by one Senior Parasitologist, and samples were examined only once, except as required for quality control (see Section 4.3 below).

The first stool examination was performed on 210 children in each neighbourhood. After this initial examination, free treatment was offered to all those examined (three day course of treatment with mebendazole, 200 mg each day donated by the State Health Department), and accepted by all. The anthelmintic mebendazole was utilized because it is considered as having a broad spectrum, being effective against the three nematodes studied (WHO, 1987b; WHO, 1990). The parents and families of examined children were not treated. To assure that all children took the drug correctly, the field worker asked the mother and the child separately about the treatment and matched their responses. Fifteen days after treatment, a second stool sample was taken from 5% of these children to study the efficacy of the drug. Four months after treatment was administered, stool samples were again collected from the same children examined with the objective of studying reinfection among the different groups and no treatment was offered. With the same purpose again, nine months after treatment, stool samples were collected from all study children, and a free treatment was again offered to all those children examined. Finally, a 10% sample of these children was taken to study the efficacy of the drug. During the study period there was no mass deworming programme in Salvador.

Although parents were suggested not to treat their children or themselves during the reinfection interval, anthelmintics were taken by few families and these families' data were excluded from the analyses.

After each round of stool examinations, the results were offered to the children's parents, assuring complete confidentiality.

4.3. Quality control measures

Each questionnaire and each completed form or diarrhoea calendar from the field was reviewed by the clerical worker (quality control officer) after it had been reviewed by the field supervisor. A sub-sample of 10% of these were then reviewed by the principal and the auxiliary investigators.

The socioeconomic, demographic and cultural data were collected only at the beginning of the study when a questionnaire was applied by the field worker resident in the neighbourhood. The compliance of the respondents was very good (over 98%) and all questionnaires were checked as to completeness by the field supervisor and the by the principal and auxiliary investigators, presenting excellent results. Only 3% of the questionnaires were returned to the field to correct and to complete informations. As a further check, interviews and field observations in all nine study neighbourhoods were carried out by the principal investigator on several questions of the questionnaire and on more localized exposure factors, aiming to check the reliability of responses and the completeness of the questionnaire. The result was excellent, since no differences were found in the 10% of the households randomly sampled.

The field was monitored throughout the study period. No new physical intervention took place in any of the study neighbourhoods, nor were substantial community-wide changes observed in the households studied that could contribute to alter their health status.

The two-week diarrhoea "calendar" was followed by each field worker who was a resident of her own community. As it was dangerous for outsiders to walk about at all hours, it was not possible interchange observers or rotate them between communities. The compliance of the children's guardians was very good and all calendars were checked as to completeness by the field supervisor and a sample of 10% by the principal and auxiliary investigators presenting more than 95% complete.

In the anthropometric measurements, the weighing scales were calibrated with the appropriate device before each measurement, and about 5% of the measurements were repeated blind by the field worker and the field supervisor on the same occasion, with the objective of checking inter-observer difference. These differences were monitored throughout the data collection, and any important discrepancies were identified and immediately corrected. Agreement between the field supervisor and the field worker was achieved, on average, for 93% of recorded heights/lengths (±0.5 cm) and for 91% of weights (±100g).

Quality control checks on the parasitological stool examination were performed using two different procedures. First, 10% of samples of each day were prepared in four different slides for blind examination by each microscopist and second, another 10% were prepared in one slide for blind examination by all four microscopists. Counts were then compared and averaged in these samples. No important disagreement/discre-pancies were identified and close agreement was reached on the majority of the counts.

4.4. Acquisition of climatological data

Climatological data were collected from the files at the 4th District of the DNMET (National Meteorological Department).

Data on rainfall (mm of precipitation and rainy days), mean temperature and mean humidity were obtained daily from the nearest official climatological station, and were aggregated by fortnight and by month.

4.5. Data handling and analysis

All the forms used were precoded. All the data were checked for completeness and coding accuracy before closing and sending for computer entry. The data were organized in several databases developed by a systems analyst, Mr. R. Oliveira, from the Federal University of Bahia Computer Centre using the program DBASE III+ and were entered into two microcomputers from the University's Department of Hydraulics and Sanitation.

After data entry, consistency checks were performed and the data were cleaned and preliminary analysis done; they were then transported in 3 1/2" HD diskettes to London for analysis on a PC 486/66 with 8Mb RAM and 340Mb disk capacity.

The statistical techniques used in these analyses included: chi-squared tests for general associations and for trends in proportion and Student's t-tests and one-way analysis of variance for comparing group means. Logistic regression and analyses of variance to study the combined effects of multiple potential confounding factors on nematode prevalence and on "frequent diarrhoea", and on anthropometric indicators, respectively, were also performed. The analyses of the data were performed using the software Statistical Package for Social Sciences-SPSS/PC+ version 4.0.1.

4.6. Operational aspects

The study was included as part of the research activities of the Department of Hydraulics and Sanitation of the Federal University of Bahia, of which the principal investigator is a member. A room in the Department of Hydraulics and Sanitation was used for the project headquarters, where the administration was located. In each neighbourhood the local project base was the Residents' Association office.

The work team consisted of the following people:

Principal Investigator (Coordinator)	1
Auxiliary Investigator (Sanitary Engineer)	1
Sanitary Engineering Students (Field Supervisor)	3
Interviewers, stool samples collectors (Field Worker)	9
Parasitologist (Laboratory Coordinator)	1
Laboratory Technicians (Microscopist)	4
Laboratory Auxiliary	1
Secretarial Worker and quality control officer (Clerk)	1
Data entry operators	4

The auxiliary investigator was a sanitary engineer from the State Health Department, working part-time on the project activities. The field supervisors were students of the Sanitary Engineering Undergraduate Course, selected on the basis of an interview, and each of them supervised three field workers and reviewed all forms from their neighbourhoods. The field workers were selected from the local population. Minimum requirements for application were the completion of high school, the availability of time to work (8 hours/day) and to be resident in the neighbourhood. Giving the opportunity of a job and personal development for one member of the neighbourhood, and increasing the linkage and confidence between the neighbourhood members and the project were the main reasons for choosing residents. The applicants were selected on the basis of a test and an interview with the principal and auxiliary investigators.

All the field team participated in training classes, particularly the field workers and field supervisors, in order to reduce observer bias. Several training techniques were used,including role-playing and a field pretest of the questionnaire, diarrhoea interviews, anthropometric measurements and on-site observation visits. The training took one month before the onset of the field work. It was organized and conducted by the principal and the auxiliary investigators and included the participation of other researchers from the Federal University of Bahia.

Throughout the period of the field work, monthly meetings were held between the field workers, the field supervisors, the clerical worker and the principal and the auxiliary investigators. At such meetings an evaluation of the field work was made and the field difficulties found were discussed.

At the end of the field work, a one-day evaluation was held with the participation of all members of the field team, with the objective of evaluating the objectivity and adequacy of the training in relation to the activities developed.

Stool samples were examined under the full supervision of the Senior Parasitologist, Dr. N. M. Alcântara and the partial supervision of the principal investigator. Two of the laboratory technicians were staff members from the State Health Department and two of them were students of the Undergraduate Course in Pharmacy. They were well trained and experienced people and all of them were employed by the project for laboratory work.

The maps utilized in the field work were produced by the Water Supply and Sanitation Company of the State of Bahia (EMBASA). The version was updated in May 1989 and the field worker, field supervisor and the principal and the auxiliary investigators together used on them to record the environmental characteristics found in the field.

CHAPTER 5

Characteristics of the three study groups

5.1. Characteristics of the population studied

5.1.1. Children of the diarrhoeal disease and nutritional status studies

At the beginning of the study 1,162 children under 5 years of age were living in 732 out of 1,005 households surveyed in the nine neighbourhoods. In addition, 113 children in the same households born during the 12-month follow-up of diarrhoea study were incorporated into the study, resulting in 1,275 children under 5 years of age studied in the period from November 1989 to November 1990.

The distribution of the children with regard to age and sex is presented in Table 5.1. In all three study groups there were slightly more children in the age group under 12 months than in the other 12-month intervals. No significant differences were found between the study groups regarding the age and sex distributions of the children.

Table 5.1
Distribution of children under 5 years of age by age, sex and study group, November 89-November 90

Variable	G1 n=432	G2 n=426	G3 n=417
Child's age			
0-5 months	76	70	72
6-11 months	28	22	33
12-23 months	86	71	81
24-35 months	79	87	80
36-59 months	163	176	151
Mean in months (std. dev.)	27.76 (18.29)	29.16 (18.18)	26.82 (17.70)
Child's sex			
Male	225	222	221
Female	207	204	196

5.1.2. Children of the nematode infections study

At the beginning of the study 1,893 children aged between 5 and 14 years were selected out of 1,928 children living in 795 households out of 1,005 surveyed in the nine study neighbourhoods. In each of Groups 1 and 2 a sample of 631 children was taken from 670 and 657 children surveyed, respectively. The excluded children were those nearest to the boundaries of the age range studied. In Group 3, only 601 children aged 5 to 14 years were found in the households surveyed. The 30 children needed to complete the sample size were selected from the same households but aged 4 years and 15 years. For the purposes of the study they were treated as if aged 5 and 14 years, respectively.

The distribution of the children with regard to age and sex is presented in Table 5.2. In all three study groups there were more children aged 5 to 9 years than 10 to 14 years of age. No significant differences were found between the study groups regarding the age and sex distributions of the children.

Table 5.2
Distribution of children aged 5-14 years by age, sex and study group, Exam 1

Variable	G1 n=631	G2 n=631	G3 n=631
Child's age			
5-6 years	157	157	180
7-8 years	171	158	141
9-10 years	126	122	124
11-12 years	111	106	112
13-14 years	66	88	74
Mean in years (std. dev.)	8.86 (2.79)	9.03 (2.79)	8.90 (2.71)
Child's sex			
Male	319	350	318
Female	312	281	313

5.2. Socioeconomic, demographic, cultural and environmental profile of the three study groups

1,005 households were surveyed in the three study groups of which 322 households were in Group 1, 345 in Group 2 and 338 in Group 3.

Table 5.3 presents a comparison of the distribution of socioeconomic, demographic, cultural and environmental indicators. No significant differences between the three groups were observed in access to electricity, number of bedrooms, household size, religion, animals in house and type of water supply.

Households in Group 1 (No Intervention) were significantly disadvantaged in many respects compared to the other study groups, with Group 3 showing the best indicators.

The mean time of schooling of the household heads in Group 1 was less than in the other study groups ($p<0.001$). A similar pattern was observed for the mean time of schooling of the mothers. Regarding the mean age of the mothers a significant difference was observed only between Group 1 and the other two; Mothers of Group 1 children tended to be younger.

Table 5.3.
Socioeconomic-demographic-cultural and environmental profile of the three study groups, Aug-Sept/1989

Variable	Levels	Group 1 No Interv n=322	Group 2 SWD n=345	Group 3 SSS n=338		Significance test G1vsG2	G2vsG3
Crowding	mean no. persons/room(sd)[a]	2.6(1.5)	2.3(1.3)	2.1(1.1)	t-test	**	NS
Head HH Schooling	mean in years(sd)	4.1(3.0)	5.7(3.5)	5.5(3.5)	t-test	***	NS
Monthly per capita income	mean in BMW[b](sd)	0.4(0.3)	0.6(0.4)	0.7(0.5)	t-test	***	***
Ownership of house plot	Owner	159(49.4%)	260(75.4%)	281(83.1%)	X^2 df=1	****	****
House floor area	<16m^2	84(26.1%)	96(27.8%)	28(8.3%)	X^2 df=1	NS	****
Number of bedrooms	mean(sd)	1.8(0.7)	1.9(0.8)	1.9(0.8)	t-test	NS	NS
House wall type	Brick Mud/other	270(83.9%)	316(91.6%)	306(90.5%)	X^2 df=1	**	NS
Electricity	Yes	317(98.4%)	339(98.3%)	336(99.4%)	X^2 df=1	NS	NS
Size of household	mean no. persons(sd)	6.3(2.7)	6.0(2.5)	6.1(2.9)	t-test	NS	NS
Time of Residence	mean in years(sd)	11.2(6.6)	17.4(9.6)	17.4(10.1)	t-test	***	NS
Mother's Origin	Salvador Oth urban Rural area	111(35.2%) 48(15.2%) 156(49.6%)	152(46.3%) 85(25.9%) 91(27.8%)	161(48.5%) 60(18.1%) 111(33.4%)	X^2 df=2	****	***
Religion	Catholic	258(80.1%)	258(74.8%)	249(73.7%)	X^2 df=1	NS	NS
Presence of washstand	No	258(80.1%)	208(60.3%)	215(63.6%)	X^2 df=1	****	NS
Animals in house	Any	157(48.8%)	173(50.1%)	157(46.4%)	X^2 df=1	NS	NS
House floor type	Earth Cement/other	42(13.0%)	12(3.5%)	16(5.0%)	X^2 df=1	****	*
No. of water taps	3+ 1-2 0	65(20.2%) 212(65.8%) 45(14.0%)	162(47.0%) 143(41.4%) 40(11.6%)	183(54.1%) 121(35.8%) 34(10.1%)	X^2 df=2	****	NS

Water consum per capita	mean in l.c.d.(sd)	48.3(38.7)	67.1(60.0)	78.1(71.4)	t-test	***	*
Toilet type	Flush Pit latr Without	236(73.3%) 11(3.4%) 75(23.3%)	236(86.1%) 3(0.9%) 45(13.0%)	304(89.9%) 4(1.2%) 30(8.9%)	X^2 df=2	****	NS
Water Supply	Piped	277(86.0%)	305(88.4%)	304(89.9%)	X^2 df=1	NS	NS
Water Supply distribution	Regular	120(38.0%)	240(71.0%)	232(69.5%)	X^2 df=1	****	NS
Excreta disposal	None	145(45.0%)	11(3.2%)	6(1.8%)	X^2 df=1	****	NS
Sullage disposal	None	235(73.0%)	39(11.3%)	21(6.2%)	X^2 df=1	****	*
No. sites w/sewage overf/visib	Any	276(85.7%)	164(47.5%)	15(4.4%)	X^2 df=1	****	****
Public remov of rubbish	Collected	70(21.8%)	268(77.7%)	318(94.1%)	X^2 df=1	****	****
Freq rubbish collection	Regular	49(15.2%)	59(17.1%)	164(48.5%)	X^2 df=1	NS	****
No. sites w/rubbish	Any	187(58.1)	103(29.9%)	38(11.2%)	X^2 df=1	****	****
Increse of vectors	Yes	270(83.9%)	225(65.2%)	250(74.0%)	X^2 df=1	****	*
Street	Unpaved	282(87.6%)	23(6.7%)	8(2.4%)	X^2 df=1	****	*

[a] (sd) = Standard deviation

[b] Monthly per capita income are given as proportion of the Brazilian Minimum Wage (US$ 63 in August/1989)

NS = Not significant at 5% level; * = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$; **** = $p<0.0005$

As expected, the ownership of the house plot presented a highly significant difference between Groups 2 and 3 and Group 1 ($p<0.001$). This difference was due to three reasons: the neighbourhoods of Group 3 were settled earlier, their population exerted greater political pressure on the Municipality, and when the sanitation interventions were constructed the Municipality also started the process of land tenure legalization.

In Brazil it is common to express household income in terms of the officially established minimum wage (BMW). At the time of the survey the BMW was equivalent to US$ 63 per month. The mean monthly household per capita income was lowest in Group 1, higher in Group 2 and highest in Group 3 ($p<0.001$).

No significant differences were found between the study groups regarding the household heads' and mothers' occupations. Most of the heads worked as construction workers, security guards, lorry drivers or as manual labourers while the mothers, if employed, were engaged as domestic workers or as casual workers in the service industry in the vicinity.

The origins of the heads of households and the mothers may provide some indication of the socio-cultural background of the neighbourhoods studied. About 49.6% of mothers originated from rural areas in Group 1 while in Groups 2 and 3 these figures were 27.8% and 33.4%. The settlement of households in the neighbourhoods of the intervention groups was earlier (mean duration of residence 17.4 years) than in the neighbourhoods of the non-intervention group (11.2 years) ($p<0.001$).

One factor contributing to this is the permanent mobility of the Group 1 residents since they do not have possession of their house plot, although the temporary mobility of the Group 3 neighbours may be greater due the owners renting their houses to increase the family income.

As expected, the reliability of water supply distribution was better in Groups 2 and 3 than in Group 1 ($p<0.001$), due the intervention. Regarding the other environmental characteristics there were significant differences between Group 1 and Groups 2 and 3. The coverage of excreta and sullage disposal, public rubbish collection, and street pavement was lower in Group 1 compared with Groups 2 and 3 ($p<0.001$), while the number of sites within ten meters of the house door where sewage was visible on the ground, or overflowing from drains or sewers, or where rubbish had accumulated, was highest in Group 1 and lowest in Group 3 ($p<0.001$). Such differences were to be expected in view of the nature of the interventions.

5.3. Discussion

The population studied is typical of the periurban areas of Salvador (Prefeitura Municipal de Salvador, 1981, 1983) and other Brazilian cities. It is characterized as a low-income population, with large families mainly Catholic and black.

Political patronage and the economic interest of private construction firms, the lack of infrastructure, particularly basic sanitation, and the pressure exercised by the local population through their neighbourhood-based organizations were the main reasons that led the Municipality to intervene in the Camarajipe Valley (see Section 4.1.1.2). The same factors, associated with the duration of residence and the economic power and political influence of the residents, were among the main causes for the choice of neighbourhoods where the basic sanitation project was installed.

Two types of causal link give rise to the associations between the level of community infrastructure provision and socio-economic and environmental variables, such as those shown in Table 5.3. On the one hand, a difference between communities may have pre-existed the intervention, and predisposed some communities to receive it, while others did not. On the other hand, the infrastructure produced a number of changes in the communities where it was installed, which may be considered as direct consequences of its installation.

In order to assess the degree to which any differences in health status between the study groups can be attributed to the intervention, it is essential to distinguish one type of association from the other. In the present study no baseline data were available before intervention, that is, before installation of the community sanitation. To extent that a factor may have predisposed some communities to receive the intervention, while itself being directly associated with better health status, it is a potential confounding factor.

If, however, it is a consequence of the intervention, then any improvement in health status it bestows can be considered to be a health benefit of the intervention itself. The three study groups, while being of low-income population, presented several differences in socioeconomic, cultural and environmental aspects, and this has some implications when comparing them. Therefore, the data analysis will take into account these differences and other risk factors.

CHAPTER 6

Impact of environmental sanitation on diarrhoeal diseases

6.1. Introduction

Although several authors have concluded that a household's excreta disposal may have a greater impact on diarrhoea morbidity than its water supply (ESREY *et al.*, 1985; ESREY and HABICHT, 1986; ESREY *et al.*, 1990; BATEMAN and SMITH, 1991), there have been very few studies conducted to evaluate the impact of a whole community's level of sanitation on diarrhoea.

This chapter has as objectives to study: a) the impact of community environmental sanitation on diarrhoea morbidity in children under 5 years of age; b) the age-specific impact; and c) seasonal variations.

6.2. Methods

The impact of environmental sanitation on diarrhoeal diseases was studied in children under five years of age comparing diarrhoeal morbidity between the intervention and control groups. The potential confounding effects of risk factors other than environmental sanitation on diarrhoea morbidity was also studied.

The definition of diarrhoea and collection of detailed data on diarrhoea are described in Section 4.3.2.1. All selected children were considered at risk of suffering a diarrhoeal attack, and temporary absences of children from their homes were also recorded, providing more accurate follow-up of children and allowing the population at risk to be adjusted accordingly.

The measure of diarrhoeal morbidity used in the following analyses represents the incidence of disease. Incidence rates, expressed as episodes per child per year, were computed from the ratio between the number of new episodes occurring and the number of child-fortnights of observation obtained from the calendars and are presented for overall diarrhoea.

Incidence rates were compared by calculating the incidence density ratio (IDR), which is the incidence rate experienced in one study group (such as the group with shallow sewerage system - Group 3), divided by the incidence rate in another study group (the group without community sanitation - Group 1, for example). Lacking a satisfactory method of analysis for comparing incidence rates (AZIZ *et al.*, 1990), the 95-percent test-based confidence intervals for the IDR (KLEINBAUM *et al.*, 1982) were calculated, although these confidence limits should be interpreted with some caution because repeated episodes of diarrhoea in a child are not always independent events.

Logistic regression analysis was used to study the combined effects of several potential confounding factors and of intervention group. The analysis followed the approach utilized by AZIZ *et al.* (1990), and the observed number of episodes that a child experienced in a year was compared to the expected number of episodes for a child of the same age group and followed up over the same time period in the year, eliminating the age and seasonal effects in the calculations. Those children who had more than twice the expected number of episodes were classified as a "frequent diarrhoea" group. The proportion of children classified as "frequent diarrhoea" was compared between the three study groups.

6.3. Results

6.3.1. Comparison between study groups

No baseline data were available on the incidence of diarrhoea in the nine study neighbourhoods before intervention. Table 6.1 shows that the overall incidence rates were 5.55 episodes per child per year in Group 1, but only 3.32 in Group 2, and 1.73 in Group 3. The mean percentage of days that children spent with diarrhoea was 4.9%, 3.5% and 1.9% in Groups 1, 2 and 3, respectively, representing a significant difference when the groups are compared. The proportion of episodes

Table 6.1
Diarrhoeal morbidity of children under 5 years of age by study group, Nov/89-Nov/90

Child-days of observation	
Group 3	114,305
Group 2	111,721
Group 1	118,217
Overall incidence (episodes/child.year)	
Group 3	1.73
Group 2	3.32
Group 1	5.55
IDR[a] G3/G1 (95% CI)	0.31**** (0.28-0.34)
IDR G2/G1 (95% CI)	0.60**** (0.56-0.65)
IDR G3/G2 (95% CI)	0.52**** (0.47-0.58)
% Days of diarrhoea	
Group 3	1.9
Group 2	3.5
Group 1	4.9
G3 vs G1****, G2 vs G1****, G3 vs G2****	

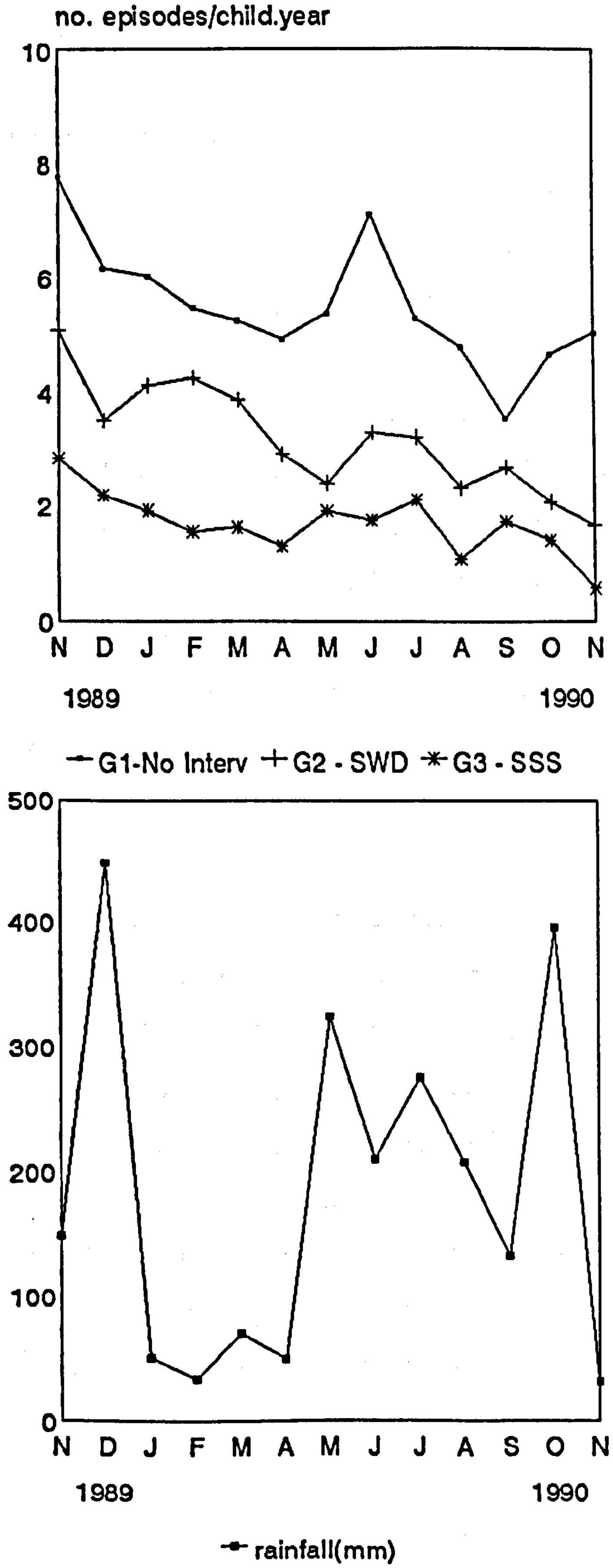
[a]IDR = Incidence Density Ratio (95% Confidence Interval)

X^2 test for significance of difference between study groups:
**** $p<0.0001$

lasting more than 14 days was 1.4% in Group 1, 3.0% in Group 2, and 2.1% in Group 3. These results show that persistent diarrhoea accounted for a very small proportion of all episodes in the three study groups. The IDR for G3/G1 of 0.31 and the IDR for G2/G1 of 0.60 mean that children living in neighbourhoods with stairways drainage and with a shallow sewerage system (the best level of community sanitation) experienced respectively, 40% and 69% fewer episodes of diarrhoea than those living in neighbourhoods without community sanitation. A significant difference in overall incidence rates can be also noted between the groups with community sanitation. The children living in neighbourhoods with a shallow sewerage system experienced 48% fewer episodes of diarrhoea than those living in neighbourhoods with only stairways drainage.

It can be seen in Figure 6.1 that the overall incidence rates calculated on a monthly basis for each study group, were highest in Group 1 (in all three neighbourhoods), intermediate in Group 2 and lowest in Group 3 (in all three neighbourhoods) throughout the study period.

Fig. 6.1. Incidence of diarrhoea in children aged under 5 years by study group and rainfall, Nov/89-Nov/90



6.3.2. Controlling for confounding factors

Aiming to identify some potential confounding variables, the association between diarrhoea incidence and several biological, demographic, socioeconomic, cultural, and environmental risk factors was also studied (Table 6.2). The factors that showed significant associations with diarrhoea and were not considered a consequence of improved environmental sanitation are child's age, child's sex, child's birth order, number of children aged under 5 years, crowding, mother's education, monthly per capita income, use of kitchen, animals in the house, presence of a washstand, water usage and house floor material. Tese factors were selected as potential confounding variables for inclusion in the multivariate logistic regression analysis.

Multivariate logistic regression analysis was then used to examine the combined effects of these potential confounding factors on the association of diarrhoea and environmental sanitation. The outcome variable used was "frequent diarrhoea" (more than twice the expected number of episodes). All the potential confounding effects of the variables listed previously were controlled. Complete data for analysis were available for 961 children. The method utilized in the logistic regression was forced entry, in which all variables

Table 6.2
Incidence of diarrhoea (episodes per child per year) for risk factors in the nine neighbourhoods studied (n=1017), Nov/89-Nov/90

Risk factor	%[a]	ECY[b]
BIOLOGICAL		
Child's sex**[c]		
female	48.1	2.83
male	51.9	3.66
Child's age***		
24-59 months	57.5	2.82
0-23 months	42.5	4.29
DEMOGRAPHIC		
Child's birth order**		
first	30.6	2.67
second or third	39.5	3.20^{NS}[d]
fourth or more	29.9	4.17***
Mother's age^{NS}		
36+ years old	36.7	3.04
24-35 years old	48.5	3.41^{NS}
less than 24 yrs	14.8	4.03^{NS}
Household size^{NS}		
6 or less persons	52.6	3.09
7 or more persons	47.4	3.65
No. of children under 5 years**		
1 or 2	66.3	3.04
3+	33.7	4.04
SOCIOECONOMIC STATUS		
Crowding***		
< 3 persons/room	79.3	2.93
3-5 persons/room	15.3	4.44***
> 5 persons/room	5.4	6.56***
Per capita income***		
0.5+ BMW/month[e]	32.9	2.11
<0.5 BMW/month	67.1	3.97***
Mother's education***		
seven or more years	34.2	2.32
three to six years	48.6	3.78***
less than three yrs	17.2	4.29***

Floor area of house***		
32+ m^2	43.1	2.33
17-31 m^2	33.2	3.43***
4-16 m^2	23.7	5.14***
Use of kitchen***		
only for cooking	60.5	2.68
sleeping, animals	39.5	4.41***
<u>CULTURAL</u>		
Presence of a washstand***		
yes	28.0	2.27
no	72.0	3.78***
Presence of a rubbish container***		
yes, with lid	57.6	2.54
yes, without lid	32.5	4.18***
no	9.9	5.49***
Animals in household***		
none	28.0	3.14
any	72.0	5.31***
<u>HOUSEHOLD ENVIRONMENT</u>		
House floor material***		
cement/other	90.7	3.03
earth	9.3	6.63***
No. water taps***		
two or more	65.0	2.64
one	20.8	4.58***
none	14.2	4.86***
Water usage***		
all uses	82.2	2.68
drinking/cooking/ personal hygiene	17.8	6.51***
Toilet type***		
flush	87.8	3.02
pit latrine	2.7	4.34^{NS}
none	9.5	6.19***

[a] Percentage of children exposed to risk factor
[b] ECY = episodes per child per year
[c] One-way analysis of variance or t-test were used to compare groups means: p values as presented below
[d] Significance of difference from incidence at least exposed level * $p<0.05$; ** $p<0.01$; *** $p<0.001$
[e] Monthly per capita income are given as proportion of the Brazilian Minimum Wage (US$63 in August/1989)

are entered in a single step (NORUSIS, 1990a). Table 6.3 shows the results in the form of unadjusted (crude) and adjusted odds ratio. The odds ratio is roughly equivalent to the ratio of risks to children in two groups of having "frequent diarrhoea", other things being equal. An odds ratio greater than one implies that the association with the risk factor is in the expected direction.

Table 6.3.
Odds Ratio (95% confidence interval) of "Frequent Diarrhoea" for Environmental Sanitation Group

Environmental Sanitation Group	% "fd"*	Odds Ratio (95% CI) Unadjusted	Adjusted
Shallow sewerage	3.8	1.00 -	1.00 -
Stairways drainage	11.6	3.33(2.15-5.15)	2.97(2.00-4.41)
No Intervention	28.0	9.89(5.81-16.83)	8.10(4.99-13.16)

* % of children with "frequent diarrhoea"

It should be noted that after adjustment for potential confounders, the estimated odds ratios were slightly lower than the crude value and that the association between diarrhoea incidence and environmental sanitation (excreta and sullage disposal) remains highly significant ($p<0.0001$). No significant interactions between potential risk factors were found.

6.3.3. Age-specific impact

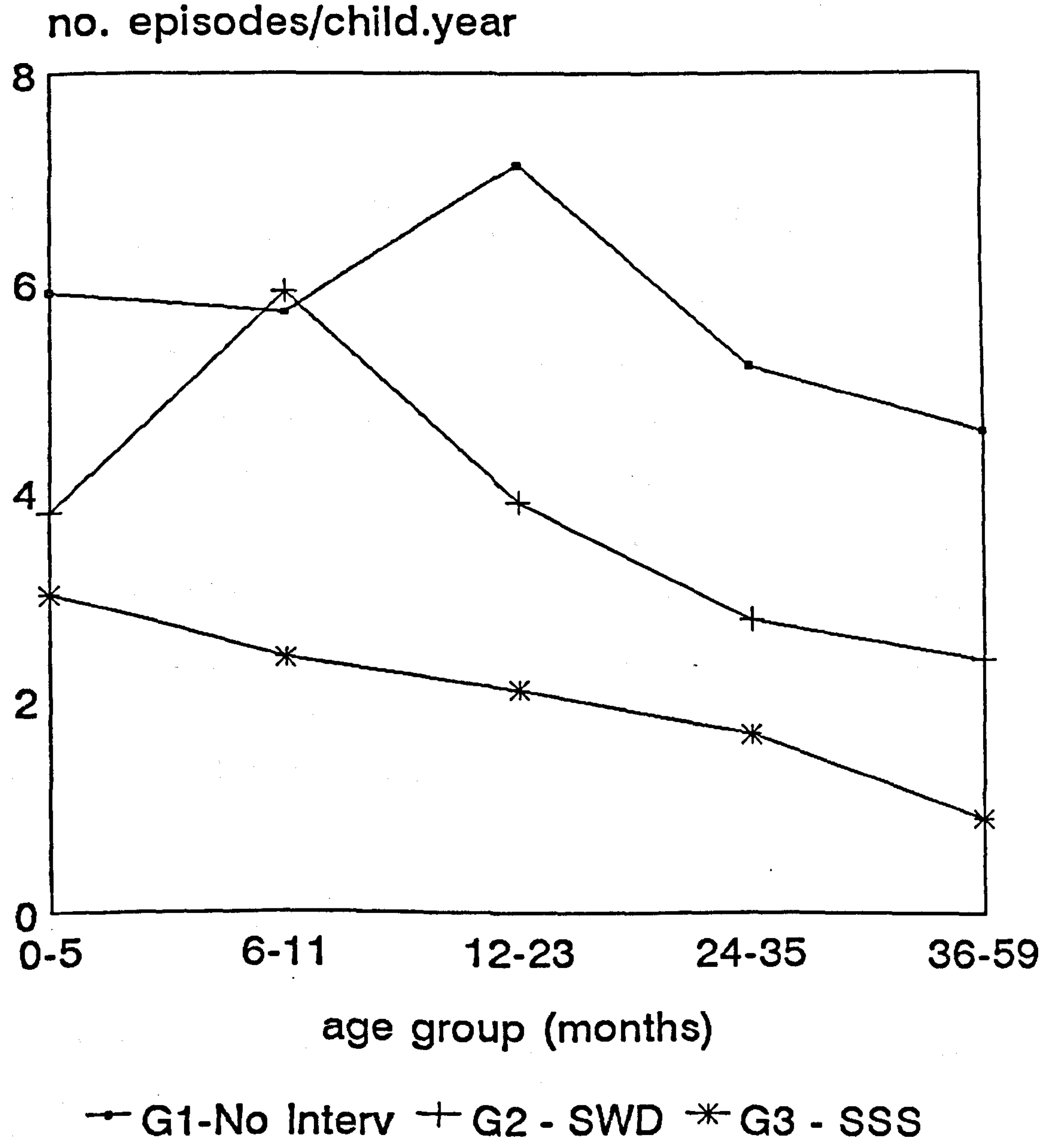
Age-specific diarrhoeal morbidity measures were calculated, and the overall incidence rates are shown in Figure 6.2. The difference between groups were most marked in expected direction above 12 months and not so clear in infancy.

The difference between study groups was similar for males and females. Males had a higher incidence of diarrhoea than females in children of Group 1 ($p<0.0001$) and Group 2 ($p<0.01$), but in children of Group 3 the incidence was very similar.

6.3.4. Seasonal variations

Seasonal variations in diarrhoea incidence were also studied. The overall incidence rates for each month and study group are shown in Figure 6.1. The monthly incidence of diarrhoea during November 1989 to November 1990 showed a varied pattern. Although there were no clear parallels between monthly precipitation and diarrhoeal peaks, the main peak was in June to July, one to two months after the rainfall peak (precipitation and rainy days) and the months of lowest mean temperature. The overall incidence rates were computed for the two main seasons, December to April (hot and dry) and May to November (warm and rainy). During the months from May to November, there were typically four or more rainy days and 50 millimetres or more of rainfall per fortnight being the period considered as "rainy season". Table 6.4 presents diarrhoea

Fig. 6.2. Incidence of diarrhoea in children by age and study group, Nov/89-Nov/90



incidence in the three study groups for each season. The results indicate that in both seasons the pattern of diarrhoea incidence between study groups is similar and that in the "rainy" season the attack rate of diarrhoeal disease was slightly lower in the three study groups than in the "drier" season.

Table 6.4
Diarrhoea incidence (episodes/child.year) in children aged under 5 years by study group and by season, Nov/89-Nov/90

Study group	"Drier season"	"Rainy season"
Shallow sewerage	1.80	1.71
Stairways drainage	3.41	3.14
No Intervention	5.62	5.51
P value[a]	<0.001	<0.001

[a] One-way analysis of variance

6.4. Discussion

In this chapter, some aspects of the epidemiology of diarrhoeal diseases were considered:

- the incidence of the disease;
- controlling for risk factors associated to the disease;
- age- and sex-specific patterns;
- influence of seasonal variations.

The primary objective in this chapter was to evaluate the impact of environmental sanitation on the incidence of diarrhoea.

Incidence of diarrhoea was consistently higher in the group of neighbourhood unimproved community sanitation throughout the study period.

The sewerage and drainage had a significant effect on diarrhoeal morbidity even after controlling for confounding factors. The incidence of diarrhoea in the group with shallow sewerage system (Group 3) fell to one third and in the group with stairways drainage system (Group 2) fell to two thirds of that in the group without community sanitation (Group 1).

The difference of incidence of diarrhoea between the study groups is unlikely to be due to observer bias. Although each field worker was a resident of her community and it was not possible to interchange observers or rotate them between communities, as mentioned in Section 4.3., this view can be supported because the difference of incidence of diarrhoea between each community within each environmental sanitation group was not significant.

The progressive fall in the incidence of diarrhoea through the period of the study (Fig. 6.1) has been found in other studies

(HUTTLY *et al.*, 1990; AZIZ *et al.*, 1990) and could be explained due to: a) interviewers'and/or interviewees' fatigue, or loss of motivation, and b) a real fall due to some educational impact from the study itself, or due to normal year-to-year variations in incidence.

The change in the peak age of diarrhoea incidence from Group 1 to Group 3 (Fig. 6.2) suggests that the component of transmission which the environmental sanitation controls is among children above 1 year old but not in infants, as well children older than 1 year are more likely to play in the street, and to be exposed to the faecal contamination of the environment.

Significant difference was found between the three study groups as for males as for females. On the other hand, the higher incidence in boys (much higher in Group 1) has been found in other studies (GIUGLIANO *et al.*, 1986; HUTTLY *et al.*, 1987; SILVA, 1988) and could be explained that diarrhoea in boys is more likely to be noticed, and hence reported by their mothers. On the other hand, the difference is greatest in Group 1, so another factor may be that boys are more exploratory, and more likely to be allowed out into the street, and hence exposed to sewage or rubbish.

Although difference between the study groups was significantly similar for "drier" and "rainy" seasons, the seasonal pattern of incidence of diarrhoea found in this study was similar with that found in other study developed in Salvador (SILVA, 1988), but different of those found in other studies from the Brazilian's north and northeast regions (GUERRANT *et al.*, 1983; GIUGLIANO *et al.*, 1986). There was no clear relationship between the monthly rainfall and the monthly incidence of diarrhoea. However, there seems to a tendency for the lowest rate to occur during the rainy season.

The present study showed the importance of environmental sanitation in the epidemiology of diarrhoeal diseases. The results provide some evidence that improved environmental sanitation can have a positive impact on diarrhoea morbidity in young children in peri-urban areas of Salvador.

CHAPTER 7

Impact of environmental sanitation on nutritional status

7.1. Introduction

Improvements in community sanitation may be associated with a reduction in the incidence of childhood diarrhoea and with a reduction in the prevalence of intestinal nematodes. If these relationships are causal, and if repeated episodes of diarrhoea, as well as intestinal nematode infections, lead to poor growth, then one might expect to see a similar association between environmental sanitation and anthropometric indicators.

This chapter has as its objectives to study the impact of environmental sanitation on the nutritional status (determined by anthropometry) of children under 5 years of age.

7.2. Methods

Seven cross-sectional surveys were conducted in the three study groups, as described in Section 4.2.3. The child's age in months was determined from the date of birth recorded in an official document kept by the parents at home.

The anthropometric data were initially processed using a computer program CASP (Anthropometric Software Package) developed by the Center for Disease Control of the U.S. Public Health Service for use in the evaluation of the nutritional status of children (JORDAN, 1987), and afterwards transformed into an SPSS file for analysis.

The data were analyzed by comparing height-for-age (h/a), weight-for-height (w/h) and weight-for-age (w/a) with the National Center for Health Statistics (NCHS) reference population (WHO, 1983). Z-scores, representing the number of standard deviations from the NCHS median value, were computed for each indicator. Comparisons of mean z-scores were made between the study groups using Student's t-test or one-way analysis of variance. Multiple regression was used to study the combined effects of environmental sanitation group and several potential confounding factors on each of the three anthropometric indicators. In these analyses the child's z-scores were used as continuous outcome measure.

7.3. Results

7.3.1. Comparison between study groups

Data on weight and height were available for 1,186 (93.0%) of the 1,275 children under 5 years of age followed-up in the diarrhoea study between November 1989 and November 1990.

Height-for-age, weight-for-age, and weight-for-height z-scores were computed for each child. After examination of the distribution of these z-scores, those of -6 and below or of +3 and above found for each survey were excluded since such outlying values are likely due to inaccuracies in measuring height, weight or age; these represented only 0.8% of the sample for height-for-age, 0.4% for weight-for-age, and 1.0% for weight-for-height.

A small loss in the study population was observed from one survey to the next in all three study groups, since some children reached the age of 60 months or moved away. The total loss was 5.4%. The mean age of the children varied from 30 to 35 months during the seven surveys, but no significant differences were found between the three study groups.

The nutritional status of children in this study was found to be poor in all three study groups when compared to the NCHS standards. The children were shorter and lighter, so that their height-for-age (h/a) and weight-for-age (w/a) z-scores were low, but their weight-for-height (w/h) z-scores were not as depressed (Table 7.1). Age- and sex-specific means for the three anthropometric indicators were calculated. For all three study groups the lowest mean h/a z-scores were observed in children aged between 12 and 23 months and the lowest mean w/a and w/h z-scores were observed in children aged between 36 and

59 months. The age patterns are similar to the growth faltering observed in many developing countries.

Table 7.1
Mean h/a, w/a and w/h z-scores by study group, Survey 1

Study group	h/a	w/a	w/h
Shallow sewerage	-0.66 (n=344)	-0.55 (n=346)	-0.20 (n=341)
Stairways drainage	-0.71 (n=353)	-0.70 (n=354)	-0.29 (n=354)
No Intervention	-1.00 (n=370)	-0.68 (n=370)	-0.08 (n=367)
P value[a]	<0.01	>0.05	<0.05

[a] One-way analysis of variance

The environmental sanitation group was associated in the expected direction only with h/a. Children living in neighbourhoods without community sanitation had lower h/a mean z-scores than those living in neighbourhoods with shallow sewerage and stairways drainage systems. The study group also was associated with w/h, but this ran contrary to expectation and it was not associated with w/a.

Figures 7.1 through 7.3 show how the mean h/a, w/a, and w/h z-scores in each study group varied during the study.

Height-for-age: Figure 7.1 shows children in Group 1 had a lower mean h/a z-score than those in the Groups 2 and 3 throughout the study. These differences were statistically significant. The mean z-scores were similar in Group 2 and Group 3, with no statistically significant difference. For Groups 1 and 2, there was a slight upward trend in the mean h/a z-score over time;
Weight-for-age: Figure 7.2 shows that throughout the study period, the children in Groups 1 and 2 had a lower mean w/a z-scores than those in the Group 3, but these differences were not statistically significant. There was a slight upward trend in the mean w/a z-score over time in all three study groups;
Weight-for-height: Figure 7.3 shows children in Group 2 had a lower mean w/h z-score than those in Groups 1 and 3 and these differences were statistically significant. No significant difference was found between Groups 1 and 3. No upward trend over time was found.

It can be observed of the three figures above that height-for-age was always more depressed than weight-for-age, and much more than weight-for-height in children of the three study groups.

Fig. 7.1. Mean height-for-age z-score of children under 5 years of age by study group and survey

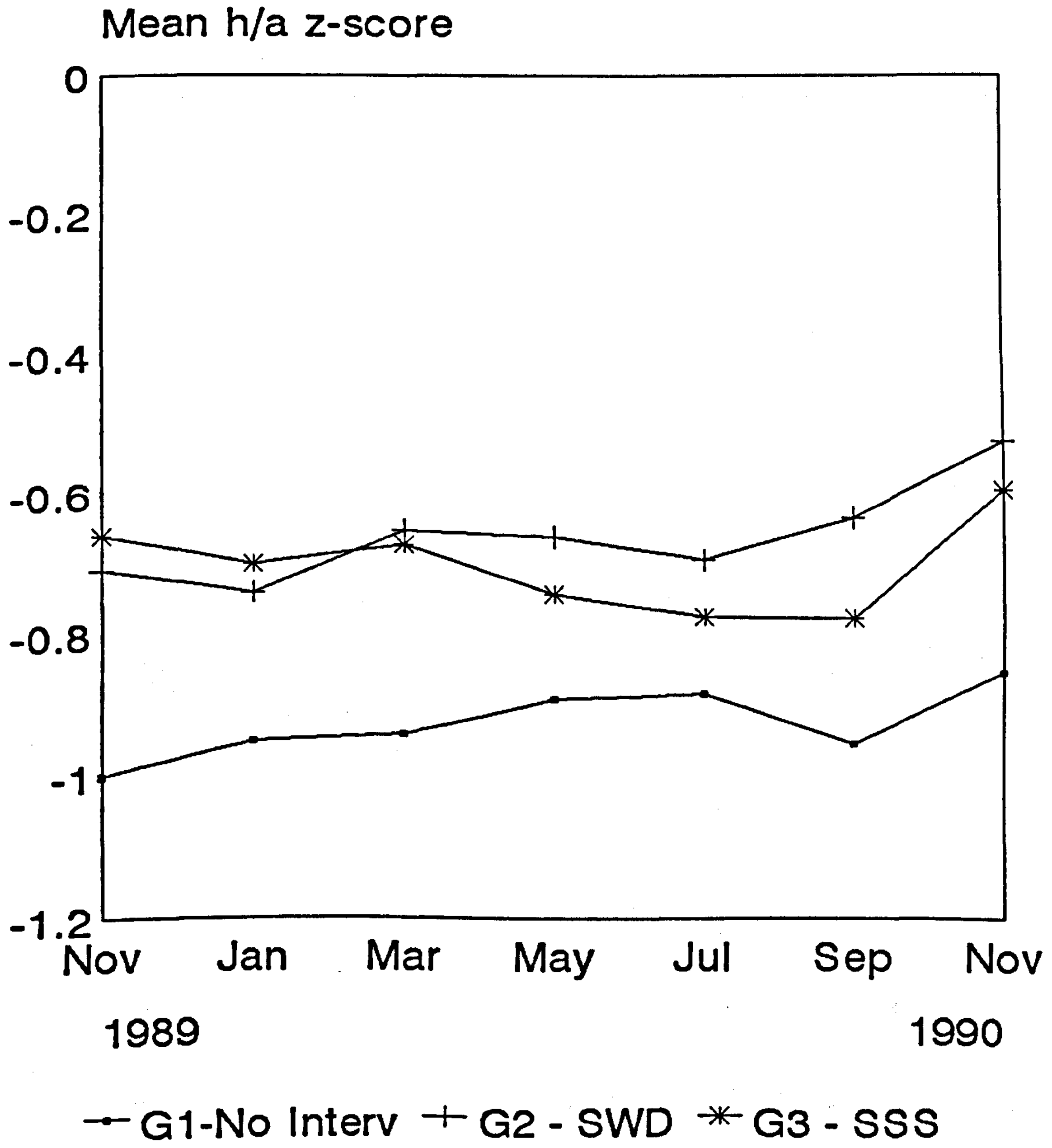


Fig. 7.2. Mean weight-for-age z-score of children under 5 years of age by study group and survey

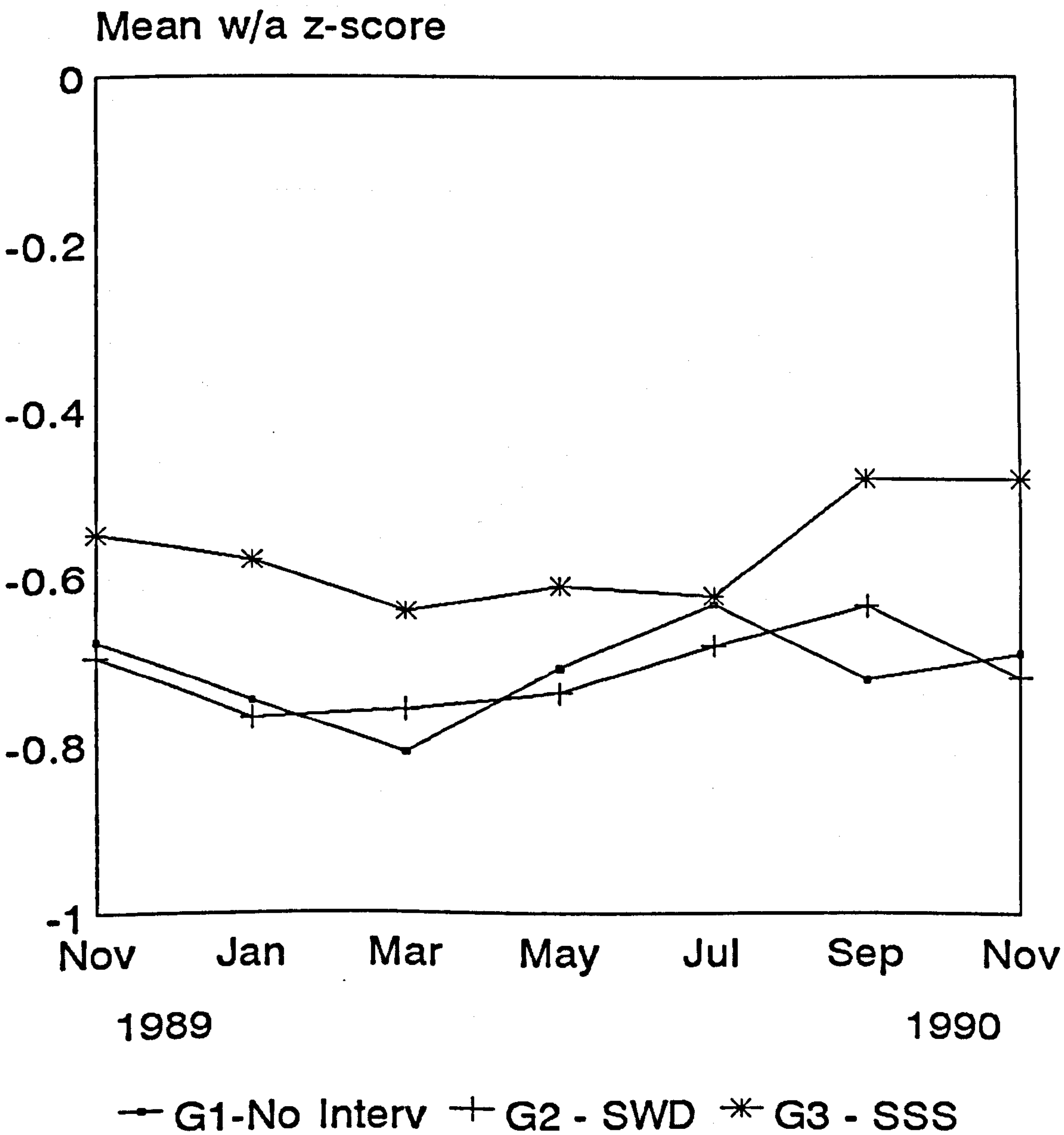
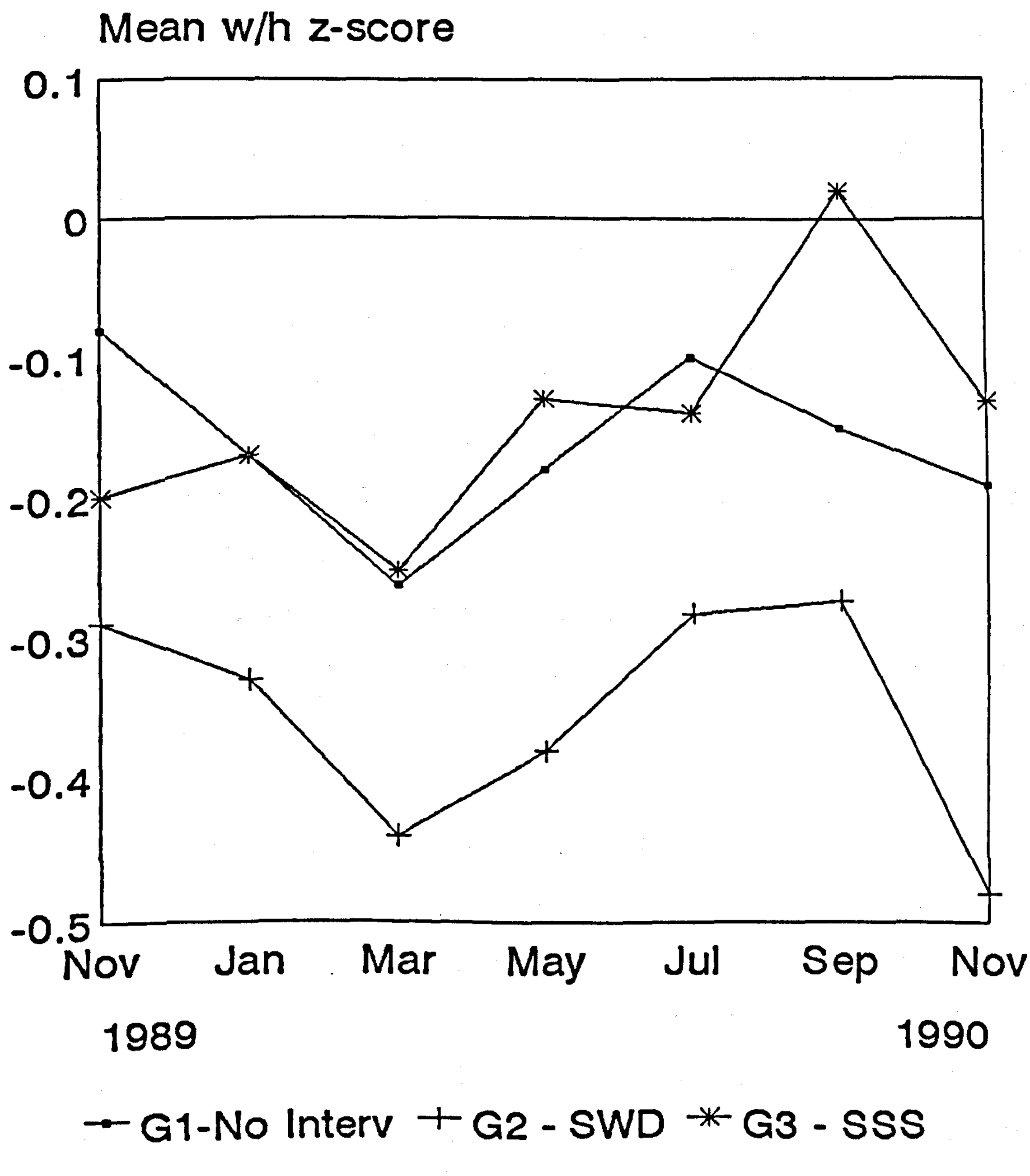


Fig. 7.3. Mean weight-for-height z-score of children under 5 years of age by study group and survey



7.3.2. Controlling for confounding factors

In order to identify some potential confounding variables, analyses of the association between each anthropometric indicator and several biological, demographic, socioeconomic, cultural, and environmental risk factors in Survey 1 were performed. Survey 1 was selected because it was carried out at the beginning of the study and so, does not suffer some imp102 act from the study itself. From these analyses, the most important potential confounders were identified by taking those that obtained more significant association with nutritional status and that were not considered a consequence of improved environmental sanitation. In this way the following potential confounding variables were selected for inclusion in the analysis of variance model: child's age, child's sex, child's birth order, mother's education, crowding, monthly per capita income, child play/stay area and religion.

Analyses of variance was then used to examine the combined effects of these potential confounding factors on the association of nutritional status and environmental sanitation. The ANOVA procedure used taken account the testing for interactions between variables (NORUSIS, 1990b). Complete data for analysis were available for 1,074 children. The F statistics (the ratio of the mean square of each source of variation to the mean square for the residual) was calculated, and the probability of F and the mean h/a, w/a and w/h z-scores for each study group after controlling for the potential confounding variables are shown in Table 7.2.

Table 7.2
Analyses of variance of mean h/a, w/a and w/h z-scores, and environmental sanitation group, controlling for potential confounding variables

Environmental Sanitation Group	h/a	w/a	w/h
Shallow sewerage	-0.64	-0.50	-0.13
Stairways drainage	-0.67	-0.64	-0.25
No Intervention	-1.00	-0.67	-0.04
Significance of F value	<0.01	>0.05	<0.05

Note: the potential confounding factors controlled are those listed in the text

After controlling for potential confounding variables, the association between anthropometric status and the variable environmental sanitation group (community excreta and sullage disposal) remains statistically significant ($p<0.01$) in the expected direction for height-for-age. No significant interactions were found between the potential confounding variables.

7.4. Discussion

This chapter has examined the impact of environmental sanitation on nutritional status.

Children living in the neighbourhoods without community sanitation presented during the study period a significantly lower nutritional status expressed by the mean height-for-age z-score, a lower (but not significantly lower) mean weight-for-age z-score and a similar mean weight-for-height z-score than those living in neighbourhoods with a shallow sewerage system.

This result is similar to the finding of BATEMAN and SMITH (1991) that children living in either urban or rural communities in Guatemala with a high level of community sanitation coverage had a lower risk of stunting, expressed as a height-for-age z-score more than 2 standard deviations below the NCHS/WHO reference median, than children living in communities with a low level of community sanitation.

Weight-for-height is typically taken as an indicator of acute undernutrition while height-for-age is considered an indicator of chronic undernutrition (WATERLOW *et al.*, 1977). The factors considered in the analyses were included because it was thought that they might be risk factors for diarrhoea, and in this way have an impact on anthropometric status. If improved environmental sanitation reduced the incidence of diarrhoea (as was noted in the previous chapter) then this effect might have contributed for a better height-for-age. Thus, the association observed suggests a long term impact of environmental sanitation on anthropometric status. No strong evidence of any short term impact was observed.

Anthropometric status has been suggested to constitute an appropriate indicator of the health impact of sanitation and water interventions (ESREY and HABICHT, 1986). While anthropometric measures may be more valid and reliable than some measures of diarrhoea morbidity (though measurement problem do exist), and while anthropometric status is clearly a measure of considerable public health importance, it is still unclear how responsive anthropometric status is to improvements in sanitation facilities, water supply and hygiene practices.

In practice, the impact of sanitation and water supply on nutritional status has not always been detected (COUSENS *et al.*, 1990; DANIELS *et al.*, 1990; ESREY *et al.*, 1992). Several studies have found an association between the use of water supply and sanitation facilities and the nutritional status of the users, although most of them have been cross-sectional of whole community, in which analysis of the data on individual households was used to detect the association. According to AZIZ *et al.* (1990) it is possible that what they have detected is an association between nutritional status and some characteristic (for example, an aspect of higher socioeconomic status) of a family that predisposes it to make better use of the facilities.

In observational studies it is never possible to be certain that confounding has been completely controlled. Some residual socioeconomic, cultural or demographic confounding may be responsible for the association. However, in this study strong crude association between improved environmental sanitation and anthropometric status (expressed by height-for-age) remained significant in the expected direction.

Even with children in Group 1 being shorter and lighter than those in Groups 2 and 3 these groups with better environmental sanitation had a growth deficit, indicating that a provision of improved community excreta and sullage disposal is only one of the factors, although vitally important to be considered to reduce malnutrition or improve nutritional status.

The growth patterns of the children in the neighbourhoods of the three study groups presented several interesting characteristics. Although low birth weight be usually much higher in the poor urban communities studied than in the NCHS reference population, the mean weights and heights of the children at birth were similar to the NCHS reference population, suggesting that maternal malnutrition during gestation can have not been a problem in these neighbourhoods; the growth of the infants during the first few months of life was similar to the NCHS reference population, indicating that the feeding practices were adequate during this period and that the majority of mothers who breastfed their infants were able to do so successfully during the initial months. On the other hand, the relative growth faltering observed after the first few months of life suggests that environmental factors, either nutrition or infectious diseases, were interfering with potential growth. This is a common pattern in developing country populations. LOPEZ DE ROMANA *et al.* (1987) have found similar characteristics in a peri-urban community near Lima, Perú.

Although both weight and height of the children studied in the three study groups faltered with respect to the NCHS reference population data, linear growth was more retarded/depressed, and the mean weight-for-height was close to the NCHS values at most age groups. It is unknown whether this growth pattern, that is, the greater depression of linear than ponderal growth, can be attributed to environmental or genetic factors.

Community-based epidemiological studies in several regions of the world have found a significant relationship between diarrhoea and annual linear, but not ponderal, growth (BLACK *et al.*, 1984). Thus, there is some evidence that environmental factors may be of greater importance in determining these patterns of growth (LOPEZ DE ROMANA et *al.*, 1987).

In summary, the present results showed some evidence that the anthropometric status of children living in poor urban areas of Salvador, mainly height-for-age indicator, was associated with environmental conditions even when socioeconomic, cultural and demographic factors were taken into account, and that children living in neighbourhoods with community sanitation had best linear growth over time.

CHAPTER 8

Impact of environmental sanitation on prevalence and intensity of nematode infections

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8.1. Introduction

The present study focused on the most widespread soil-transmitted nematodes: *Ascaris lumbricoides, Trichuris trichiura* and hookworm (see Section 2.4.3), in children aged 5-14 years.

The study used three surveys, one before and two (4 and 9 months) after chemotherapy in three groups of neighbourhoods with different types of community sanitation.

8.2. Methods

The study methodology is described in Section 4.2.4.

Two different approaches were used to study the impact of environmental sanitation on prevalence and intensity of nematode infections. One compared prevalence and intensity of infection between intervention and no intervention (control) groups. The other compared subgroups of the study groups according to different levels of exposure to potential risk factors. Data on these risk factors were collected in the socioeconomic survey (see Section 4.2.1). This permitted control for confounding by socioeconomic, demographic and cultural factors, but also made it possible to study the importance of other, more localized environmental variables than sewerage and drainage interventions, such as unreliability of the water supply, proximity to visible and overflowing sewage (due to poor maintenance) and proximity to rubbish (due to inadequate solid waste collection).

Because the distribution of egg counts was highly skewed, the average intensity was calculated as the geometric mean of eggs per gram (epg) for those infected and intensity epg ranges were classified as light, medium and heavy as suggested by WHO (1987b) for *Ascaris lumbricoides* and *Trichuris trichiura*. Thus, light infection with *A. lumbricoides* was defined as "lower than 5,000 epg" and heavy infection "higher than 50,000 epg", while for *T. trichiura* these values were "lower or equal to 1,000 epg" and "higher than 10,000 epg", respectively. For hookworm there is no WHO guideline. After consideration of the literature (LACAZ *et al.*, 1972; FEACHEM *et al.*, 1983b; WHO, 1987b) light infection was defined as "lower or equal than 500 epg" and heavy infection as "higher than 2,000 epg". Since the two hookworm species were not distinguished (Section 4.3.2.4), this study does not provide separate estimates of average intensity for each, and the data are considered to represent infection by either or both.

A three-day course of treatment with mebendazole (100 mg twice daily) was offered and accepted by all children examined in the first stool examination. Fifteen days after treatment a single second stool sample was taken randomly from 5% of the infected children and examinations were conducted to assess the efficacy of cure. The absence of nematode eggs in a child's stool after treatment was taken to indicate a cure. 89% of these children were then free of *A. lumbricoides* (92%, 89% and 87% for Groups 1, 2 and 3 respectively), 93% were free of hookworm (91%, 80% and 100% for Groups 1, 2 and 3 respectively) while 69% were free of *T. trichiura* (62%, 77% and 69% for Groups 1, 2 and 3 respectively). No significant differences in efficacy of cure were found between the study groups. These cure rates are within the efficacy range known for this drug (VERONESI, 1982; WHO, 1987b; NEVES, 1988; ALBONICO *et al.*, 1994). Mebendazole is less effective against *Trichuris* than for *Ascaris* and hookworm. Moreover, the egg counts in the few children found to be still infected were relatively very low (the reduction based in average intensity for *Ascaris* was 99.6%, 97.8% and 98.7%, for Trichuris 99.5%, 98.8% and 93.7% and for hookworm 92.0%, 94.8% and 100.0% in Groups 1, 2 and 3, respectively). These results were interpreted as indicating that virtually almost all *Ascaris, Trichuris* and hookworms were expelled by mebendazole therapy.

For ethical reasons, at the end of the third examination a final three-day course of treatment with mebendazole was offered and accepted by all children examined. Again, fifteen days after the last treatment a single stool sample was taken from 10% of the infected children to check the efficacy of the drug. The results indicated cure rates similar those found after the first treatment.

8.3. Results

8.3.1. Comparison between study groups

The households that participated in the nematodes study presented similar characteristics to the total presented in Chapter 5. There was a close similarity between the study groups in terms only of mean age of children, household size, number of bedrooms, religion, animals in house, electricity supply, and connections to the public water supply system.

631 children between 5-14 years of age were studied in each study group, giving a total of 1893 in 795 households (as presented in Table 4.1). The children's age and sex distribution at the beginning of the study was shown in Table 5.2.

8.3.2. The impact of environmental sanitation intervention on the prevalence and intensities of nematode infections: first examination

Table 8.1 shows the prevalence of infection by at least one intestinal helminth and of polyparasitism with two or more and three or more helminth species (*S. mansoni, E. vermicularis, H. nana* and *H. diminuta* were also included in the calculations), and of each helminth identified by study group. The mean number of helminth infections among those infected is presented. There was a significant difference in the prevalences between Group 1 and Groups 2 and 3 in all cases. The groups which exhibited the greatest differences in prevalence were the children in Group 1 and Group 3 neighbourhoods ($p<0.0001$). The prevalence was highest in children of Group 1 (the "worst" sanitary areas or without community sanitation) and lowest in children of Group 3 (the "best" sanitary areas with drainage and a simplified sewerage system). Of the three nematodes of greater interest for the study, *Trichuris trichiura* was the most prevalent in all three study groups. Although there was a significant difference in the prevalence of *Ascaris* between Group 2 and Group 3, this was not so for *Trichuris* and hookworm.

Table 8.2 and Figures 8.1, 8.2 and 8.3 presents the prevalence and intensity of *Ascaris, Trichuris* and hookworm infections in the children at the first examination, by study group. No significant difference between the three study groups regarding intensity of infection of those infected was found for *Ascaris,* although *Trichuris* had a significantly higher intensity in Group 1 than Groups 2 and 3 ($p<0.001$). For hookworm, the geometric mean intensity was greater ($p<0.01$) in Group 3 than in Groups 1 and 2.

Table 8.1
Prevalence rates (%) for helminth infections in children 5-14 years of age in the three groups of neighbourhoods, Exam 1

Infection	Group 1 No Interv (n=631)	Group 2 SWD (n=631)	Group 3 SSS (n=631)
Ascaris lumbricoides	66.4^{e}	$47.1^{e,c}$	$38.0^{e,c}$
Trichuris trichiura	87.8^{e}	$71.8^{e,a}$	$68.3^{e,a}$
hookworm[1]	25.2^{e}	$8.6^{e,a}$	$9.4^{e,a}$
Schistosoma mansoni	4.6^{e}	$0.5^{e,a}$	$0.2^{e,a}$
Hymenolepis nana	$3.0^{b,c}$	$0.8^{b,a}$	$0.6^{c,a}$
Hymenolepis diminuta	1.1^{a}	0.2^{a}	0.2^{a}
Enterobius vermicularis	$0.6^{c,c}$	$3.2^{c,a}$	$3.0^{c,a}$
Any helminth infection	93.7^{e}	$78.1^{e,a}$	$73.5^{e,a}$
Two+ helminth infections	69.7^{e}	$44.4^{e,b}$	$38.4^{e,b}$
Three+ helminth infections	22.3^{e}	$9.0^{e,a}$	$7.6^{e,a}$
Mean number of helminth species in those infected	$2.0^{d,c}$	$1.7^{d,a}$	$1.6^{c,a}$

[1] *Necator americanus* or *Ancylostoma duodenale*

For each line of the table, the significance levels of differences between groups are shown as follows:
$^{a\text{-}a}$ Not significant ($p>0.05$); $^{b\text{-}b}$ $p<0.05$; $^{c\text{-}c}$ $p<0.01$;
$^{d\text{-}d}$ $p<0.001$; $^{e\text{-}e}$ $p<0.0001$;

Table 8.2
Prevalence of nematode infection and intensity of those infected in children aged 5-14 years, Exam 1

	Group 1 n(631)	(%)	Group 2 n(631)	(%)	Group 3 n(631)	(%)
A. lumbricoides						
Infected	419	(66.4)	297	(47.1)	240	(38.0)
<5,000 epg	96	(22.9)	55	(18.5)	46	(19.9)
5,000-50,000 epg	254	(60.6)	182	(61.3)	150	(62.5)
>50,000 epg	69	(16.5)	60	(20.2)	44	(18.3)
Geom. mean epg (95% CI)	12,303 (10,386-14,373)		14,125 (11,661-17,190)		13,804 (11,140-17,026)	
T. trichiura						
Infected	554	(87.8)	453	(71.8)	431	(68.3)
<1,000 epg	253	(45.7)	283	(62.5)	278	(64.5)
1,001-10,000 epg	274	(49.5)	153	(33.8)	142	(32.9)
>10,000 epg	27	(4.8)	17	(3.7)	11	(2.6)
Geom. mean epg (95% CI)	1,072 (940-1,199)		603 (523-704)		550 (478-626)	
hookworm						
Infected	159	(25.2)	54	(8.6)	59	(9.4)
<500 epg	124	(78.0)	48	(88.9)	41	(69.5)
501-2,000 epg	22	(13.8)	3	(5.6)	12	(20.3)
>2,000 epg	13	(8.2)	3	(5.5)	6	(10.2)
Geom. mean epg (95% CI)	191 (154-234)		158 (113-220)		302 (205-437)	

Fig. 8.1. Prevalence and Intensity of Ascaris Infection in children aged 5-14 years by study group, Exam 1

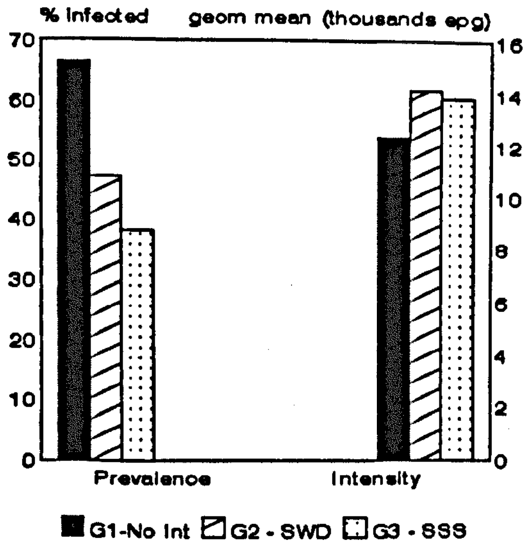


Fig. 8.2. Prevalence and Intensity of Trichuris Infection in children aged 5-14 years by study group, Exam 1

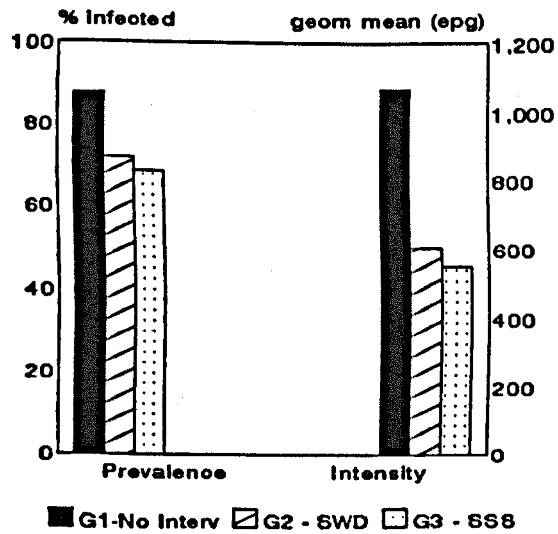
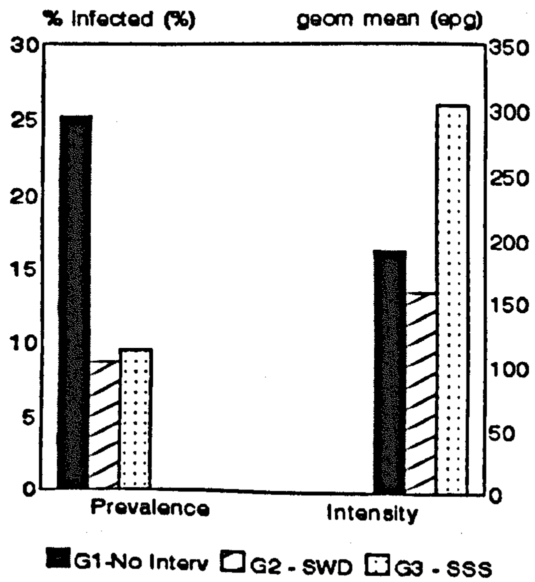


Fig. 8.3. Prevalence and Intensity of hookworm Infection in children aged 5-14 years by study group, Exam 1



In each of the three study groups a small number of highly infected children accounted for a large proportion of all excreted eggs. 15.8% of the children infected in Group 1 (10.5% of the total population studied) excreted half the *Ascaris* eggs. In Groups 2 and 3 these figures were 17.8% (8.4%) and 15.8% (6.0%), respectively. Regarding *Trichuris* and hookworm, there was a trend, although weak, between the study groups. For *Trichuris*, 10.8% of the children infected in Group 1 (10.5% of the total) excreted 50% of eggs, while for Groups 2 and 3 these figures were 8.2% (5.9%) and 7.0% (4.8%), and for hookworm the figures were 7.5% (1.9%) in Group 1, 7.4% (0.6%) in Group 2 and 5.1% (0.5%) in Group 3.

The prevalence rates of *Ascaris* and *Trichuris* found in this study population show that these nematodes are highly endemic in this area. FARIA (1972) found similar prevalence rates of the three nematodes (*Ascaris* 76.5%, *Trichuris* 97.8% and hookworm 36.2%) in school children aged between 7 and 14 years attending public schools and living in Salvador. Again *Trichuris* was the most prevalent nematode while hookworm was of lowest prevalence. However, the prevalence rates of *Ascaris, Trichuris* and hookworm found in the present study, even in children of the non-intervention group (66.4%, 87.8% and 25.2%, respectively) were lower than those found in 1972. The improved standard of living and environmental conditions in the last twenty years, including the provision of community water supply and sanitation together with other factors, or even, better microscopists and laboratory methods to detect more low intensity infections, may have contributed to this slight reduction in prevalence rates. Similar prevalence rates of these three nematodes have also been found in urban slum children of other developing countries (SILVA and JAYATILLEKA, 1981; BUNDY *et al.*, 1988; HARPHAM *et al.*, 1988; HETTIARACHCHI *et al.*, 1989; KAN *et al.*, 1989; AUER, 1990).

The results of the study suggest that there was a significant difference in the prevalence of *Ascaris, Trichuris* and hookworm and in the intensity of *Trichuris*, but not in the intensity of *Ascaris* and hookworm infections, in the children of the groups of neighbourhoods with a environmental sanitation intervention as compared with those living in the three neighbourhoods without any. The greatest differences observed were between the group of neighbourhoods with a shallow sewerage system and the group without community sanitation.

8.3.3. Age- and sex-specific prevalences and intensities of nematode infections at the first examination

Age-specific and sex-specific prevalences and geometric mean intensities of nematode infections at the first examination are presented in Table 8.3. Two age groups were considered: children aged between 5 to 9 years and between 10 to 14 years. A significant difference in *Ascaris* prevalence between age groups was observed only in Group 1 ($p<0.05$), but not in the geometric mean intensities. For *Trichuris*, no significant

Table 8.3
Prevalence and epg geometric mean of nematode infections in children by age group, sex and study group, Exam 1

Age Group (years)	Sex	Prevalence (% infected) and geometric mean(epg) Group 1 %	gm(epg)	Group 2 %	gm(epg)	Group 3 %	gm(epg)
Ascaris							
5-9	Male	67.0	11,668	49.7	12,659	40.4	13,388
	Female	59.4	12,497	46.4	14,282	33.3	15,300
10-14	Male	72.7	11,711	53.3	17,100	49.2	13,747
	Female	70.4	13,274	40.0	13,440	30.6	12,266
Trichuris							
5-9	Male	90.4	1,188	71.8	764	70.7	686
	Female	83.8	1,113	72.2	725	65.1	646
10-14	Male	88.4	993	73.0	647	77.5	441
	Female	89.6	865	70.0	316	60.5	352
hookworm							
5-9	Male	21.2	227	6.6	187	11.1	385
	Female	19.8	180	4.0	63	4.2	683
10-14	Male	35.5	205	17.5	169	16.7	235
	Female	30.4	148	7.7	184	7.3	133
Number Examined			n=631		n=631		n=631
5-9	Male		198		213		198
	Female		197		151		189
10-14	Male		121		137		120
	Female		115		130		124

difference was found in the prevalence rates between age ranges in any of the three study groups, although geometric mean intensities were significantly higher in younger children in Groups 2 and 3 ($p<0.01$ and $p<0.001$, respectively) infected. The hookworm prevalence rates presented a significant difference between age groups in all the three study groups, the oldest group having highest prevalences, although significant differences of geometric mean intensities were observed between age groups only in Group 3 ($p<0.05$).

There was a tendency for males to be more frequently infected with *Ascaris* than females, but the geometric mean intensity of infection in females aged between 5 to 9 years was slightly greater than for males in the three study groups. For *Trichuris*, no significant difference was found in the prevalence rates between sexes, although they tended to be higher in males, and geometric mean intensities presented significant differences between sexes only in Group 2. The hookworm prevalence rates tended to be higher in males, although no significant difference was found in the geometric mean intensities. In each age and sex group there was a small proportion of heavily infected children.

The age-prevalence and age-intensity profiles for *Ascaris*, *Trichuris* and hookworm observed in the three study groups was not different from the patterns typically found in other studies (ANDERSON and MAY, 1985; BUNDY *et al.*, 1987). The difference between age groups for *Ascaris* infection was only significant for one group and sex (females in Group 1), and no overall significant difference was found. The level of hookworm infection differed markedly among the different age groups. But hookworm prevalence increasing with age corresponds to a low force of infection and is also a common result.

This study has shown that children of both sexes living in periurban areas of Salvador have high levels of infection with *Ascaris* and *Trichuris*, with an overall tendency for males to be more infected than females, a well known phenomenon. For hookworm the level of infection differed markedly among males and females in Groups 2 and 3.

8.3.4. The contribution of other risk factors to the prevalence of nematode infections: controlling for confounding and comparison within study groups

8.3.4.1. Controlling for confounding factors

With the aim of identifying some potential confounding variables, the association between the prevalence of intestinal nematode infections and several potential risk factors, classified as biological, demographic, socioeconomic, cultural and environmental, was also investigated.

Table 8.4 presents the list of potential risk factors studied by class and possible levels that they may take.

Table 8.4
List of potential risk factors and possible levels by class

Class	Risk factor	Level
BIO	Child's age[#]	5-9 years old 10-14 years old
	Child's sex[#]	male female
	Child's race	black mixed white
DEM	Household size[#]	number of residents
	Number of children <5 years[#] (No. child <5yrs)[a]	number of children
	Number of children 5-14 years[#] (No. child 5-14)[a]	number of children
SES	Years of schooling of hh head[#] (Years sch head)[a]	0-6 years 7+ years
	Schooling of the child	primary complete primary incomplete has not attended school
	Social class	business/professional labourer/worker
	Ownership of house plot[#]	yes, with legalization yes, without legalization no ownership
	Monthly per capita income[#b] (Per cap income)[a]	<0.5 0.5+
	Monthly family income[b] (Family income)[a] Monthly income of hh head[b] (Income of head)[a]	<1.0 1.0-3.0 3.0+

	Possession of luxury items[#] (No. luxu items)[a]	<3 3+
	Possession of fridge	yes no
	Floor area of house[#] (Floor area hse)[a]	4-16 m^2 17-31 m^2 32+ m^2
	Number of rooms (No. of rooms)[a]	1-2 3-4 5+
	Number of bedrooms	1 2 3+
	Crowding[#] (number of people per room)	5+ 3-5 <3
	Use of kitchen[#]	only for cooking people sleep/children play animals present
	House wall material[#] (House wall mat)[a]	brick mud/other
CUL	Religion[#]	Catholic Other/none
	Origin	Salvador other urban areas rural areas
	Animals in household[#] (dogs, cats, chickens, pigs) (Animals in hh)[a]	none any
	Presence of a washstand[#] (Washstand)[a]	yes no
	Presence of a rubbish[#] container (Rubb container)[a]	yes, with lid yes, without lid no container
HEN	House floor material[#] (House floor)[a]	cement/other earth
	Housing quality (based on wall, floor and roof)	good bad

	Number of water taps[#] (No. water taps)[*]	none 1 2+
	Water consumption per capita per day[#] (Water per cap)[*]	<40 lcd 40-80 lcd 80+ lcd
	Household water consumption	<6 m^3/month 6-15 m^3/month 15+ m^3/month
	Water usage	all usages at home drinking/cooking/personal hygiene only drinking/cooking
	Type of water storage container[#] (Water storage)[*]	tank with lid/no storage other vessels with lid other vessels without lid
	Possession of toilet (Toilet possess)[*]	yes no
	Toilet type[#]	flush toilet pit latrine no toilet
CEN	Water supply	piped other
	Frequency of interruption of public water supply[#] (Freq interr WS)[*]	rare occasional frequent
	Environmental sanitation group[#]	shallow sewerage system stairways drainage system no intervention
	Excreta disposal[#]	drains or sewers on-site facilities none
	Sullage disposal[#]	drains or sewers none
	Distance between house door and excreta disposal facility[#] (Dist sewage hse)[*]	1-10 meters 11-20 meters 20+ meters
	Rubbish disposal (Rubb disposal)[*]	collected other

Frequency of rubbish collection[#] (Freq rubb coll)[a]	regular irregular not collected
Number of sites within 10m of house door with: .visible sewage on the ground; (No. site vis sew)[a] .overflowing sewage on the ground; (No. site ove sew)[a] .overflowing or visible sewage on the ground[#]; (No. site v/o sew)[a] .rubbish[#]; (No. site rubb)[a] .overflowing or visible sewage on the ground or rubbish (No. site v/o/rub)[a]	none any
Increase of vectors last year[#] (rats, flies and cockroaches) (Increase vector)[a]	no yes
Street pavement	yes no

Classes: BIO=Biological; DEM=Demographic; SES=Socioeconomic Status;CUL=Cultural; HEN=Household Environment; CEN=Community Environment

[#] Risk factor selected for logistic regression analysis

[a] Abbreviation used in Table 8.7

[b] Monthly incomes are given as proportion of the Brazilian Minimum Wage (US$ 63 in August/1989)

Origin was classified as a cultural factor since people living in rural or urban areas acquire different habits and beliefs. Religion was also classified as cultural, for its influence on human behaviour. The author classified animals in the household and the presence of a washstand and of a rubbish container as cultural factors, rather than household environment or socioeconomic status factors, because they seem be more dependent on the habits of the household residents than due to their income.

Using bivariate analyses significant associations with the prevalence of *Ascaris, Trichuris* and hookworm infections in children were found for several potential risk factors of the fifty studied.

Those factors that showed significant associations with the prevalence of intestinal nematode infections and that were not considered a consequence of improved environmental sanitation interventions were selected as potential confounding variables for an aggregated multivariate logistic regression analysis of the data for all three groups.

These were child's sex, child's age, number of children of 5-14 years old in the household, crowding, years of schooling of the household head, monthly per capita income, religion, animals in the house and the house floor material.

Multivariate logistic regression analysis was then used on the data for all three study groups, to examine the combined effects of these potential confounding factors on the association between prevalence of intestinal nematode infections and environmental sanitation. The potential confounding effects of all the variables listed previously were controlled. Complete data for analysis were available for 1893 children (631 in each environmental sanitation group). The method utilized in the logistic regression was forced entry, in which all variables are entered in a single step (NORUSIS, 1990a). Table 8.5 shows the results in the form of unadjusted (crude) and adjusted odds ratio (95% confidence interval) of the prevalence of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm for environmental sanitation group.

Table 8.5
Odds Ratio (95% confidence interval) of nematode prevalence for Environmental Sanitation Group

Environmental Sanitation Group	%[a]	Odds Ratio (95% CI) Unadjusted	Adjusted
Ascaris lumbricoides			
Shallow sewerage	38.0	1.00	1.00
Stairways drainage	47.1	1.45(1.35-1.56)	1.34(1.29-1.39)
No Intervention	66.4	3.22(2.58-4.02)	2.72(2.39-3.10)
Trichuris trichiura			
Shallow sewerage	68.3	1.00	1.00
Stairways drainage	71.8	1.18(1.14-1.22)	1.08(1.07-1.09)
No Intervention	87.8	3.34(2.57-4.34)	2.59(2.25-2.98)
hookworm			
Shallow sewerage	9.4	1.00	1.00
Stairways drainage	8.6	0.91(0.89-0.93)	0.85(0.83-0.87)
No Intervention	25.2	3.27(2.54-4.20)	2.78(2.38-3.25)

[a] Prevalence (%)

After controlling for confounding variables, the estimated odds ratios were slightly lower than the crude values and the association between the prevalence of intestinal nematode infections and the variable environmental sanitation (community excreta and sullage disposal) group remained highly significant ($p<0.0001$) for each of the three nematodes studied. No significant interactions between potential risk factors were found.

Aiming to give some idea of a "maximum achievable impact", the crude and confounder-adjusted effects of environmental sanitation group were obtained excluding those children from households which were not connected to the shallow sewerage system in Group 3 (after exclusion, n=461) and to the stairways drainage system in Group 2 (n=386) while in Group 1 only children from households without any excreta disposal facilities were considered (n=305).

The results presented in Table 8.6 show that after controlling for confounding variables, the adjusted odds ratios were slightly lower than the crude values but that the association between the prevalence of intestinal nematode infections and the variable "environmental sanitation group" remained highly significant ($p<0.0001$) for each of the three nematodes studied. The crude and adjusted odds ratios for the "maximum achievable impact" were greater that those obtained for the whole groups without exclusions.

This implies that health impact in Groups 2 and 3 could have been greater if coverage of the systems were extended to the whole population, although in practice full coverage is rarely achieved with any system.

Table 8.6
Odds Ratio (95% confidence interval) of a "maximum achievable impact" of nematode prevalence for Environmental Sanitation Group

Environmental Sanitation Group	%[a]	Odds Ratio (95% CI) Unadjusted	Adjusted
Ascaris lumbricoides			
Shallow sewerage	33.0	1.00	1.00
Stairways drainage	45.3	1.69(1.52-1.88)	1.54(1.44-1.65)
No Intervention	68.9	4.49(3.33-6.05)	3.33(2.76-4.02)
Trichuris trichiura			
Shallow sewerage	64.4	1.00	1.00
Stairways drainage	71.5	1.39(1.30-1.48)	1.26(1.21-1.31)
No Intervention	93.4	7.87(5.24-11.82)	5.51(4.21-7.22)
hookworm			
Shallow sewerage	8.2	1.00	1.00
Stairways drainage	7.8	0.94(0.93-0.95)	0.87(0.85-0.89)
No Intervention	27.5	4.23(2.99-5.99)	3.69(2.92-4.67)

[a] Prevalence (%)

8.3.4.2. Comparison within study groups

To study the effect of differentials within each group of neighbourhoods on the prevalence of each nematode, the same biological, demographic, socioeconomic, cultural and environmental potential risk factors were used as those studied to controll for confounding variables.

Using bivariate analyses, for each group of neighbourhoods, significant associations with the prevalence of *Ascaris, Trichuris* and hookworm infections in children were found for several potential risk factors of the fifty studied. Fewer risk factors in number were significantly associated with the prevalence of *Ascaris* from Group 1 (without community sanitation) than in Groups 2 (with stairways drainage) and 3 (with shallow sewers) (Table 8.7). A similar pattern emerged for *Trichuris* but not for hookworm. All these associations were in the anticipated direction, with more hygienic conditions being associated with reduced risk of infection. For all three nematodes, the number of significant risk factors classified under "socioeconomic status", as "cultural" and as "housing environment" increased from Group 1 to Groups 2 and 3. In Group 1, no significant association was found between *Ascaris* prevalence and any of the factors classified as community environment. Demographic risk factors were found to be significant for the three nematodes in all groups of neighbourhoods studied.

For the purpose of evaluating the impact of environmental sanitation measures, the risk factors of principal interest concern access to and use of the measures, where they exist. Of these, the factors that showed much higher significant associations with nematode prevalence were excreta and sullage disposal; frequency of rubbish collection; the number of sites within 10 meters from house door with sewage overflowing or visible on the ground and with rubbish; and the frequency of interruption of water supply.

Of the fifty potential risk factors listed in Table 8.4, thirty were selected for logistic regression analysis (marked '#' in the Table) to study the combined effects of multiple risk factors on prevalence of the three nematodes in each group of neighbourhoods. The selection excluded redundant variables and those that did not present any association in the bivariate analyses.

The method utilized in the logistic regression was forced entry, in which all variables are entered in a single step (NORUSIS, 1990a).

Table 8.7
Significant risk factors in bivariate analyses for *Ascaris infection* in children 5-14 years old by variable class and study group, Exam 1

Class	Group 1 Variable	p	Group 2 Variable	p	Group 3 Variable	p
BIO	Age	*			Sex	2*
					Race	*
DEM	No child 5-14	4*	No child 5-14	*	No child 5-14	2*
	Household size	*			Household size	2*
					No child <5yrs	3*
SES	Crowding	2*	Crowding	4*	Crowding	4*
	Kitchen usage	2*	Kitchen usage	4*	Kitchen usage	*
	House's Wall	2*	Family income	2*	Family income	4*
			Per cap incom	3*	Per cap income	4*
			No luxu items	2*	No luxu items	*
			No of rooms	3*	Land ownership	3*
					Schooling child	2*
					Years sch head	4*
					Income of head	3*
CUL			Washstand	2*	Washstand	4*
			Rubb container	*	Rubb container	4*
			Animals in hh	3*	Religion	*
HEN			Water storage	4*	Water storage	2*
			No water taps	*	No water taps	2*
			Water usage	3*	Water per cap	2*
			Toilet possess	2*		
			Toilet type	2*		
CEN			No site vis sew	*	No site vis sew	*
			Rubb disposal	4*	Freq rubb coll	*
			No site v/o sew	2*	Sullage disposal	*
			No sites rubb	2*	Dist sewage hse	*
			No site ove sew	3*		
			Freq interr WS	2*		
			No sit v/o/rub	*		

Significance (X^2 test): *=p<0.05;2*=p<0.01;3*=p<0.001;4*p<0.0001

A similar pattern was found to that presented above for the results of bivariate analyses, although the number of significant risk factors diminished. The results are in Tables 8.8, 8.9 and 8.10, which show only the significant factors. The socioeconomic and cultural factors presented the strongest association (the greatest odds ratio) with the prevalence of *Ascaris, Trichuris* and hookworm in the three study groups, although for hookworm the biological factors were also present.

The most consistent of these socioeconomic and cultural risk factors for the three nematodes studied within the intervention areas (Groups 2 and 3) was the presence a rubbish container, which seems can be considered as an indicator or proxy variable for domestic hygiene behaviour.

Table 8.8
Significant risk factors in the multivariate logistic regression model for prevalence of *Ascaris lumbricoides*, Exam 1

a. Group 1 - No Intervention (n=631)

Class	Risk factor	Percent[a]	OR
DEM	No. Children 5-14 years[*b]		
	Continous		1.13
SES	House Wall Material[*]		
	Brick	80.7	1.00
	Mud/Other	19.3	1.81
	Floor Area of House[*]		
	32+ m^2	38.7	1.00
	17-31 m^2	38.8	1.29[*c]
	4-16 m^2	22.5	1.37[*]
	Crowding[*]		
	<3 person/room	71.9	1.00
	3-5 person/room	20.1	1.31[*]
	5+ person/room	8.0	1.54[**]
HEN	House Floor Material[*]		
	Cement/Other	83.8	1.00
	Earth	16.2	0.52

b. Group 2 - Stairways Drainage System (n=631)

Class	Risk factor	Percent[a]	OR
DEM	No. Children 5-14 years[***b]		
	Continous		1.26
SES	Floor Area of House[**]		
	32+ m^2	34.4	1.00
	17-31 m^2	39.1	0.66[***c]
	4-16 m^2	26.5	1.35
	Possession of Luxury Items[*]		
	2+	86.7	1.00
	<2	13.3	1.79
CUL	Animals in Household[**]		
	None	43.3	1.00
	Any	56.7	1.76
	Presence of a Rubbish Container[**]		
	Yes, with lid	60.7	1.00
	Yes, without lid	29.6	1.32[*]
	No container	9.7	1.47[**]
HEN	Type of Water Storage Container[***]		
	Tank with lid/no storage	21.9	1.00
	Other vessels with lid	54.3	1.31[*]
	Other vessels without lid	23.8	1.72[***]
CEN	Sullage Disposal[*]		
	Drains and/or Sewers	86.8	1.00
	None	13.2	2.00
	No.Sites with Visible/Overflowing Sewage[*]		
	None	51.8	1.00
	Any	48.2	1.52
	Frequency of Interruption of Water Supply[*]		
	Rare	70.2	1.00
	Occasional	10.6	1.17
	Frequent	19.2	1.43[*]

c. Group 3 - Shallow Sewerage System (n=631)

Class	Risk factor	Percent[a]	OR
BIO	Sex***[b]		
	Female	49.6	1.00
	Male	50.4	1.90
DEM	Household Size**		
	Continous		1.11
SES	Years of Schooling of HH Head***		
	7+	37.7	1.00
	0-6	62.3	2.21****[c]
	Use of Kitchen***		
	Only cooking	78.6	1.00
	People sleep/child play	19.3	2.17**
	Animals present	2.1	3.81***
	House Plot Owner**		
	Owner with legalization	64.2	1.00
	Owner without legalization	20.1	1.08
	No ownership	15.7	1.54*
CUL	Presence of a Washstand****		
	Yes	65.5	1.00
	No	34.5	2.76
	Presence of a Rubbish Container**		
	Yes, with lid	72.6	1.00
	Yes, without lid	23.6	2.12**
	No container	3.8	2.05**
CEN	Excreta Disposal*		
	Drains and/or Sewers	73.1	1.00
	On-site Facilities	25.2	1.18*
	None	1.7	1.56**
	Frequency of Rubbish Collection**		
	Regular	55.9	1.00
	Irregular	38.7	1.82**
	Not collected	5.4	1.92**
	Sullage Disposal*		
	Drains and/or Sewers	91.4	1.00
	None	8.6	1.89
	Frequency of Interruption of Water Supply*		
	Rare	70.2	1.00
	Occasional	22.3	0.92
	Frequent	7.5	1.22

[a] Percentage of children in category of factor
OR = Odds Ratio
[b]Significance for the factor overall (Log LR) and [c]significance of difference for the individual factor levels *p<0.05; **p<0.01; ***p<0.001; ****p<0.0001

Table 8.9
Significant risk factors in the multivariate logistic regression model for prevalence of *Trichuris trichiura*, Exam 1

a. Group 1 - No Intervention (n=631)

Class	Risk factor	Percent[a]	OR
DEM	No. Children 5-14 years[***b]		
	Continous		1.39
SES	House Plot Owner[*]		
	Owner with legalization	7.6	1.00
	Owner without legalization	45.6	1.08
	No Ownership	46.8	0.87
HEN	Type of Water Storage Container[**]		
	Tank with lid/no storage	7.0	1.00
	Other vessels with lid	48.2	1.85[*c]
	Other vessels without lid	44.8	2.44[**]
CEN	Excreta Disposal[*]		
	Sewers/Drains	24.7	1.00
	On-site facilities	26.9	1.15
	None	48.4	1.47[*]

b. Group 2 - Stairways Drainage System (n=631)

Class	Risk factor	Percent[a]	OR
DEM	No. Children 5-14 years[***b]		
	Continous		1.24
SES	Floor Area of House[****]		
	32+ m^2	34.4	1.00
	17-31 m^2	39.1	1.27
	4-16 m^2	26.5	1.64[**c]
	House Plot Owner[**]		
	Owner with legalization	35.0	1.00
	Owner without legalization	40.3	1.02
	No ownership	24.7	0.64
CUL	Presence of a Rubbish Container[**]		
	Yes, with lid	60.7	1.00
	Yes, without lid	29.6	1.15
	No container	9.7	1.75[*]
CEN	No.Sites with Visible/Overflowing Sewage[*]		
	None	51.8	1.00
	Any	48.2	1.56

c. Group 3 - Shallow Sewerage System (n=631)

Class	Risk factor	Percent[a]	OR
BIO	Sex**[b]		
	Female	49.6	1.00
	Male	50.4	1.83
DEM	Household Size**		
	Continous		1.11
SES	Use of Kitchen**		
	Only cooking	78.6	1.00
	People sleep/children play	19.3	2.67*[c]
	Animals present	2.1	0.87
	Years of Schooling of HH Head*		
	7+ years	37.7	1.00
	0-6 years	62.3	1.62
	House Plot Owner*		
	Owner with legalization	64.2	1.00
	Owner without legalization	20.1	1.05
	No ownership	15.7	1.92**
CUL	Presence of a washstand**		
	Yes	65.5	1.00
	No	34.5	1.73
	Religion*		
	Catholic	72.6	1.00
	Other	27.4	0.65
CEN	Frequency of Rubbish Collection****		
	Regular	55.9	1.00
	Irregular	38.7	2.15**
	Not collected	5.4	2.45*
	No.Sites with Visible/Overflowing Sewage**		
	None	95.9	1.00
	Any	4.1	8.83
	Frequency of Interruption of Water Supply*		
	Rare	70.2	1.00
	Occasional	22.3	0.79
	Frequent	7.5	1.78*

[a] Percentage of children in category of factor
OR = Odds Ratio
[b]Significance for overall factor (Log LR) and [c]significance of difference for the individual factor levels *$p<0.05$; **$p<0.01$; ***$p<0.001$; ****$p<0.0001$

Table 8.10. Significant risk factors in the multivariate logistic regression model for prevalence of hookworm, Exam 1

a. Group 1 - No Intervention (n=631)

Class	Risk factor	Percent[a]	OR
BIO	Age[***b]		
	5-9 years	62.6	1.00
	10-14 years	37.4	1.94
DEM	No. Children 5-14 years[***]		
	Continous		1.25
	No. Children < 5 years[**]		
	Continous		1.26
CUL	Religion[*]		
	Catholic	83.0	1.00
	Other/none	17.0	1.66
HEN	No. of Water Taps[*]		
	2+	57.5	1.00
	1	30.9	1.02
	None	11.6	1.52[*c]
CEN	Increase of Vectors last year[***]		
	No	60.9	1.00
	Yes	39.1	2.06

b. Group 2 - Stairways Drainage System (n=631)

Class	Risk factor	Percent[a]	OR
BIO	Age[***b]		
	5-9 years	57.7	1.00
	10-14 years	42.3	3.49
	Sex[*]		
	Female	44.5	1.00
	Male	55.5	2.17
DEM	No. Children < 5 years[**]		
	Continous		1.40

SES	Crowding**		
	<3 person/room	80.3	1.00
	3-5 person/room	14.1	3.25*[c]
	5+ person/room	5.6	3.53*
CUL	Presence of a Rubbish Container***		
	Yes, with lid	60.7	1.00
	Yes, without lid	29.6	1.44*
	No container	9.7	2.27**
CEN	Frequency of Interruption of Water Supply*		
	Rare	70.2	1.00
	Occasional	10.6	2.30**
	Frequent	19.2	0.93

c. Group 3 - Shallow Sewerage System (n=631)

Class	Risk factor	Percent[a]	OR
BIO	Sex***[b]		
	Female	49.6	1.00
	Male	50.4	3.04
CUL	Presence of a Washstand**		
	Yes	65.5	1.00
	No	34.5	2.80
	Presence of a Rubbish Container*		
	Yes, with lid	72.6	1.00
	Yes, without lid	23.6	1.32*[c]
	No container	3.8	1.94
HEN	Water Consumption Per Capita*		
	80+ lcd	28.8	1.00
	40-80 lcd	40.6	1.02
	< 40 lcd	30.6	1.63*
CEN	Frequency of Rubbish Collection****		
	Regular	55.9	1.00
	Irregular	38.7	1.72**
	Not collected	5.4	2.86***

[a] Percentage of children in category factor
OR = Odds Ratio
[b] Significance for the factor overall (Log LR) and [c] significance of difference for the individual factor levels *$p<0.05$; **$p<0.01$; ***$p<0.001$; ****$p<0.0001$

The risk factors studied, excluding child's age, child's sex, and the "community environment" risk factors, are characteristics of the household, rather than of the individuals. Then, the residual transmission of intestinal nematode infections which has not been controlled by environmental sanitation measures is more dependent on these characteristics and it would be likely to occur within or close to the household environment, rather than in the public domain.

Many of these risk factors can be interrelated in probably causal patterns, and this should be considered when undertaking interventions to prevent intestinal nematode infections.

8.3.5. Household clustering of nematode infections in groups of neighbourhoods with different types of community sanitation

The clustering by household of cases of infection in each study group was also studied, aiming to examine any effect of environmental sanitation on the degree to which it occurs.

In order to study whether infected children were randomly distributed among households in each group of neighbourhoods, it was important to consider the number of participating children in the household. Analyses were done separately for

A. lumbricoides, *T. trichiura* and hookworm. The number of participating children in the household was taken as household size. Three frequency tables were constructed for each nematode, one for each group of neighbourhoods, by household size, indicating the number of households containing various numbers (cases) of infected children. If infected children were randomly distributed among households, the observed frequency of households with 1, 2, 3 or more such children should not have differed from that predicted by a binomial distribution. The observed and expected frequencies were compared using the X^2 significance test, and the overall results are presented in Table 8.11.

Taking into account the household size there was a tendency for fewer households to occur with one, two or three children infected with *Ascaris*, one or two children infected with *Trichuris*, and a single infected child with hookworm than would be expected by chance, and a tendency for more households to occur with no, or more than three, two or one, children infected with *Ascaris*, *Trichuris* and hookworm, respectively, than would be expected if infected children were randomly distributed in the study groups. Significant household clustering was observed for *A. lumbricoides* ($p<0.01$) and hookworm ($p<0.05$) in study Groups 2 and 3, but it was not significant in Group 1 for any of the nematode species.

Table 8.11
Clustering of cases of nematode infection by household and study group, Exam 1

a. *Ascaris lumbricoides*

No. of hh with:	0 cases	1 case	2 cases	3 cases	4 cases	5+cases
Group 1 (NS)						
Expected	36.7	99.3	66.1	33.9	14.3	5.7
Observed	60	76	58	33	20	9
Group 2 (***)						
Expected	80.7	114.0	53.0	17.7	5.6	
Observed	116	71	53	16	15	
Group 3 (**)						
Expected	102.4	109.3	42.0	11.4	2.9	
Observed	133	76	36	10	13	

b. *Trichuris trichiura*

No. of hh with:	0 cases	1 case	2 cases	3 cases	4 cases	5+ cases
Group 1 (NS)						
Expected	28.3	69.3	71.5	44.9	25.9	16.0
Observed	25	82	54	45	28	22
Group 2 (NS)						
Expected	33.1	107.8	72.6	37.5	13.6	6.3
Observed	52	94	58	42	15	10
Group 3 (NS)						
Expected	37.1	107.5	72.1	32.8	13.1	5.3
Observed	59	94	54	34	15	12

c. hookworm

No. of households with:	0 cases	1 case	2 case	3+ cases
Group 1 (NS)				
Expected	135.9	89.7	24.7	5.7
Observed	153	70	19	14
Group 2 (*)				
Expected	221.5	45.2	4.3	
Observed	233	27	11	
Group 3 (*)				
Expected	214.5	48.4	5.1	
Observed	224	32	12	

X^2 test: NS=not significant at 5%level; *=p<0.05; **=p<0.01; ***=p<0.001

A similar analysis was also done to determine whether heavily-infected children were clustered or randomly distributed among households for the same three nematodes in each study group of neighbourhoods. All children found to have egg counts in the top 20% of the range, for each nematode and for each study group were classified as heavily infected with that nematode for the purpose of this analysis. This is the criterion used by FORRESTER *et al.* (1988) for a similar study. As ANDERSON and MEDLEY (1985) noted, in the context of community control strategies, there is little advantage in being too selective in the definition of "heavy infection". Three tables were constructed for each nematode, one for each study group, by household size, indicating the number of households containing various numbers of "heavily infected" children. After the calculation of the proportion of heavily infected children and the estimate of the expected frequency distribution, the observed and expected frequencies were compared, and the results are presented in Table 8.12.

For all but one of the nine cases (3 species x 3 groups), there were more households without cases and fewer single-case households than expected. This suggested that in all these cases a degree of clustering was occurring, although not great enough to be statistically significant ($p>0.05$) perhaps because the numbers of cases were smaller . Also, the differences between observed and expected numbers of households without cases were greater for *Trichuris* than for *Ascaris* and

Table 8.12
Clustering of cases of heavy nematode infection by household and study group, Exam 1

a. *Ascaris lumbricoides*

No. of households with:	0 cases	1 case	2 cases	3+ cases
Group 1 (NS)[a]				
Expected	184.3	60.4	9.9	1.4
Observed	196	43	12	5
Group 2 (NS)				
Expected	222.0	41.6	5.0	0.4
Observed	225	36	7	1
Group 3 (NS)				
Expected	226.4	33.7	4.0	1.9
Observed	229	30	3	4

b. *Trichuris trichiura*

No. households with:	0 cases	1 case	2 cases	3 cases	4+ cases
Group 1 (NS)[b]					
Expected	171.4	62.7	17.1	4.0	0.8
Observed	185	42	19	8	2
Group 2 (NS)					
Expected	191.9	63.8	12.4	2.6	0.3
Observed	205	46	12	6	2
Group 3 (NS)					
Expected	197.7	56.8	10.4	1.7	0.4
Observed	209	43	9	2	4

c. hookworm

No. of households with:	0 cases	1 case	2+ cases
Group 1 (NS)[c]			
Expected	229.1	23.5	3.4
Observed	233	19	4
Group 2 (NS)			
Expected	260.0	10.4	0.6
Observed	260	10	1
Group 3 (NS)			
Expected	253.8	11.5	0.7
Observed	255	9	2

X^2 test: NS=not significant at 5% level
[a] : df=3 ; [b] : df=4 ; [c] : df=2

hookworm, suggesting a stronger tendency for household clustering of heavy infections than for the other two nematodes.

Evidence for household clustering of infected children exists for a variety of parasites. Among the directly transmitted infections, significant household clustering has been demonstrated for *Ascaris* and *Trichuris* (FORRESTER *et al.*, 1988; HASWELL-ELKINS *et al.*, 1989; KILLEWO *et al.*, 1991; CHAN *et al.*, 1994). In this study stronger household clustering was observed for *Ascaris* and hookworm in the two study groups with community sanitation, suggesting that when the environmental sanitation condition is poor, much of the transmission is between rather than within households.

Contrary to the findings of FORRESTER *et al.* (1988) the results of the present study did not show significant clustering of heavily-infected children within the household in this endemic area, irrespective of the environmental sanitation conditions, with respect to *Ascaris, Trichuris* and hookworm infections.

8.3.6. Reinfection after chemotherapy

Four and nine months after treatment was administered stool samples were again collected from the full study population (exams 2 and 3, respectively), with the objective of studying the reinfection pattern among the three different groups of neighbourhoods.

The mean loss to the study of children examined at four months and nine months after treatment was 5.5% (varying between groups from 3.6%-6.8%) and 7.3% (5.4%-8.7%) respectively; all these losses were due to the child's family moving away. Those children treated by their parents with anthelminthic drugs between the 2nd and 3rd examinations (5.4%) were also excluded, resulting in a total mean loss during the study period of 12.7% (10.9%-14.6%), lower than 25.0% used for the original sample size calculations.

8.3.6.1. The prevalence and intensity of nematode reinfection after chemotherapy in the groups with varying community sanitation

Tables 8.13 and 8.14 show the prevalence and the intensity of nematode infection at exams 2 and 3, respectively. The intensity is presented in epg ranges (light, medium and heavy) for each nematode and in geometric mean epg of the children infected. The Tables show also the number of children examined.

Table 8.13
Prevalence of nematode infection and intensity of those infected in children aged 5-14 years, Exam 2

	Group 1 n(608)	(%)	Group 2 n(594)	(%)	Group 3 n(588)	(%)
A. lumbricoides						
Infected	297	(48.8)	227	(38.2)	159	(27.0)
<5,000 epg	72	(24.2)	51	(22.5)	46	(28.9)
5,000-50,000 epg	187	(63.0)	141	(62.1)	92	(57.9)
>50,000 epg	38	(12.8)	35	(15.4)	21	(13.2)
Geom. mean epg (95% CI)	11,220 (9,260-13,286)		10,471 (8,243-13,180)		9,120 (6,832-12,064)	
T. trichiura						
Infected	402	(66.1)	307	(51.7)	212	(36.2)
<1,000 epg	283	(70.4)	256	(83.4)	179	(84.4)
1,001-10,000 epg	113	(28.1)	48	(15.6)	32	(15.1)
>10,000 epg	6	(1.5)	3	(1.0)	1	(0.5)
Geom. mean epg (95% CI)	407 (351-469)		257 (220-307)		269 (224-322)	
hookworm						
Infected	84	(13.8)	43	(7.2)	31	(5.3)
<500 epg	65	(77.4)	39	(90.7)	29	(93.5)
501-2,000 epg	19	(22.6)	3	(7.0)	2	(6.5)
>2,000 epg	-	-	1	(2.3)	-	-)
Geom. mean epg (95% CI)	186 (149-233)		102 (74-144)		98 (68-144)	

Table 8.14
Prevalence of nematode infection and intensity of those infected in children aged 5-14 years, Exam 3

	Group 1 n(562)	Group 1 (%)	Group 2 n(539)	Group 2 (%)	Group 3 n(551)	Group 3 (%)
A. lumbricoides						
Infected	343	(61.0)	243	(45.1)	196	(35.6)
<5,000 epg	51	(14.9)	37	(15.2)	40	(20.4)
5,000-50,000 epg	205	(59.8)	143	(58.8)	117	(59.7)
>50,000 epg	87	(25.4)	63	(26.0)	39	(19.9)
Geom. mean epg (95% CI)	18,197 (15,332-21,999)		17,378 (15,849-21,391)		14,791 (11,722-18,408)	
T. trichiura						
Infected	423	(75.3)	313	(58.1)	238	(43.2)
<1,000 epg	272	(64.3)	257	(82.1)	195	(81.9)
1,001-10,000 epg	139	(32.9)	51	(16.3)	41	(17.2)
>10,000 epg	12	(2.8)	5	(1.6)	2	(0.9)
Geom. mean epg (95% CI)	562 (492-651)		324 (276-372)		295 (251-351)	
hookworm						
Infected	102	(18.1)	44	(8.2)	40	(7.3)
<500 epg	80	(78.4)	41	(93.2)	34	(85.0)
501-2,000 epg	21	(20.6)	3	(6.8)	5	(12.5)
>2,000 epg	1	(1.0)	-	-	1	(2.5)
Geom. mean epg (95% CI)	229 (185-288)		129 (93-178)		174 (124-248)	

Figures 8.4 to 8.9 show the prevalence and the geometric mean of intensity of infection with *Ascaris, Trichuris* and hookworm before, 4 and 9 months after treatment. The prevalence reached by all three nematodes 9 months after treatment was lower than before, while the geometric mean intensity for those infected with *Ascaris* in all study groups (18,197 epg, 17,378 epg and 14,791 epg in Group 1, 2 and 3, respectively) was greater than the pre-treatment level and for hookworm in Group 1 (229 epg) was slightly greater. The pre-treatment geometric mean intensity for *Ascaris* was almost reached 4 months after treatment in all study groups. For all three nematodes and study groups, the rate of increase of prevalence and of geometric mean intensity slowed down in the second period after treatment (months 4 to 9). This is a common finding, as prevalence and intensity return to their pre-treatment equilibrium levels. It may also have been due to a fall in the number of infective eggs/larvae in the environment after chemotherapy.

In exams 2 and 3, the relative intensities of *Ascaris* and *Trichuris* infections in the study groups did not change when compared with exam 1, but for hookworm the anomalously high intensity in Group 3, found in exam 1, was not apparent in the subsequent stool examinations.

Fig. 8.4. Prevalence of infection and reinfection with Ascaris in children aged 5-14 years by study group

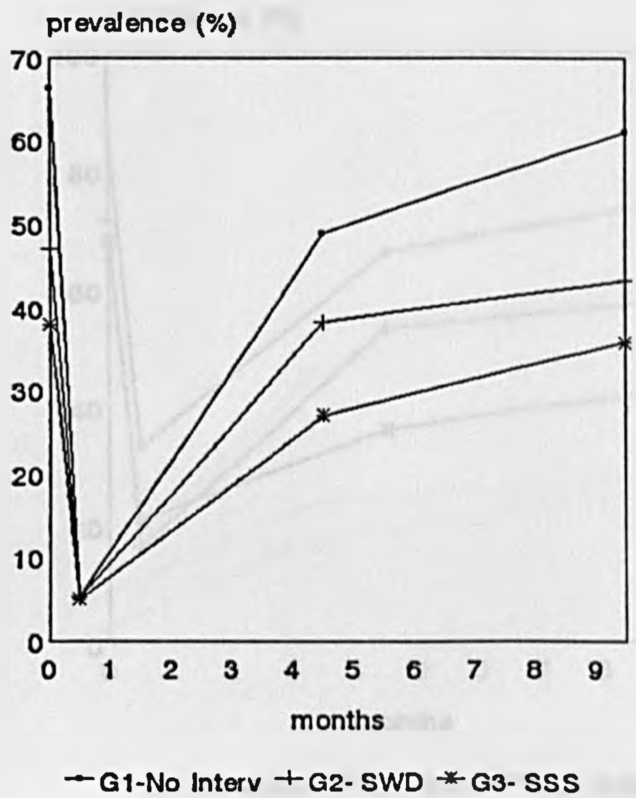


Fig. 8.5. Intensity of infection and reinfection with Ascaris in children aged 5-14 years by study group

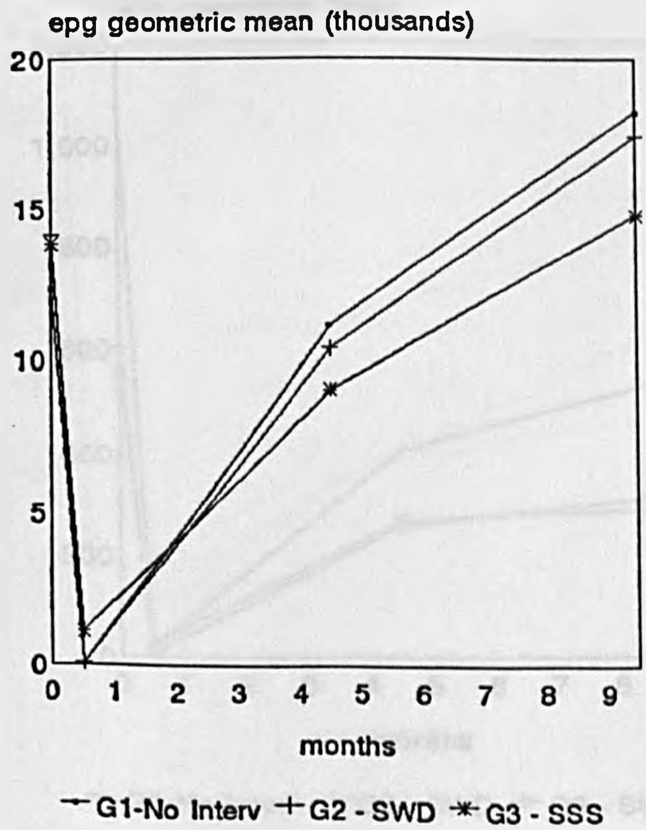


Fig. 8.6. Prevalence of infection and reinfection with Trichuris in children aged 5-14 years by study group

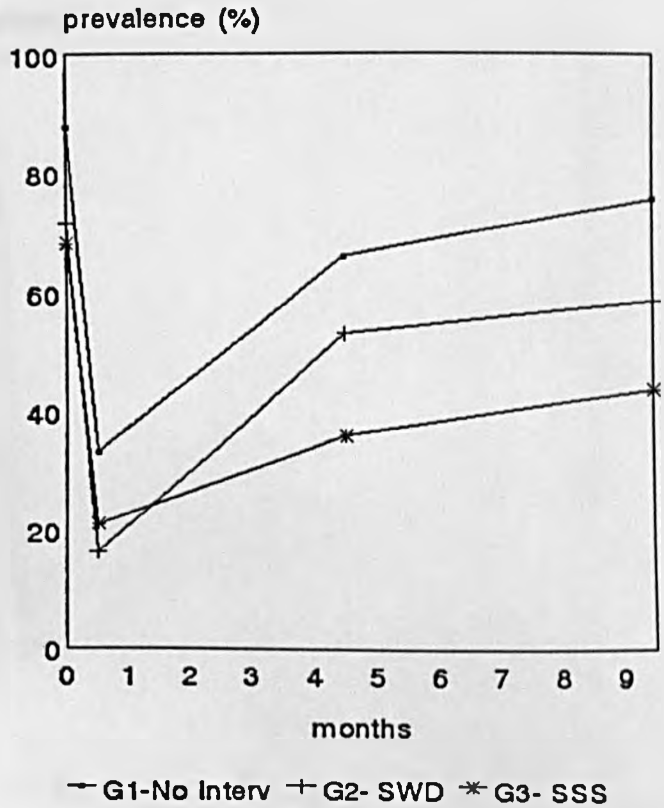


Fig. 8.7. Intensity of infection and reinfection with Trichuris in children aged 5-14 years by study group

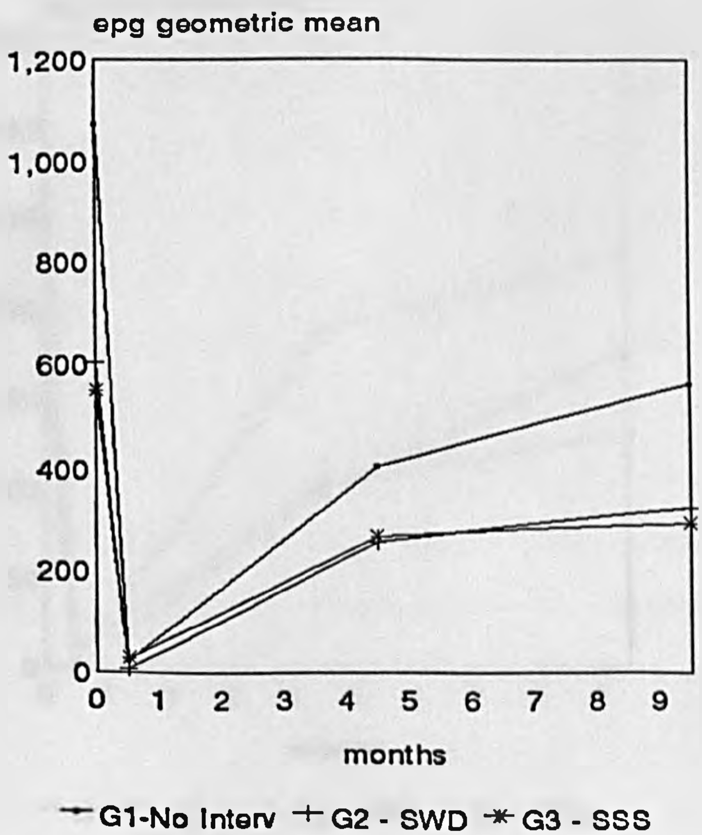


Fig. 8.8. Prevalence of infection and reinfection with hookworm in children aged 5-14 years by study group

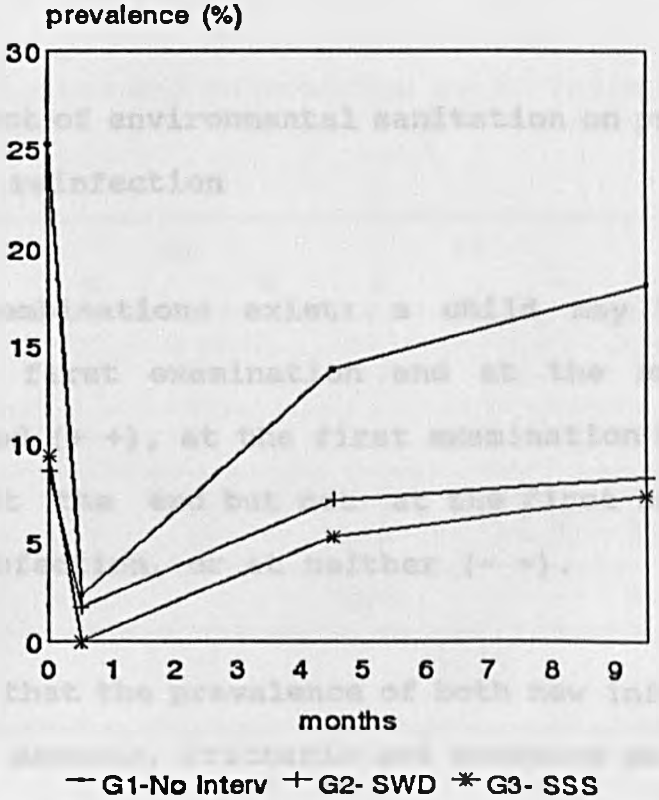
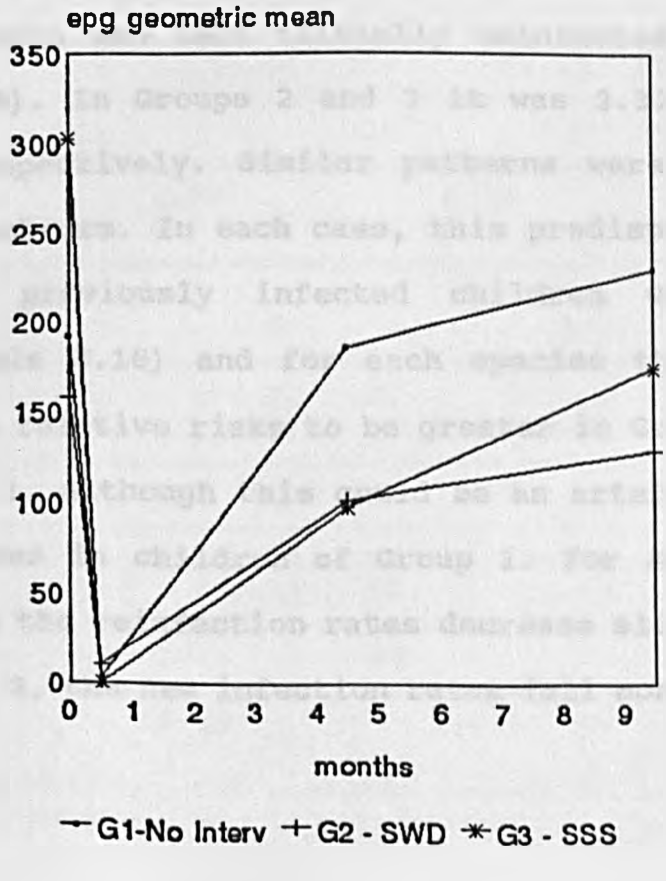


Fig. 8.9. Intensity of infection and reinfection with hookworm in children aged 5-14 years by study group



8.3.6.2. The effect of environmental sanitation on predisposition to reinfection

Four possible combinations exist: a child may have been infected at the first examination and at the end of the reinfection period (+ +), at the first examination but not at the end (+ -), at the end but not at the first examination (- +) i.e. new infection, or at neither (- -).

Table 8.15 shows that the prevalence of both new infection and reinfection with *Ascaris, Trichuris* and hookworm was lower in Groups Groups 2 and 3 than in Group 1. For children in Group 1, the relative risk that those infected with *Ascaris* before treatment would again be infected 9 months later when compared with those children who were initially uninfected was 1.30 (66.0% vs. 50.8%). In Groups 2 and 3 it was 2.33 and 2.20 times higher respectively. Similar patterns were seen for *Trichuris* and hookworm. In each case, this predisposition to reinfection by previously infected children was highly significant (Table 8.16) and for each species there was a tendency for the relative risks to be greater in Groups 2 and 3 than in Group 1, although this could be an artefact of the higher prevalences in children of Group 1. For *Ascaris* and *Trichuris*, while the reinfection rates decrease slightly from Group 1 to Group 3, the new infection rates fall more sharply.

Table 8.15
Comparison of infection and reinfection rates (nine months after treatment) in children aged 5-14 years of the three study groups, Exams 1 and 3

Ascaris	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
– – *	90	(49.2)	204	(72.6)	259	(75.5)
– +	93	(50.8)	77	(27.6)	84	(24.5)
	183		281		343	
+ –	129	(34.0)	92	(35.7)	96	(46.2)
+ +	250	(66.0)	166	(64.3)	112	(53.8)
Totals	379		258		208	
RR=	1.30		2.33		2.20	

Trichuris	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
– –	30	(50.0)	103	(68.7)	133	(78.7)
– +	30	(50.0)	47	(31.3)	36	(21.3)
	60		150		169	
+ –	109	(21.7)	123	(31.6)	180	(47.1)
+ +	393	(78.3)	266	(68.4)	202	(52.9)
Totals	502		389		382	
RR=	1.57		2.19		2.48	

hookworm	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
– –	371	(88.3)	472	(96.3)	478	(95.4)
– +	49	(11.7)	18	(3.7)	23	(4.6)
	420		490		501	
+ –	89	(62.7)	23	(46.9)	33	(66.0)
+ +	53	(37.3)	26	(53.1)	17	(34.0)
Totals	142		49		50	
RR=	3.19		14.35		7.39	

* – – , never infected; – + , gained infection ;
+ – , lost infection; + + , reinfected

Table 8.16
Predisposition to reinfection in children aged 5-14 years by study groups, Exams 1 and 2 and Exams 1 and 3

		Group 1 - No Interv		Group 2 - SWD		Group 3 - SSS	
		RR	p	RR	p	RR	p
Ascaris	(1x2)	1.47 (1.26-1.71)	****	1.98 (1.60-2.45)	****	3.20 (2.45-4.18)	****
	(1x3)	1.30 (1.12-1.52)	***	2.33 (1.93-2.86)	****	2.20 (1.76-2.75)	****
Trichuris	(1x2)	2.45 (1.98-3.04)	****	2.57 (2.05-3.22)	****	3.35 (2.44-4.60)	****
	(1x3)	1.57 (1.30-1.89)	****	2.19 (1.79-2.66)	****	2.48 (1.91-3.22)	****
hookworm	(1x2)	3.03 (2.06-4.46)	****	11.99 (7.54-19.06)	****	11.77 (6.73-20.60)	****
	(1x3)	3.19 (2.28-4.49)	****	14.35 (9.25-22.55)	****	7.39 (4.35-12.62)	****

(1x2): Exam1 (Oct-Nov/89) vs. Exam2 (Mar-Apr/90 : 4 months after treatment with mebendazole)
(1x3): Exam1 (Oct-Nov/89) vs. Exam3 (Aug-Sep/90 : 9 months after treatment with mebendazole)

RR = Relative Risk of reinfection in previously infected children, compared with previously uninfected children (95% confidence interval)

Significance (X^2 test): ***=p<0.001; ****=p<0.0001

For all children studied in both examinations 1 and 3, a comparison of heavy infection was also made with four possible combinations: a child may have been heavily infected at the first examination and also at the end of the reinfection 4 or 9 months period (H H), heavily infected at the first examination but not at the end (H L), heavily infected at the end but not at the first examination (L H), or uninfected, lightly or moderately infected in both examinations (L L) (Table 8.17). Aiming to avoid combinations with very small number of cases, heavy infection was defined as egg counts in the top 20% of the range (FORRESTER *et al.*, 1988) for each nematode and for each study group.

For the three nematodes studied, the predisposition to heavy infection by previously heavily infected children was highly significant in all three study groups (Table 8.18). The relative risk of those heavily infected before treatment and 9 months later (HH), when compared with those who were not heavily infected initially (LH), was greater in Groups 2 and 3 for *Ascaris*, *Trichuris* and hookworm than in Group 1. For *Ascaris* and *Trichuris*, the heavy reinfection rates were similar in the three study groups but the new heavy infection rates are decreasing from Group 1 towards Group 3; this determines the relative risk patterns (Table 8.17).

Table 8.17
Comparison of heavy infection rates before and 9 months after treatment in children aged 5-14 years of the three study groups, Exams 1 and 3

Ascaris	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
L L [a]	431	(89.4)	451	(92.8)	480	(94.7)
L H	51	(10.6)	35	(7.2)	27	(5.3)
	482		486		507	
H L	60	(75.0)	38	(71.7)	31	(70.4)
H H	20	(25.0)	15	(28.3)	13	(29.6)
Totals	80		53		44	
RR=		2.36		3.93		5.55

Trichuris	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
L L	407	(88.9)	423	(91.8)	454	(96.2)
L H	51	(11.1)	38	(8.2)	18	(3.8)
	458		461		472	
H L	70	(67.3)	53	(67.9)	49	(62.0)
H H	34	(32.7)	25	(32.1)	30	(38.0)
Totals	104		78		79	
RR=		2.94		3.89		9.96

hookworm	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
L L	520	(97.2)	523	(99.1)	533	(98.7)
L H	15	(2.8)	5	(0.9)	7	(1.3)
	535		528		540	
H L	21	(77.8)	7	(63.6)	9	(81.8)
H H	6	(22.2)	4	(36.4)	2	(18.2)
Totals	27		11		11	
RR=		7.96		38.40		14.03

[a] L L, uninfected, light or medium infection; L H, gained heavy infection;H L, lost heavy infection; H H, heavily reinfected
RR = relative risk of heavily infected 9 months later, when compared with those who were not heavily infected initially

Table 8.18
Predisposition to heavy reinfection in children aged 5-14 years by study group, Exams 1 and 3

	Group 1 - No Interv RR	p	Group 2 - SWD RR	p	Group 3 - SSS RR	p
Ascaris	2.36 (1.44-3.86)	***	3.93 (2.24-6.89)	****	5.55 (3.06-10.08)	****
Trichuris	2.94 (1.99-4.35)	****	3.89 (2.47-6.12)	****	9.96 (6.29-15.81)	****
hookworm	7.96 (3.33-19.02)	****	38.40 (15.48-95.24)	****	14.03 (2.27-71.77)	****

RR = Relative Risk (95% Confidence Interval)
Significance (X^2 test): ***=p<0.001; ****=p<0.0001

8.3.6.3. Predisposition to reinfection: discussion

Many children in this study as in other studies had light and only a few children heavy infections, a common finding (CROLL *et al.*, 1982; MARTIN *et al.*, 1983; THEIN-HLAING *et al.*, 1984; BUNDY *et al.*, 1985; ANDERSON, 1986; HASWELL-ELKINS et al., 1987; HOLLAND *et al.*, 1989; FERREIRA *et al.*, 1991; KROEGER et *al.*, 1992; SCHULZ and KROEGER, 1992; CHAN *et al.*, 1992; HALL *et al.*, 1992; CHAN *et al.*, 1994).

The results show that a greater proportion of children heavily infected with *Ascaris*, *Trichuris* and hookworm tended to become heavily reinfected and, therefore, seem to be predisposed to this state. These results are in agreement with studies of

Ascaris, *Trichuris* and hookworm developed in different countries (ANDERSON and MEDLEY, 1985; SCHAD and ANDERSON, 1985; BUNDY *et al.*, 1987b; HASWELL-ELKINS *et al.*, 1987; THEIN-HLAING *et al.*, 1987; HOLLAND *et al.*, 1989; FORRESTER *et al.*, 1990; CHAN *et al.*, 1992; HALL *et al.*, 1992; CHAN *et al.*, 1994). The factors responsible for predisposition to heavy infection are still unknown. According to ANDERSON (1986), they may be genetic, environmental, behavioural, nutritional or combined in nature. The household size and age of children lightly and heavily reinfected in the three study groups were checked and found to be similar, indicating that infection was not a consequence of the household size or number of children.

Predisposition to reinfection has been reported after one chemotherapeutic intervention for *Ascaris* (ELKINS *et al.*, 1986; THEIN-HLAING *et al.*, 1987; FORRESTER *et al.*, 1990), *Trichuris* (HASWELL-ELKINS *et al.*, 1987; BUNDY *et al.*, 1987a,b,1988; BUNDY and COOPER, 1988b) and hookworm (SCHAD and ANDERSON, 1985). In this present study also, reinfection was examined over a single reinfection period (9 months), so it was not then possible to study the reinfection pattern over repeated treatments (HALL *et al.*, 1992; CHAN *et al.*, 1994), and thus to check if the factors responsible for predisposition to light or heavy infection are stable through time (ANDERSON, 1986).

8.3.7. The effect of environmental sanitation on predisposition to multiple species

An interaction was apparent between infections with different species. Table 8.19 shows that, taking two species at a time, children infected with one species are more likely than others be infected with the second. The relative risks are significantly greater than 1 for *Ascaris* vs. *Trichuris, Ascaris* vs. hookworm and *Trichuris* vs. hookworm, and for each pair of species they are greater in Groups 2 and 3 than in Group 1.

The same pattern could be seen with respect to infection at greater than average intensity. This is shown in Table 8.20, for which heavy infection is again defined as an epg egg count in the top 20% of the range, for each nematode and for each study group (FORRESTER *et al.*, 1988). The relative risk between those heavily infected with *Ascaris* and those also heavily infected with *Trichuris* increased from Group 1 to Group 3 in both Exam 1 and 3 (Table 8.21).

Table 8.19
Interaction between infections with nematode species in children aged 5-14 years of the three study groups, Exam 1

Ascaris vs. *Trichuris*	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
- -*	46	(21.7)	141	(42.2)	176	(45.0)
- +	166	(78.3)	193	(57.8)	215	(55.0)
	212		334		391	
+ -	31	(7.4)	37	(12.5)	24	(10.0)
+ +	388	(92.6)	260	(87.5)	216	(90.0)
Totals	419		297		240	
RR=	1.18		1.51		1.64	

Ascaris vs. hookworm	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
- -	173	(81.6)	324	(97.0)	371	(95.1)
- +	39	(18.4)	10	(3.0)	19	(4.9)
	212		334		390	
+ -	299	(71.4)	253	(85.2)	202	(83.8)
+ +	120	(28.6)	44	(14.8)	39	(16.2)
Totals	419		297		241	
RR=	1.55		4.93		3.31	

Trichuris vs. hookworm	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
- -	71	(92.2)	177	(99.4)	195	(97.5)
- +	6	(7.8)	1	(0.6)	5	(2.5)
	77		178		200	
+ -	401	(72.4)	400	(88.3)	377	(87.5)
+ +	153	(27.6)	53	(11.7)	54	(12.5)
Totals	554		453		431	
RR=	3.53		19.50		5.00	

* - - , infected with neither; - + , infected with the second; + - , infected with the first; + + , infected with both

RR = relative risk of infection with the second species in those who are infected with the first, compared with those who are not

Table 8.20
Interaction between heavy infections with more than one nematode species in children aged 5-14 years of the three study groups, Exam 1

Ascaris vs. *Trichuris*	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
L L [a]	461	(84.4)	504	(88.3)	514	(88.3)
L H	85	(15.6)	67	(11.7)	68	(11.7)
	546		571		582	
H L	58	(68.2)	36	(60.0)	30	(61.2)
H H	27	(31.8)	24	(40.0)	19	(38.8)
Totals	85		60		49	
RR=	2.04		3.42		3.31	

Ascaris vs. hookworm	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
L L	521	(95.4)	562	(98.4)	572	(98.3)
L H	25	(4.6)	9	(1.6)	10	(1.7)
	546		571		582	
H L	78	(91.7)	58	(96.6)	47	(95.9)
H H	7	(8.3)	2	(3.4)	2	(4.1)
Totals	85		60		49	
RR=	1.80		2.12		2.41	

Trichuris vs. hookworm	G1 n	G1 %	G2 n	G2 %	G3 n	G3 %
L L	506	(97.5)	535	(99.1)	534	(99.1)
L H	13	(2.5)	5	(0.9)	5	(0.9)
	519		540		539	
H L	93	(83.0)	85	(93.4)	85	(92.4)
H H	19	(17.0)	6	(6.4)	7	(7.6)
Totals	112		91		92	
RR=	6.80		7.33		8.44	

[a] L L , not heavily infected with either; L H , heavily infected only with the second; H L , heavily infected only with the first; H H , heavily infected with both

RR = relative risk of heavily infected with the second species in those who are heavily infected with the first, compared with those who are not

Table 8.21
Association of infection[a] and of heavy infection[b] with two nematode species in children aged 5-14 years by study group, Exam 1 and Exam 3

	Group 1 - No Interv RR	Group 2 - SWD RR	Group 3 - SSS RR
[a] **Any infection**			
Ascaris with *Trichuris*			
Exam 1	1.18****	1.51****	1.64****
	(1.11-1.26)	(1.37-1.67)	(1.49-1.81)
Exam 3	1.29****	1.69****	1.69****
	(1.17-1.43)	(1.46-1.95)	(1.39-2.05)
Ascaris with hookworm			
Exam 1	1.55**	4.93****	3.31****
	(1.13-2.15)	(2.70-9.09)	(1.95-5.55)
Exam 3	1.87**	7.71****	2.45**
	(1.24-2.83)	(3.77-15.76)	(1.32-4.55)
Trichuris with hookworm			
Exam 1	3.53***	19.50****	5.00***
	(1.94-6.45)	(5.12-74.22)	(2.22-11.30)
Exam 3	6.37****	15.16****	6.20****
	(3.08-13.16)	(5.32-43.18)	(3.05-12.58)
[b] **Heavy infection only**			
Ascaris with *Trichuris*			
Exam 1	2.04***	3.42****	3.31****
	(1.37-3.04)	(2.25-5.20)	(2.08-5.26)
Exam 3	2.41****	2.79***	4.26****
	(1.53-3.79)	(1.58-4.73)	(2.32-7.83)
Ascaris with hookworm			
Exam 1	1.80^{NS}	2.12^{NS}	2.41^{NS}
	-	-	-
Exam 3	1.15^{NS}	4.89*	1.83^{NS}
	-	(4.87-24.51)	-
Trichuris with hookworm			
Exam 1	6.80****	7.33***	8.44***
	(3.68-12.56)	(2.32-23.18)	(2.73-26.13)
Exam 3	1.32^{NS}	26.40****	3.49^{NS}
	-	(8.59-81.13)	-

RR = Relative Risk (95% Confidence Interval)
Significance (X^2 test): ^{NS}not significant at 5% level; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$; $^{****}p<0.0001$

For the purposes of this table, "heavy infection" means epg egg counts in the top 20% of the range

8.4. Discussion

In this chapter, the following aspects of the epidemiology of three species of intestinal nematode in low-income areas of Salvador were considered:

- prevalence and intensity of infection;
- risk factors for infection, by bivariate and logistic regression analysis;
- clustering of cases of infection, and of heavy infection, by household;
- prevalence and intensity of reinfection;
- predisposition of individuals to reinfection and to heavy infection, in terms of relative risk;
- association between infections, and of heavy infections, with different species, in terms of relative risk.

In much of the literature, some of these aspects are discussed as if they were intrinsic aspects of the parasites concerned; predisposition to reinfection is an example. However, the results presented here have shown all these aspects to vary, with few exceptions in a consistent manner between communities whose principal difference is their level of environmental sanitation provision. As the level of sanitation improves (as we pass from Group 1 to Group 2 and then to Group 3, even considering their levels of coverage), the following trends can be noted:

- prevalence and (for *Trichuris*) intensity of infection declines;
- risk factors for infection become more numerous and more significant, particularly for *Ascaris* and *Trichuris*;
- clustering of cases by household becomes more marked, and hence more significant;
- prevalence and (to some extent) intensity of reinfection decline;
- predisposition of individuals to reinfection and to heavy reinfection becomes more marked;
- infections with different species are increasingly aggregated in the same individuals.

It is hard to avoid the conclusion that these trends are consequences of the sanitation improvements. In that case, and to the extent that this is so, these phenomena cannot be entirely explained by biological factors such as variations in host susceptibility; rather, we must seek causes in the host's environment, where the parasites are transmitted.

The decline in overall prevalence and intensity of infection indicate that the sanitation measures have succeeded in controlling transmission, or at least an important component of it. The increased significance of the characteristics of the individual implies that the residual transmission which has not been controlled depends more on these characteristics than the component which has been interrupted. With the exception of the child's age and sex, the risk factors found are in fact all characteristics of the household, rather than the individual. If, then, the residual transmission is more dependent on the household's characteristics, it would follow that relatively more of it occurs within or close to the household environment, rather than in the public domain.

Clustering of intestinal helminth infections by household is a well-known phenomenon. Indeed, CORT *et al*. (1929) concluded from their studies that the family, and not the individual, should be considered the unit of infection. What is new in the present study is the finding that the degree of clustering by household depends on environmental conditions.

There are two ways in which the environmental transmission of intestinal helminths could produce a pattern of infection clustered by household. First, a substantial amount of transmission could be occurring within the household, from one member to another. Second, if the characteristics of some households are such as to expose them heavily to infection from other households (for example, in a household living beside an open sewer), then cases of infection are likely to be clustered in such households in a non-random way.

Whichever phenomenon is the cause of the household clustering (whether intra- or inter-household transmission is primarily responsible), the conclusion is the same; that in the communities which lack sanitation, most of the transmission is unaffected by the characteristics of the household, while this component has been substantially reduced in the communities which have it.

As pointed out by ANDERSON and MAY (1985), predisposition to reinfection may have its origins in variations in host susceptibility or exposure. To the extent that such predisposition has been shown here to be largely dependent on environmental conditions, it cannot be related to susceptibility. The high degree of predisposition to reinfection encountered in the communities with improved sanitation must therefore be explained largely in terms of the environmental conditions of the individual and her household - whether these refer to (i) environmental hygiene in general, or (ii) the degree to which the household environment has remained contaminated with worm eggs or larvae excreted before the first round of chemotherapy.

The second of these, of course, cannot account for the association found between infections with different species of helminth in the same children. Moreover, the lack of interaction between species found in a number of studies (CROLL and GHADIRIAN, 1981; KROEGER *et al.*, 1992) implies that there is no biological factor intrinsic either to the host or the parasites which would account for it. Rather, the fact that the environment of certain households, in certain neighbourhoods, renders them far more exposed to faecal contamination than others, is a more than adequate explanation for the interactions found here. The tendency for the interaction to be stronger in the neighbourhoods with better sanitation facilities only underlines the environmental explanation and confirms the public/domestic transmission paradigm above.

To summarise, the evidence from a number of aspects of the epidemiology of three different species of parasite all points in the same direction. That is, that where sanitation is lacking, a significant part of transmission occurs in ways which are not affected by characteristics of individual households, and therefore are presumably out of their control. It is reasonable to presume that this transmission occurs outside the household, somewhere in the public domain.

This component would appear to be largely controlled by sanitation improvements, leaving a residual degree of transmission which does depend on household risk factors, and presumably occurs within the domestic domain, the household environment and the areas immediately adjoining it.

CHAPTER 9

Conclusions, final remarks and recommendations

9.1. Conclusions

a. Diarrhoeal disease

The present study has shown that community environmental sanitation can have a significant health effect on diarrhoea, nutritional status and intestinal nematode infections.

The results provided some evidence that improved environmental sanitation can have had a positive impact on diarrhoea morbidity in young children in peri-urban areas of Salvador.

The incidence of diarrhoea was consistently higher in the group of neighbourhoods without community sanitation throughout the study period.

Sewerage and drainage had a significant effect on diarrhoeal morbidity even after controlling for confounding factors. The incidence of diarrhoea in the group with simplified sewerage was one third and in the group with stairways drainage was two thirds of that in the group without community sanitation.

The component of transmission which is prevented by the environmental sanitation is among children above 1 year old, as children older than 1 year are more likely than infants to play in the street, and to be exposed to the faecal contamination in the environment.

b. Nutritional status

Children living in the neighbourhoods without community sanitation presented during the study period a significantly lower nutritional status expressed by the mean height-for-age z-score, a lower (but not significantly lower) mean weight-for-age z-score and a similar mean weight-for-height z-score to those living in neighbourhoods with a simplified sewerage system.

Even so, children in communities with environmental sanitation nevertheless had a growth deficit, indicating that provision of improved community excreta and sullage disposal is only one of the important intervention needed to reduce malnutrition or improve nutritional status.

The results showed some evidence that the anthropometric status of children living in poor urban areas of Salvador, mainly height-for-age, was associated with environmental conditions even when socioeconomic, cultural and demographic factors were taken into account, and that children living in neighbourhoods with community sanitation had the best linear growth over time.

c. Intestinal nematode infections

The evidence of the health impact was strongest for intestinal nematode infections, as there is no possibility of observer bias.

For the intestinal nematode infections, as the level of community sanitation improves (from the none intervention group to the stairways drainage group and then to the simplified sewerage group) the following trends were noted:

- prevalence and (for *Trichuris*) intensity of infection declines;
- risk factors for infection become more numerous and more significant, particularly for *Ascaris* and *Trichuris*;
- clustering of cases by household becomes more marked, and hence more significant;
- prevalence and (to some extent) intensity of reinfection decline;
- predisposition of individuals to reinfection and to heavy reinfection becomes more marked;
- infections with different species are increasingly aggregated in the same individuals.

The evidence from a number of aspects of the epidemiology of three different species of parasite pointed in the same direction. That is, the disease transmission which is controlled by community sanitation occurs largely in the public domain; there is a residual component of transmission which depends on individual household characteristics (the private/domestic domain), and presumably occurs within the domestic domain, the household environment and the areas immediately adjoining it.

This is not necessarily under the control of individual/households; for instance, proximity to overflowing or visible sewage/rubbish. The significance of risk factors such as these is an indication that the health impact of the environmental sanitation could have been greater if the system had been properly maintained.

The epidemiologic differentiation of the two domains for disease transmission has important implications for environmental control strategies (CAIRNCROSS *et al.*, 1996).

The finding that domestic factors assume greater importance when transmission in the public domain is controlled implies that environmental sanitation creates conditions for other inputs, aimed as such domestic factors, to produce synergistic effects.

9.2. Needs in the physical environment. Environmental sanitation measures

Several researchers say that the provision of latrines and education in their proper usage and maintenance are crucial to the control of nematode infections, possibly because the majority of studies were realized in rural areas. In urban areas, this must be extended to community sanitation.

In contrast to the dramatic decline in helminth infections in developed countries during the past century, intestinal helminth infections still represent a major problem in urban and rural areas in most of the developing countries (SAVIOLI *et al.*, 1992; CROMPTOM and SAVIOLI, 1993; WORLD BANK, 1993).

Some attempts have been made to reduce the prevalence and intensity of helminth infections in developing countries. In particular, mass treatment with anthelminthic drugs has been recommended by several national and international organizations as a basis for helminthiasis control (BUNDY, 1990). Anthelminthic drugs are an effective, safe and relatively inexpensive method of reducing morbidity caused by helminth infections. However, the cost of mass treatment campaigns, their operational difficulties, the problem of compliance of the individuals in taking the drugs, and so on, have mean that their effectiveness may be limited. A more fundamental question is their sustainability as a public health measure, if they have to be repeated frequently.

However, preventive, non-clinical measures for controlling helminth infections can be justified (GROSS *et al.*, 1989). One of the preventive strategies is the improvement of environmental conditions, mainly community sanitation, water supply, rubbish collection and drainage facilities, so that transmission of the agent can be prevented or at least impeded. In urban areas the improvement of these environmental conditions can be established by the construction of basic infrastructure systems.

9.3. Needs in social environment

Ascaris lumbricoides, hookworm and *Trichuris trichiura*, the three most prevalent soil-transmitted helminth infections, are among the most common infections in the world, and each has been estimated to infect between one-sixth and one-quarter of the world's population (STEPHENSON and HOLLAND, 1987). These infections often occur together in the same communities and in the same persons.

Some authorities suggest that the control of soil-transmitted helminths would improve productivity, health, and the overall quality of life in endemic areas (WHO, 1987b; KOCH-WESER, 1988). However, it still is not known how much societies could improve their functional capacity through effective prevention and control of soil-transmitted helminths. Given scarce financial resources and the large national debts of most developing countries (MUKHERJEE, 1987), it is important to measure these improvements in order further to encourage both large scale introduction of successful water and sanitation programmes (CAIRNCROSS, 1989) and also the community chemotherapy programmes that are the only way in the short term to reduce the prevalence and intensity of soil-transmitted helminths in most endemic countries (STEPHENSON *et al.*, 1989).

The transmission and persistence of nematodes requires, in addition to the necessary environmental conditions, specific behavioural actions by the individual and specific practices in communities. It is therefore not surprising that the transmission of these infections is not only due the environmental sanitation conditions but also a function of various socioeconomic and cultural factors interacting with each other. SANJUR (1989), in reviewing the current empirical evidence, concluded that no single factor appears to be responsible for either the development or the distribution of nematode infections in communities or households. Several factors - of a medical, biological, environmental, political, social, economic and cultural nature, and behaving in a synergistic and dynamic fashion - appear to be more significant than any single factor working independently.

9.4. Recommendations and further research needs

Aiming to improve health and their cost-effectiveness, the environmental sanitation measures should have full coverage and be carried out as part of an integrated (holistic) project, including:

- community sanitation, water supply, drainage, rubbish collection and control of vectors (flies, cockroaches and rats)
- setting up institutions for maintenance
- hygiene promotion
- land tenure
- income generation
- child care for working mothers
- etc.

The assessment of priorities for research must be an ongoing exercise, while attempts at control and prevention of nematode infections through the application of existing knowledge should continue.

Efforts should take into account cost-benefit analyses for improvement of environmental sanitation services. The health impact (reduction in infectious disease) and the improvement in quality of life must be considered in these analyses. Further research to develop methodologies for (rapid) assessment of the costs and the benefits of environmental sanitation interventions, about how to organise maintenance of drainage/sewerage systems and about cost-effective operation of urban solid waste systems are needed. Behavioural research is also needed in order to understand and modify patterns of life that maintain the transmission of nematode infections (DUNN, 1979).

The present project has identified some important risk factors that need to be followed up to confirm that changing them has a health impact. Then we need research into how to change the risk factors (e.g. overflowing sewage) cost-effectively.

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Appendix 1. Questionnaire

UNIVERSIDADE FEDERAL DA BAHIA
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IDENTIFICAÇÃO DA RESIDÊNCIA E MORADORES

1. COM/CASA 2.ENDEREÇO NO. BAIRRO NO. SUCAM

3. NOME OU APELIDO DO (A) CABEÇA DA FAMÍLIA

4. MORADORES (INSTRUÇÕES PARA PREENCHIMENTO - VIDE TABELA ABAIXO)

NO.	NOME	P/C	ID.	S	OC	ES.	T/B	R/D	L/N	P	C
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

Instruções para o preenchimento - Ítem 4 - Moradores

P/C: Parentesco c/ o cabeça
01-cabeça
02-conjuge
03-filho
04-filho adotivo
06-sobrinho
06-neto
07-enteado
08-pai
09-mãe
10-agregado
11-empregado
12-outro

ID-Idade
M - <5 anos
A - >=5 anos

S-Sexo
1-masc.
2-fem.

OC-Ocupação
(escrever)

ES-Escolaridade
01-nunca estudou
02-mobral
03-prim. compl.
04-prim. incompl.
05-gin. compl.
06-gin. incompl.
07-col. compl.
08-col. incompl.
09-univ. compl.
10-univ. incompl.
11-supl. 1º grau
12-supl. 2º grau
13-pré-escolar

T/B-Tempo que reside no bairro
R/D-Tempo que reside no domicílio
M - <5 anos
A - >=5 anos

L/N-Local de nascimento
(escrever)

P-Procedência
1-Salvador
2-Bahia-zona rural
3-Bahia-zona urbana
4-outro estado zona rural
5-outro estado zona urbana

C-cor
1-negra
2-branca
3-amarela
4-outros

5. Números de famílias no domicílio:

Instruções para utilização dos anexos:
se houver crianças:
- com idade < 5 anos (nascidos a partir de 10/09/84→ Preencher Anexo 1
- com idade < 15 anos (nascidos a partir de 10/09/74→ Preencher Anexo 2

Preencher sempre Anexo 3

6. Dos três anexos, quantos utilizou ?

TC______ DATA___ SC______ DATA___ REV______ DATA___ DIG______ DATA___

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ANEXO 1 - DIARRÉIA - PARA CRIANÇAS ENTRE 0 E 5 ANOS

IDENTIFICAÇÃO DA CRIANÇA
COMUNIDADE ⎣_⎦ CASA ⎣_⎦⎣_⎦⎣_⎦ CRIANÇA ⎣_⎦⎣_⎦

NUMIDENT ⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦
1. NOME ⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦
2. DTNASC ⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦⎣_⎦

3. Primeiro filho ?
1-sim;
2-não, indique o número ______
3-enteado/adotivo;
4-outro

PRIFILHO ⎣_⎦
NORDEM ⎣_⎦⎣_⎦

4. Teve diarréia nos últimos 15 dias?
(caso não, prosseguir no item 13)
1-sim; 2-não 3-não sabe

DIARRÉIA ⎣_⎦

DURANTE A DIARRÉIA

5. Quantas evacuações foram feitas por dia ?
1-menos de 3;
2-entre 4 e 8;
3-mais de 8;
4-não sabe;

EVACUAÇÕES ⎣_⎦

6. As fezes tinham:

a)sangue	b)catarro (muco)	c)pus
1-sim;	1-sim;	1-sim;
2-não	2-não;	2-não
3-não sabe	3-não sabe	3-não sabe

SANGUE ⎣_⎦
MUCO ⎣_⎦
PUS ⎣_⎦

7. A criança teve:

a)febre	b)vômitos	c)naúseas (enjôo)
1-sim;	1-sim;	1-sim;
2-não	2-não	2-não
3-não sabe	3-não sabe	3-não sabe

FEBRE ⎣_⎦
VÔMITO ⎣_⎦
NAÚSEA ⎣_⎦

8. Quantos dias durou a diarréia ?
se ainda continua, quantos dias até hoje ?

DIAS ⎣_⎦⎣_⎦
CONTINUA ⎣_⎦⎣_⎦

9. A criança foi atendida em algum serviço médico ?
1-sim; 2-não 3-não sabe
Qual ? ______

SMÉDICO ⎣_⎦
QSMÉDICO ⎣_⎦⎣_⎦

10. A criança tomou alguma medicação ?
1-sim; 2-não; 3-não sabe
Qual ? ______

REMÉDIO ⎣_⎦
QREMÉDIO ⎣_⎦

11. Como esteve o apetite da criança ?
1-diminuido; 2-inalterado; 3-outro;

APETITE ⎣_⎦

12. A alimentação da criança mudou por causa da diarréia?
1-não;
2-parou de amamentar;
3-parou com a mamadeira;
4-diluiu a mamadeira;
5-deu soro;
6-outro ______

ALIMENTA ⎣_⎦

PERGUNTAS A MÃE DA CRIANÇA

13. A criança foi amamentada no seio durante quanto tempo (meses) ? — MAMA |__|__|

14. O desmame foi iniciado com que idade (meses) ? — IDADE |__|__|

15. Onde a criança fica a maior parte do dia ? — ONDE |__|__|

1-no berço; 7-na creche;
2-no quarto; 8-na casa da vizinha;
3-na sala; 9-na casa de parente;
4-na cozinha; 10-na varanda;
5-no quintal; 11-outro
6-na rua;

16 Quem toma conta da criança diariamente ? — QUEM |__|

1-mãe; 6-avó(ô);
2-pai; 7-vizinha;
3-irmã(o)maior de 10 anos; 8-empregada;
4-irmã(o)menor de 10 anos; 9-outro
5-tia(o);

17. Quantas pessoas dormem no mesmo quarto com a crian ça ? — QUANTAS |__|__|

18. Quando acha que a criança está com diarréia ? — QUANDO |__|

____

Anotar: no. de evacuações — EVACUA |__|__|
consistência das fezes ________________ — CONSIST |__|

19. Como a criança pode pegar diarréia ? — COMO |__|

____

20. O que pode acontecer se a criança pegar diarréia e não for tratado ? — SEPEGAR |__|

____

21. De mais importante, o que deve ser feito para curar a diarréia da criança ? — CURA |__|__|

1-dar o soro de reidratação oral ou soro caseiro;
2-tratar com remédio;
3-remédio caseiro;
4-suspender alimentação;
5-modificar alimentação;
6-melhor casa;
7-água encanada;
8-sanitário/esgoto;
9-melhor salário para o cabeça da família;
10-melhores condições de vida;
11-outro ________________

22. A senhora tem conhecimento da campanha do soro de reidratração oral ou do soro caseiro ? — SRO |__|

1-sim, pela TV;
2-sim, pelo rádio;
3-sim, pela vizinha, parente ou conhecido;
4-sim, pelo sistema público de saúde;
5-sim, pelo sistema privado de saúde;
6-sim, pela organização comunitária;
7-não

23. A senhora sabe preparar o soro caseiro ? — PREPSRO |__|

1-sim;
2-não

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ANEXO 2 - NEMATÓIDES - PARA CRIANÇAS DE ZERO A QUINZE ANOS

IDENTIFICAÇÃO DA CRIANÇA

COMUNIDADE ☐ CASA ☐☐☐ CRIANÇA ☐☐

1.NOME ☐☐☐☐☐☐☐☐☐☐☐☐
NUMIDENT ☐☐☐☐☐☐
2.DATA NASC ☐☐☐☐☐☐

DADOS SOBRE A CRIANÇA

3. A criança sabe ler ? — LEH ☐
   1-sim;
   2-não;
4. Se estiver estudando, em que escola estuda ? — ESCOLA ☐
   1-pública; 2-comunitária;
   3-particular
   Nome:____________________
   Bairro:____________________
5. A criança sempre morou em casa com
   a) Água encanada ? — ÁGUA ☐
      1-sim;
      2-não
   b) Sanitário ? — SANIT ☐
      1-sim;
      2-não
6. Durante este ano a criança fez algum exame de fezes ? — EXAME ☐
   1-sim;
   2-não;
   3-não sabe
7. Em caso afirmativo, por quê ? — PORQUE ☐
   1-apresentou sinais/sintomas;
   2-devido a sintomas digestivos;
   3-revisão geral (check-up);
   4-solicitação médica;
   5-não sabe;
   6-outro
8. Quantos exames de fezes a criança fez durante o ano ? — QUANTOS ☐
9. Quem pagou o último exame? — PAGOU ☐
   1-particular;
   2-município/IPS;
   3-estado/IAPSEB;
   4-SUDS;
   5-INAMPS/INPS;
   6-outro;
   7-não sabe

10. Qual o resultado do último exame ? 1-negativo; 2-ascaris (lombriga); 3-shistossoma mansoni (xistose); 4-enterobius (caseira); 5-tricocefalo; 6-ancilóstomo (amarelão); 7-giardia; 8-ameba; 9-outro; ______ 10-não sabe	RESULT	__|__
11. Quando a criança fez o último tratamento para vermes (meses)?	TRATA	__|__
12. Quantas vezes a criança tomou remédio para vermes este ano ?	QUANTAS	__|__
13. Atualmente tem visto a criança: 1-eliminar ascaris (lombriga); 2-coçar o ânus por causa da caseira; 3-não tem visto 1 e 2; 4-tem visto 1 e 2	VISTO	__
14. A criança apresenta gases/arroto/ventosidade ? 1-sim; 2-não	GASES	__
15. Onde a criança defeca regularmente ou onde suas fezes são jogadas ? 1-sanitário em casa; 2-sanitário outro local; 3-próximo ao canal/rio; 4-terreno baldio; 5-no meio da rua; 6-no quintal; 7-outro ______ 8-não sabe	ONDE	__
16. A criança têm o costume de lavar as mãos após defecar ? 1-sim, sempre; 2-sim, quase sempre; 3-sim, raramente; 4-não; 5-não sabe; 6-não se aplica	LAVA	__
17. A senhora lava as mãos após limpar o ânus da criança quando ele defeca ? 1-sim, sempre; 2-sim; quase sempre; 3-sim, as vezes; 4-não; 5-não se aplica	LIMPA	__
18. Onde as crianças brincam a maior parte do tempo ? 1-na sala; 6-no parque; 2-na cozinha; 7-na escola; 3-no quarto; 8-na varanda; 4-no quintal; 9-na casa da vizinha; 5-na rua; 10-outro: ______	BRINCA	__|__
19. Com que idade a senhora acha que as crianças do bairro devem brincar na rua (anos) ?	IDADE	__|__

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ANEXO 3 - CONDIÇÕES DO DOMICÍLIO E DE SANEAMENTO DOMICILIAR E AMBIENTAL

IDENTIFICAÇÃO DO DOMICÍLIO
COMUNIDADE |__| CASA |__|__|__|

IDCASA |__|__|__|__|

1. Esta casa é:
   1-própria, já paga;
   2-própria, financiada;
   3-alugada;
   4-cedida;
   5-outro ______

CASA |__|

2. Quanto paga pela casa ?
   Valor (NCz$)
   Período
   1-semanal;
   2-mensal;
   3-semestral;
   4-anual;
   5-outro ______

VALOR |__|__|__|__|
PERÍODO |__|

3. O terreno da casa é:
   1-próprio, com escritura;
   2-próprio, sem escritura;
   3-foreiro;
   4-rendeiro;
   5-invadido;
   6-cedido;
   7-outro;
   8-não sabe

TERRENO |__|

4. Quantos cômodos tem a casa (exceto o banheiro) ?
5. Quantos são usados para dormir ?
6. A sua cozinha é utilizada só para preparar alimentos ?
   1-pessoas dormirem;
   2-animais repousarem;
   3-crianças ficarem durante o dia;
   4-itens 1 e 2;
   5-itens 1 e 3;
   6-itens 2 e 3;
   7-itens 1, 2 e 3;
   8-só para preparar alimentos;
   9-outro

COMODOS |__|
DORMIR |__|
COZINHA |__|

7. Qual o material predominante nas paredes ?
   1-alvenaria com reboco;
   2-alvenaria sem reboco
   3-taipa com reboco;
   4-taipa sem reboco;
   5-madeira;
   6-palha;
   7-plástico;
   8-outro

PAREDE |__|

8. Qual o tipo de piso predominante na casa ?
   1-terra;
   2-cimento;
   3-cerâmica;
   4-madeira;
   5-mármore, carpete, plástico;
   6-outro

PISO |__|

9. Qual o material predominante na cobertura ?
   1-laje de concreto;
   2-telha de barro;
   3-telha de cimento-amianto(Eternit);
   4-madeira;
   5-zinco ou flandres;
   6-palha;
   7-plástico;
   8-outro

COBERTURA |__|

10. Qual a área média construída da casa ? (estimar em m2)		ÁREA
11. A casa tem energia elétrica ?		ENERGIA
1-sim;	2-não	
12. Tem fogão em casa ?		FOGÃO
1-sim, a gás;	4-sim, outro;	
2-sim, lenha;	5-não	
3-sim, elétrico		
13. Tem geladeira em casa ?		GELADEIRA
1-sim;	2-não	
14. Tem televisão em casa ?		TV
1-sim, a cores;		
2-sim, preto e branco;		
3-não		
15. Tem rádio em casa ?		RÁDIO
1-sim;		
2-não		
16. Tem automóvel ?		CARRO
1-sim, uso particular;		
2-sim, uso profissional;		
3-sim, 1 e 2;		
4-não		
17. De onde vem a água usada em sua casa ?		ÁGUA
1-rede da EMBASA com medidor;	5-riacho/rio;	
2-rede da EMBASA sem medidor;	6-lagoa;	
3-poço/cisterna domiciliar;	7-fonte de encosta ou da bica	
4-poço/cisterna coletiva;	8-outro	
18. Como a água chega até a casa ?		CHEGA
1-canalização interna completa;	7-coleta do poço/cisterna coletiva;	
2-canalização interna incompleta;	8-coleta do riacho/rio;	
3-torneira na entrada/fundo do terreno;	9-compra na porta;	
4-coleta na casa da vizinha;	10-coleta da fonte de encosta ou da bica;	
5-chafariz;		
6-coleta do poço/cisterna domiciliar;	11-coleta da lagoa;	
	12-outro	
(se responder 4,5 ou 9 saber de onde vem e responder pergunta 17)		
19. Com que frequência ocorre falta de água ?		FALTA
1-nunca falta;	5-falta toda semana;	
2-raramente falta;	6-falta todo mês;	
3-falta todo dia;	7-outro ____	
4-falta o dia inteiro;	8-não se aplica	
20. Onde a água é guardada em casa ?		GUARDA
1-no tanque com tampa;	5-pote e vasilhas de barro;	
2-no tanque sem tampa;	6-vasilhas de plástico;	
3-tonel/lata/panela com tampa;	7-outro ____	
4-tonel/lata/panela sem tampa;	8-não guarda	
21. A água é usada em casa para:		USO
1-só beber;	4-item 3 e lavar roupa;	
2-beber, cozinhar;	5-item 4 e manter a casa limpa;	
3-beber, cozinhar e tomar banho;	6-outro ____	
22. Como a água é tratada em casa ?		TRATA
1-só fervida;	4-usa produto químico;	
2-só filtrada;	5-outro ____	
3-fervida e filtrada;	6-não é tratada	

23. Que quantidade de água é usada em casa ?
Informar: a) 1-____ (No.) de latas de 20 l
2-____ (No.) de vasilhames____ l
3-____ m3 (veja no recibo, caso a casa tenha medidor)
b) Periodicidade:
1-diariamente;
2-semanalmente;
3-mensalmente

QTDE |_|_|_|_|_|

TEMPO |_|

24. Quanto você pagou de água no último mês (NCz$) ?

QUANTO |_|_|_|

25. Tem sanitário em casa ?
1-sim, na área interna;
2-sim, na área externa;
3-não, mas usa o do vizinho;
4-não, mas usa o coletivo;
5-não usa terreno baldio;
6-não, usa riacho, rio/canal;
7-não, outra
(se a resposta foi 5,6 ou 7 pule para pergunta 29)

SANIT |_|

26. Qual o tipo do(s) sanitário(s) ?
1-vaso com descarga automática;
2-vaso com descarga manual;
3-VDR;
4-casinha com buraco;

TIPO |_|

27. Dentro do sanitário ou próximo dele tem lavatório (pia) ?
1-sim;
2-não;

PIA |_|

28. Quem na casa usa sanitário ?
1-todos;
2-os pais e crianças maiores de 2 anos;
3-os pais e crianças maiores de 5 anos;
4-os pais e os maiores de 15 anos;
5-só os adultos;
6-só o pai;
7-só a mãe;
8-ninguém;
9-outro,____

QUSA |_|

29. Qual o destino dos dejetos sanitários (fezes/urina) ?
1-rede de esgotos;
2-escadaria/rampa drenante;
3-fossa séptica-escadaria/rede;
4-fossa séptica-infiltra no solo;
5-fossa absorvente/sumidouro ;
6-fossa seca/rudimentar;
7-superficie/vala;
8-superficie-riacho/rio;
9-canal;
10-outro

DESTINO |_|_|

30. Há quantos metros da casa os dejetos são lançados ?

METROS |_|_|_|

31. Qual o destino das águas utilizadas em pias, chuveiros, etc ?
(para responder use códigos da questão 29)

AGUAUTIL |_|_|

32. Há quantos metros da casa estas águas são lançadas ?

LANÇA |_|_|_|

33. Com que frequência a SUMAC/PMS limpa as escadarias/rampas drenantes e os canais ?
1-1 vez por mês;
2-1 vez por semestre;
3-1 vez por ano;
4-nunca limpou;
5-outro____
6-não se aplica

SUMAC |_|

34. Onde o lixo é guardado dentro de casa ?
1-caixa de pepelão;
2-caixote de madeira;
3-lata/balde com tampa;
4-lata/balde sem tampa;
5-saco de papel;
6-saco plástico;
7-varrido para o quintal;
8-varrido para a rua;
9-outro____

ONDE |_|

35. Qual o destino do lixo ? — DESTLIXO
1-jogado no quintal;
2-jogado no canal;
3-jogado no terreno baldio/rua;
4-jogado dentro da escadaria;
5-colocado numa caixa estacionária, container ou ponto de lixo e coletado pela LIMPURB;
6-coletado pela LIMPURB de casa em casa;
7-queimado;
8-enterrado;
9-serve de alimentos para animais;
10-é vendido;
11-outro ______

36. Com que frequência ocorre a coleta do lixo ? — COLETA
1-diária;
2-dias alternados;
3-1 vez por semana;
4-1 vez por mês;
5-esporádica;
6-não é feita;
7-não se aplica

37. Quantos pontos de resíduos existem próximos (até 10 m) da casa ?
a) esgotos a céu aberto; — CEUABER
b) esgotos estravazando; — ESGOTO
c) a+b — CEUESG
d) lixo; — LIXO
e) total (c+d) — TOTAL

38. Durante este ano tem aumentado dentro/próximo da casa o número de: — NÚMERO
1-ratos;
2-baratas;
3-moscas;
4-mosquitos;
5-muriçocas;
6-nenhum deles;
7-outro ______

39. Na sua opinião este número aumentou devido a: — OPINIÃO
1-falta de limpeza na casa;
2-acúmulo de lixo em terrenos próximos a casa;
3-acúmulo de lixo e falta de limpeza nas escadarias/rampas drenantes;
4-esgoto na rua;
5-outro

40. Tem animais na casa ? — ANIMAIS
1-sim, cachorro;
2-sim, gato;
3-sim, cachorro e gato;
4-sim, outro;
5-sim, cachorro e outro;
6-sim, gato e outro;
7-sim, cachorro, gato e outro
8-não
Quantos ? — QUANTOS

41. Tipo de pavimentação da rua — RUA
1-barro;
2-escadaria;
3-rampa;
4-cimentado;
5-asfalto;
6-paralelepipedo;
7-outro

42. Quando chove muito o que acontece na sua casa ? — DRENA
1-alaga a casa toda;
2-alaga uma parte da casa;
3-entra água e empoça;
4-não acontece nada

SITUAÇÃO SÓCIO-ECONÔMICA

Com relação ao cabeça da família:

43. *Qual sua ocupação atual ?* — OCUPAÇÃO [ ]

(SE DESEMPREGADO PULE PARA A PERGUNTA 47)

44. Você é: — VOCÊ [ ]
    1-diarista;
    2-semanalista;
    3-mensalista;
    4-empregado por tempo indeterminado
    5-conta própria/autônomo;
    6-empregador;
    7-biscateiro;
    8-outro ______

45. Tem carteira assinada ? — CARTEIRA [ ]
    1-sim;
    2-não;
    3-não tem CT

46. Tem quanto tempo no emprego (meses) ? — TEMPREG [| | |]

47. Há quanto tempo está desempregado (meses) ? — TDESEMP [| | |]

48. Por que veio morar em Salvador ? — SALVADOR [ ]
    1-nasceu em Salvador;
    2-para conseguir emprego;
    3-porque familiares e amigos me chamaram;
    4-porque desejava morar em uma cidade grande;
    5-outro ______

49. Por que veio morar no bairro ? — BAIRRO [ ]
    1-porque não havia outro lugar para morar;
    2-foi o lugar mais barato que achou;
    3-fica perto do trabalho;
    4-porque existiam parentes no bairro;
    5-outro ______

50. Quanto ganha em média (NCz$)? — GANHA [| | | | |]
    por: — POR [ ]
    1-dia; 2-semana; 3-mês; 4-ano

51. Além do cabeça da família, quantas pessoas tem renda ?

no.	nome	valor (NCz$)	P
1	______	______	[ ]
2	______	______	[ ]
3	______	______	[ ]
4	______	______	[ ]
5	______	______	[ ]

Informar: No. de pessoas que tem renda — PRENDA [ ]
total mensal ______ — TRENDA [| | | | |]
p-periodicidade: 1-dia; 2-semana; 3-mês; 4-ano

52. *Quem da família tem previdência social ?* — PSOCIAL [ ]
    1-só o cabeça;
    2-cabeça e cônjugue;
    3-toda a família;
    4-outro ______
    5-ninguém

    Qual ? — TIPO [ ]
    1-INPS/INAMPS/IAPAS;
    2-IAPSEB;
    3-IPS;
    4-outro

53. Em caso de doença grave com seu filho, o que faz em primeiro lugar ?	GRAVE	
54. Quanto gasta com alimentação (NCz$) por: 1-dia; 2-semana; 3-mês; 4-outro ____	ALIMENTO TEMPO	
55. Você tem horta no seu terreno ? 1-sim; 2-não	HORTA	
56. Qual a religião predominante na família ? 1-católica; 2-protestante; 3-testemunha de jeová; 4-candomblé; 5-umbanda; 6-espírita 7-outra ____ 8-não tem	RELIGIÃO	