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Prevention and control of intestinal parasitic infections

Report of a WHO
Expert Committee

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WHO EXPERT COMMITTEE ON PREVENTION AND CONTROL OF
INTESTINAL PARASITIC INFECTIONS

Geneva, 3-7 March 1986

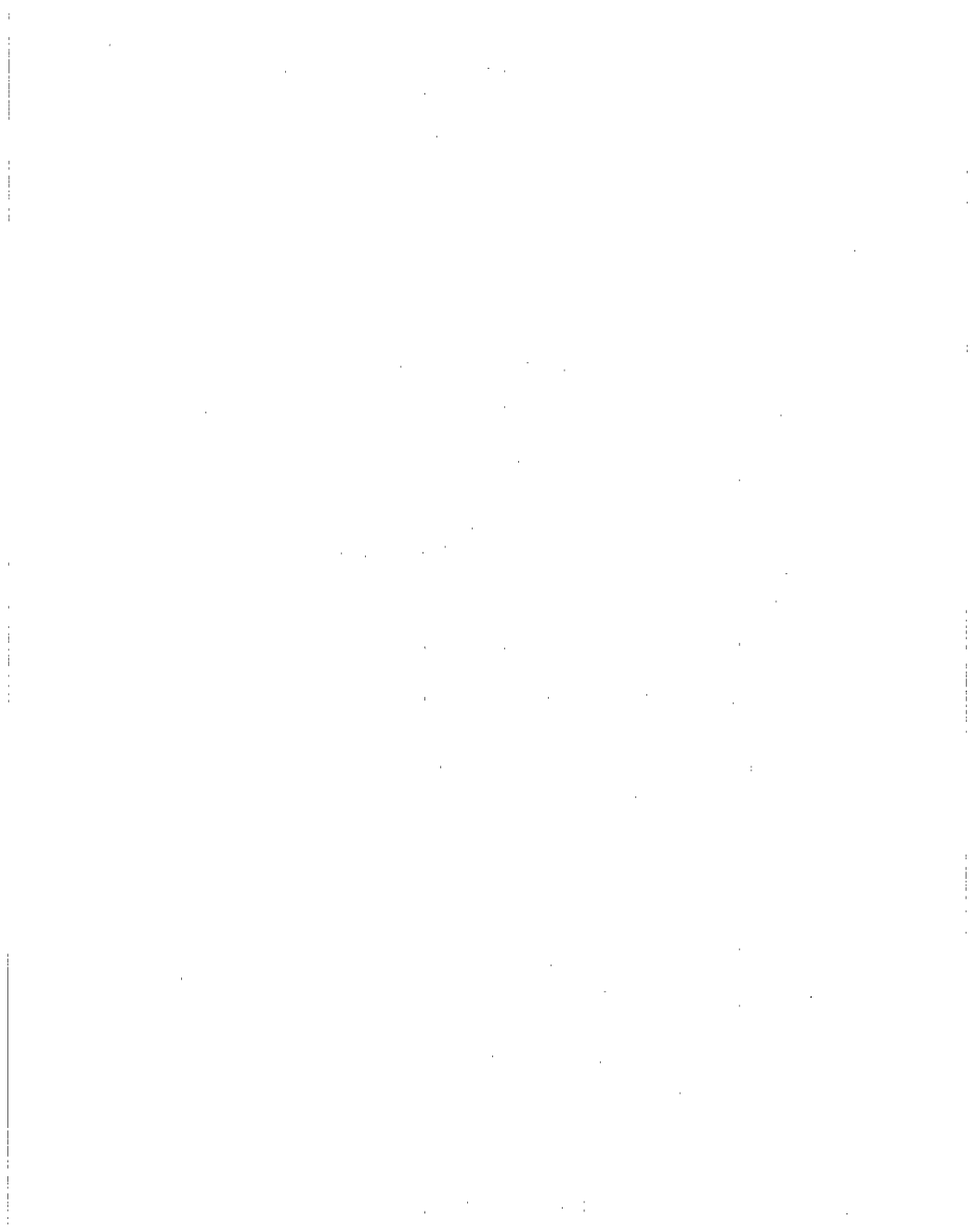
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PREVENTION AND CONTROL OF INTESTINAL PARASITIC INFECTIONS

Report of a WHO Expert Committee

A WHO Expert Committee on Prevention and Control of Intestinal Parasitic Infections met in Geneva from 3 to 7 March 1986. The meeting was opened by Dr A. Davis, Director, Parasitic Diseases Programme, on behalf of the Director-General.

1. INTRODUCTION

Intestinal parasitic infections are distributed virtually throughout the world, with high prevalence rates in many regions. Amoebiasis, ascariasis, hookworm infection, and trichuriasis are among the ten most common infections in the world (1). Although mortality from these infections is relatively low, complications are not uncommon and many cases need hospital care. In many countries, malabsorption, diarrhoea, blood loss, impaired work capacity, and reduced growth rate due to intestinal parasitic infections constitute important health and social problems. Furthermore, other parasitic infections such as abdominal angiostrongyliasis, intestinal capillariasis, and strongyloidiasis are of local or regional public health concern (1, 2).

The prevention and control of intestinal parasitic infections are now more feasible than ever before owing to the discovery of safe and efficacious drugs, the improvement and simplification of some diagnostic procedures, and advances in parasite population biology. In recent years, general health care strategies have emphasized preventive medicine and community cooperation in the control of endemic disease and have created a favourable climate for the design and implementation of control measures against intestinal parasitic infections (3, 4, 5).

In many countries, endemic intestinal parasitic infections are closely related to economic and social developmental processes and therefore their control may be a sensitive issue, both socially and politically. In others, the control of intestinal parasitic infections has proved a useful entry point for other primary health care activities, e.g., in family planning, child care, health education, and nutrition.

The present report includes some of the scientific information reviewed by the WHO Scientific Group on Intestinal Protozoan and Helminthic Infections in 1980 (2). However, in this report a special effort has been made to present practical information on the control of intestinal parasitic infections that can be readily used by those authorities wishing to take action against these major health problems. Thus, it is directed mainly towards the following five groups:

- those who are expected to endorse it and support it (UNICEF, WHO, and other international agencies);
- those who will implement its recommendations (national health authorities, staff of national health services);
- those responsible for the training of health workers (teaching staff of medical and nursing schools, university staff, trainers of community health workers);
- those who will develop its scientific base further (scientific community, funding agencies, pharmaceutical industry); and
- those who influence the opinion of the affected population at large (health educators, journalists, local leaders).

2. PUBLIC HEALTH SIGNIFICANCE OF INTESTINAL PARASITIC INFECTIONS

2.1 Methods of assessment

The amount of harm caused by intestinal parasitic infections to the health and welfare of individuals and communities depends on: (a) the parasite species; (b) the intensity and course of the infection; (c) the nature of the interactions between the parasite species and concurrent infections; (d) the nutritional and immunological status of the population; and (e) numerous socioeconomic factors. All the above factors may in turn be modulated by seasonal and climatic conditions. Thus, while it is generally extremely difficult to measure the suffering caused by infectious diseases, in the case of intestinal parasitic infections this is even more true because so many cases of the diseases are asymptomatic and therefore remain undetected.

The public health significance of intestinal parasitic disease would be best assessed if the available quantitative techniques could be adopted to evaluate morbidity (6). The willingness of societies to pay for the elimination or the control of disease might be readily

harnessed if government policy-makers and health planners could be given the chance to compare cost–benefit or cost–effectiveness analyses of the various courses of action with estimates of the predicted economic losses due to morbidity.

For a given intestinal parasitic infection quantitative information might be sought about years of potential life lost, number of healthy days lost, incidence rates of the disease, and prevalence and case fatality rates by using quantitative methods now being used for other diseases (e.g., cancer and cardiovascular diseases). However, great care should be taken in selecting the indicators for assessing the public health significance of intestinal parasitic infections because of regional variations in their importance. Although calculations of years of potential life lost are valuable in the measurement of the public health consequences of malignant and cardiovascular diseases, both of which are killing diseases, such data have but limited application in the assessment of the public health significance of intestinal parasitic diseases because they are usually characterized by low mortality (1, 6). However, in the case of intestinal parasitic diseases the cost to the health care system and services as well as to individuals and the community, in terms of lost nutrients and reduced productivity, can be easily estimated and measured.

The data required for this purpose can be obtained if efforts are made to collect accurate epidemiological, parasitological, and pathological data. Such data are essential for every aspect of prevention and control programmes—from policy decisions about implementation to the routine monitoring of progress. They also provide the basis for reviewing the public health significance of these diseases in terms of the advantages to communities of controlling intestinal parasitic infections.

Current experience suggests that intestinal parasite control programmes are appropriate and socially advantageous because people can (a) actually see the effects of primary health care interventions (in terms of expelled worms, etc.), and (b) start to learn some simple facts about health care (simple health education) by watching their village or community become healthier as a result of the control measures. Control programmes against intestinal parasitic infections also have public health significance because they serve to bring together different sectors of the primary health care services.

Attempts to measure the morbidity of individual intestinal parasitic infections must be continued in different regions and among different societies. The study of morbidity will be made easier

and results will become comparable if certain definitions of cases and levels of intensity of infection are agreed. A summary of recommended terms for cases of intestinal parasitic infections is presented in Table 1.

The difficulties in assessing the public health significance of intestinal parasitic diseases can be appreciated by understanding the debate about the magnitude of the role of ascariasis in the complex etiology of protein-energy malnutrition in children (7, 8). The investigation of this problem relies upon field research in communities where the prevalences of ascariasis and protein-energy malnutrition are high and where sufficient time is allowed for growth improvement to occur and be detected in some participants receiving anthelmintic treatment. The study design should rely on double-blind procedures using infected and uninfected subjects randomly allocated to either treatment or placebo groups. The use of a placebo should be approved by an independent ethical committee. The sample size for the study should be calculated in advance according to the level of significance sought when the results are analysed, and the statistical analysis must accommodate confounding variables including polyparasitism.

Secure evidence for the existence of a causal relationship between ascariasis and impaired growth will have been obtained when two statistically supported effects are detected (7). First, the severity of the aspect of ascariasis under study should be shown to increase with increasing intensity of infection. Secondly, in the infected group of subjects, morbidity should decrease after treatment or should not change after the use of the placebo. Conversely, there should be no demonstrable change in the subjects of the uninfected group in response to the administration of either drug or placebo.

Finally, it cannot be stressed too strongly that the use of the collective term "intestinal parasitic infections" is arbitrary and for convenience only. Even the seemingly closely related species have differences in their biology and in the form and severity of the disease they cause. Thus, each parasitic infection must be evaluated at the regional or local level according to its prevalence, the morbidity it causes, and its relative importance with regard to other health problems—an approach which should be borne in mind when considering tactics for prevention and control. Experience has shown that many of those infected with intestinal helminths remain asymptomatic, while a few become ill and even fewer die. It must be remembered, however, that intestinal helminthiases affect an

enormous number of people and a few in this context can be a million.

2.2 Helminthic infections

Intestinal helminths are so named because their life history includes a period of obligatory residence in the human alimentary tract or because they induce pathological changes in that site. Not surprisingly, nutritional impairment is often associated with chronic intestinal helminthiases, with those infected suffering from protein-energy malnutrition, iron-deficiency anaemia, and vitamin A deficiency. Although malnutrition is now recognized as having many causes, closely related to socioeconomic factors, available evidence indicates that several of the intestinal helminthiases contribute to the generation and persistence of malnutrition in developing countries.

Estimates of the global prevalence of the intestinal nematode infections transmitted through soil are as follows: 1000 million cases for *Ascaris lumbricoides*; 900 million for hookworms (*Ancylostoma duodenale* and *Necator americanus*); and 500 million for *Trichuris trichiura* (1).¹ It should be noted, however, that, since many people are likely to be infected by more than one species concurrently, the total prevalence of all nematode infections may be lower than the sum of the above figures. Another perspective of the high prevalences of these infections can be gained by noting that an average prevalence figure for *A. lumbricoides* infection for the population of Africa, extracted from some 300 published studies during roughly the last decade, is 32%, with children (≤ 17 years old) showing a higher prevalence rate than adults (≥ 18 years old). These figures do not take into account such factors as climate and population density. Some countries have overall average prevalences ranging from 16 to 48%, and within a country the prevalence rate may range from 0 to over 70%.

In Brazil, the laboratories of the Ministry of Health carried out 2.5 million examinations of stool samples and found the prevalence of *A. lumbricoides* to be 59.5%; the prevalence rates in the different

¹ These estimates of the global prevalences of intestinal parasitic infections have been made on the basis of meagre data. The purpose of presenting these tentative figures is to draw attention to the probable scale of parasitic infections in relation to other diseases.

Table 1. A summary of terms used to describe cases of intestinal parasitic infections, their definitions, and suitable diagnostic methods

Term	Definition	Diagnosis ^a	International Classification of Diseases code no.
Ascariasis	Any infection by <i>Ascaris</i>	Faecal examination Expulsion of worms	127.0
Light ascariasis ^b	Infection with less than 5000 EPG ^c	Egg count	
Heavy ascariasis	Infection with over 50 000 EPG ^c	Egg count	
Fatal ascariasis	Death attributed directly to <i>Ascaris</i> (intestinal obstruction, biliary ascariasis, etc.)	Hospital records Postmortem examination records	(560.9) (576.2)
Ancylostomiasis	Any infection with <i>Ancylostoma duodenale</i> ; if <i>A. ceylanicum</i> involved <i>A. ceylanicum</i> infection is the preferred term	Examination of expelled adult worms or of cultured 3rd-stage larvae	126.0
Necatoriasis	Any infection with <i>Necator americanus</i>	As above	126.1
Hookworm infection	Any infection with <i>Ancylostoma</i> or <i>Necator</i> (species not specified)	Faecal examination	126.9
Mixed hookworm infections	Any infection caused by more than one hookworm species	Examination (at least in subsamples) of expelled adult worms or of cultured 3rd-stage larvae	
Hookworm anaemia	Iron-deficiency anaemia in heavily infected individuals	Signs of anaemia, measurement of haemoglobin level, egg count	(280)
Heavy hookworm infections	Hookworm infection intensive enough to cause anaemia (critical worm load differs locally depending on age, sex, iron intake, and species of hookworm)	Egg count plus haemoglobin level	
Trichuriasis	Any infection with <i>Trichuris</i>	Faecal examination	127.3
Light trichuriasis	Infection with 1000 EPG or less ^c	Egg count	
Heavy trichuriasis	Infection with over 10 000 EPG ^c	Demonstration of <i>Trichuris</i> by proctoscopy	
Strongyloidiasis	Any infection caused by <i>Strongyloides stercoralis</i> ; if other species are involved: <i>S. fuelleborni</i> infection or " <i>S. cf. fuelleborni</i> " infection are preferred terms	Faecal examination (special techniques) Duodenal content examination Faecal examination As above	127.2
Disseminated strongyloidiasis	Any infection with <i>S. stercoralis</i> with involvement of other organs (lungs, central nervous system)	As above, plus clinical examination	

Heavy strongyloidiasis	Any infection with <i>S. stercoralis</i> , usually symptomatic and easily diagnosed, occurring mainly in immunosuppressed patients	Faecal examination (not necessarily by concentration or special techniques) Examination of duodenal contents and demonstration of a high number of larvae	127.8
Mixed intestinal helminthiasis (nematodiasis)	Any infection caused by more than one common species of nematode worms (<i>Ascaris</i> , <i>Trichuris</i> , <i>Ancylostoma</i> or <i>Necator</i> , <i>Strongyloides</i>)	Faecal examination	127.8
<i>Taenia solium</i> taeniasis	Any infection with <i>T. solium</i> tapeworm	Examination of scolex or proglottid	123.0
<i>T. solium</i> cysticercosis	Any infection with larval form of <i>T. solium</i>	Clinical examination	123.1
<i>T. saginata</i> taeniasis	Any infection with <i>T. saginata</i> tapeworm	Examination of scolex or proglottid	123.2
Taeniasis	Any infection with unspecified <i>Taenia</i>	Faecal and/or anal swab examination	123.3
Giardiasis	Any infection with <i>Giardia intestinalis</i> (asymptomatic or symptomatic)	Faecal examination Duodenal content examination	007.1
Symptomatic giardiasis	Infection with <i>G. intestinalis</i> with symptoms such as diarrhoea, abdominal pain, or discomfort which disappear after specific treatment	As above plus clinical examinations before and after treatment	
Amoebiasis	Any infection of the large intestine with <i>Entamoeba histolytica</i> (for other species the preferred terms are, e.g., <i>E. hartmanni</i> infections)	Faecal examination (it is necessary to show that infection is not due to <i>E. hartmanni</i> , <i>E. coli</i> , or other amoebae)	006
Asymptomatic carrier/ Luminal amoebiasis (acceptable alternative term)	Any infection of the large intestine with <i>E. histolytica</i> without symptoms or signs; "cyst passer" is not a correct term	Faecal antigen examination	
Invasive amoebiasis	Any tissue infection with <i>E. histolytica</i> (intestinal or extraintestinal)	Faecal examination Clinical examination Serological tests and negative rectosigmoidoscopy examination Faecal antigen examination positive	
Amoebic dysentery	Dysentery (diarrhoea with blood, mucus, and tenesmus) caused by pathogenic <i>E. histolytica</i>	Faecal and clinical examination Serological examination (demonstration of specific antibodies)	006.0
Amoebic abscess	Focal necrosis of liver caused by pathogenic <i>E. histolytica</i>	Erythrophagous <i>E. histolytica</i> trophozoites in fresh stool; clinical examination	006.3
		Clinical examination; serological examination (demonstration of specific antibodies)	

*Methods most suitable for public health purposes are given in bold type.

^b A proportion of light infections can also be expressed as the U-rate, i.e., the percentage of *Ascaris*-positive faecal examinations in which only unfertilized *Ascaris* eggs were found.

^c Definition is arbitrary; EPG = eggs per gram of stool.

states of Brazil 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%. In another extensive survey, of 25 000 children and adults in Malaysia (from birth to over 60 years of age), the overall prevalence of intestinal parasitic infections was found to be 39.6%, with as much as 89% in a subsample of children between the ages of 6 and 12 years.

There are other helminth infections associated with the intestinal tract that are less widespread in man than the intestinal nematodes transmitted through soil, but which must be mentioned because they already do or may have local or regional public health significance. These include infections caused by *Hymenolepis nana*, *Taenia saginata*, *T. solium*, *Fasciolopsis buski*, *Angiostrongylus costaricensis*, and *Capillaria philippinensis* (1, 9).

2.2.1 Ascariasis

Ascaris lumbricoides occurs throughout the world. It is transmitted through the ingestion of infective eggs from contaminated food, hands or water (7, 9, 10). An adult female worm living inside an infected person produces on average about 240 000 eggs per day for about a year, which are passed in the faeces. The eggs develop in the soil within 2–3 weeks, given optimal temperatures, presence of oxygen, and moisture. On being swallowed, each egg develops into a larval worm in the small intestine. The larvae migrate through the body via the hepatic portal system to the liver and lungs where they develop further for 1–2 weeks. Then, they return to the small intestine and attain sexual maturity. The release of eggs by the female worms begins about 2 months after ingestion of infective eggs. Adult worms are large, with the male worms measuring up to 20 cm and females up to 45 cm in length. *A. lumbricoides* is highly specific for man and the infection does not produce a strong protective immunity. For its survival the parasite depends greatly on a high reservoir of infective eggs in an environment and thrives in areas where there is a lack of sanitation, particularly where people defecate indiscriminately around human settlements and where human excrement (night-soil) is used as a fertilizer in agriculture. The eggs are able to survive in adverse environmental conditions (owing to their protective shell), and this further helps the parasite to persist.

Several types of complication are associated with ascariasis. Intestinal obstruction may be produced by a bolus of worms, or adult worms may migrate from the small intestine into the bile and pancreatic ducts, respiratory passages, and peritoneum. These conditions may cause medical or surgical emergencies. *Ascaris* pneumonitis due to larval migration is probably quite common although it is rarely detected clinically. *A. lumbricoides* releases powerful allergens which may induce hypersensitivity (7).

Statistics for hospital admissions due to ascariasis are scarce, but recent data from Burma show that 1185 of the 2057 patients admitted to the surgical wards of the Rangoon Children's Hospital with acute abdominal problems during 1981–1983 were, in fact, suffering from ascariasis (7). A series of investigations is needed to estimate the mortality rate associated with ascariasis in areas where the prevalence is known to be high.

Chronic ascariasis is the most common form of *Ascaris* infection since people tend to be reinfected repeatedly for much of their lives. Preschoolchildren are the group at greatest risk to actual or potential deleterious effects. Controlled experiments with pigs infected with *A. suum* have shown that the infection causes a significant reduction in food intake and rate of body weight gain, with impaired nitrogen balance and fat absorption and some degree of malabsorption including lactose intolerance. These unequivocal findings, which are not seen in pigs kept free from the intestinal stages of *A. suum*, suggest that the nutritional status of children may be adversely affected during ascariasis, particularly if their food intake is marginal in quantity or quality.

Some clinical studies with small numbers of children have shown increased losses of nitrogen in faeces, decreased absorption of fat and nitrogen, malabsorption and accompanying villous atrophy, and impaired absorption of vitamin A; however, certain other similar studies have shown no such effects. Recent larger-scale studies in Panama have demonstrated lactose maldigestion or intolerance during ascariasis in preschoolchildren and have detected a decreased intestinal transit time. Some epidemiological data from Panama indicate that the presence of the intestinal stages of the parasite can explain why *Ascaris*-infected children have significantly lower plasma vitamin A concentrations than similar uninfected children.

Community studies of children in their normal home environments, carried out with minimum interference from the

observers, have shown that differing degrees of growth retardation (as assessed by standard anthropometric methods) can occur during ascariasis. On the other hand, chemotherapeutic expulsion of *A. lumbricoides* is accompanied by small, but significant improvements in the rate of weight gain, as has been shown in: Deoria district, Uthar Pradesh, India; Lushoto, Tanzania; Machakos district, Kenya; Bali, Indonesia; and Kuala Lumpur, Malaysia. In Bali, the improvement in the rate of weight gain was most marked in under-nourished children (7). Findings of several other studies fit this pattern, although because of confounding variables such as intestinal polyparasitism, it is often difficult to attribute malnutrition in cases of parasitic infections to ascariasis alone. Not every investigation has found an improvement in the growth rate following treatment for ascariasis (8), but this is not surprising since communities vary in cultural practices, economic and nutritional status, availability of health care, climate, and other factors. Furthermore, *A. lumbricoides* may vary in pathogenicity in different regions of the world.

In September 1984, a conference on Ascariasis and its Public Health Significance was held in Banff, Canada. The delegates reviewed present knowledge concerning the relationship between *A. lumbricoides* infection and childhood malnutrition and concluded that ascariasis contributed to poor nutritional status in children. The conference stressed that the extent of the contribution could not be fully determined at present and that further studies were needed to assess it more fully and to determine its public health significance (7, 11).

2.2.2 Hookworm infections

The adult stages of the blood-sucking nematodes *Ancylostoma duodenale* and *Necator americanus* are found attached to the mucosa of the small intestine, particularly of the jejunum, in many people living in tropical and subtropical countries (9). These intestinal parasites are known as hookworms and their pathogenicity is closely related to their mode of feeding. They may occur as single or mixed infections in the same person. There is no direct evidence that man develops protective immunity to hookworm infection, but epidemiological studies predict that some degree of immunity probably develops with time.

The hookworm life cycle is direct and begins with the eggs being released by the female worms into the lumen of the small intestine and being passed in the faeces. The embryos within the eggs develop rapidly, given moisture, warmth, and oxygen, and skin-penetrating, third-stage infective larvae are formed within 5–10 days after the deposition of the eggs. Infection occurs when the larvae enter the body through the skin, most commonly through the feet. Larvae of *A. duodenale* are also infective by mouth.

In an endemic area, contaminated soil may continually or seasonally bear large numbers of infective larvae, which are found at the surface of the ground when the soil is damp. 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. The skin-penetrating larvae probably do not survive for more than a month under tropical conditions, but adult *A. duodenale* and *N. americanus* are believed to be capable of surviving for on average about 1 and 4 years, respectively. In light infection *N. americanus* may live for up to 15 years. Following infection, the prepatent period for *N. americanus* is 7 weeks, while that for *A. duodenale* is unpredictable, ranging from 5 weeks to 9 months; reasons for this extreme variation are not fully understood, but arrested development of the larvae in the tissue is a possibility.

Hookworm infection causes chronic blood loss and depletion of the body's iron stores, leading to iron-deficiency anaemia. The blood haemoglobin concentration below which anaemia is considered to be present varies with age, sex (and whether a woman is pregnant), and altitude. Moreover, the blood haemoglobin concentration gives no indication of the state of the body's iron stores, which may be seriously depleted before anaemia becomes apparent.

The body's iron stores are maintained by the daily absorption of iron from the small intestine. The availability of dietary iron for absorption depends on the quantity and type of iron in the food (vegetable or animal sources), the ratio of vegetable to animal iron, dietary factors that promote or inhibit iron absorption, the absorptive capacity of the intestinal mucosa, and the body's iron reserves. The most serious cause of iron loss from the body is chronic haemorrhage; estimates show that a blood loss of 15–20 ml per day into the lumen of the small intestine will produce a state of negative iron balance. This is because the normal absorption of iron from the diet and reabsorption of some of the iron lost from intestinal

bleeding together do not result in absorption of enough iron to make up the loss of iron in 15–20 ml of blood. Thus, the body is forced to use up its iron stores (about 1 g) to maintain the blood haemoglobin concentration. *Ancylostoma duodenale* and *N. americanus* have been estimated to cause a daily loss into the small intestine of 0.14–0.26 ml and 0.02–0.07 ml per worm, respectively. When several hundred hookworms are present in the small intestine, the daily blood loss is sufficient to cause anaemia, even in well-nourished children or adults.

Hookworm infection 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 (1). Anaemia is always associated with a diminished capacity for sustained hard work and exercise. Hookworm infection also causes a loss of blood plasma into the small intestine, which can lead to hypoalbuminaemia in some subjects. It has been suggested that a sudden loss of plasma albumin due to hookworm might be enough to precipitate an episode of kwashiorkor in a susceptible malnourished child. A severe impairment of the nitrogen balance in heavily infected hookworm patients has been detected, but it is not clear whether the imbalance results from some degree of malabsorption or from enteropathy leading to protein loss. Reduced food intake has been reported in anaemic hookworm patients, and a survey in Papua New Guinea revealed an association between the intensity of hookworm infection and poor nutritional status. The contribution of hookworm infection to malnutrition is in general not as well established as its role in iron-deficiency anaemia.

2.2.3 Trichuriasis

Considering its worldwide distribution and high prevalence, trichuriasis has been neglected more than most of the other intestinal parasitic diseases (1). The nematode *Trichuris trichiura* has a simple life cycle, with eggs serving as the infective stage. The adult worms survive for as long as 5 years, firmly attached to the epithelial lining of the large intestine, with the caecum being the most commonly affected region. Each female worm has been estimated to produce from about 2000 to 14 000 eggs per day and these leave the host in

the stools and contaminate the human environment, as do the eggs of *A. lumbricoides* and the hookworms. Under suitable conditions, infective larvae develop inside the eggs in about 3 weeks and some may retain their viability for months. About 70–90 days after infective eggs are swallowed, the host begins to pass *T. trichiura* eggs, indicating that adult worms are present in the large intestine.

The morbidity associated with trichuriasis is due to the worms' unique mode of attachment to the wall of the large intestine. Each worm is about 50 mm long and has a thin anterior part with which it burrows into the intestinal wall where it feeds on the intestinal tissues. 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. *T. trichiura* is likely to cause anaemia less frequently than do hookworms; when anaemia does occur, it is due to the ulceration of the intestine resulting from a very heavy worm burden (10).

2.2.4 *Strongyloidiasis*

Strongyloidiasis occurs in various forms, depending on the species (*Strongyloides stercoralis* or *Strongyloides fuelleborni*), geographical location, and age of the host (1, 9). *Strongyloides stercoralis* is widely distributed in the tropics and subtropics in areas of poor sanitation. Infection occurs when third-stage larvae, which have developed in soil contaminated by human defecation, penetrate the skin. The larvae migrate first through the tissues and then via the lungs to gain access to the small intestine where parthenogenetic adult females develop and live in the epithelium of the jejunal mucosa. The females penetrate deep into the mucosal glands and begin to release eggs from which larvae emerge while still in the intestine. Larvae reach the external environment in the stools and some develop into infective, skin-penetrating, third-stage larvae, while some others grow into free-living adult male and female worms.

Sometimes, the larvae become infective before they are passed out. This leads to auto-infection, and explains how some people have remained infected with *S. stercoralis* for more than 30 years after leaving an endemic area.

Strongyloides fuelleborni occurs in tropical Africa and parts of Asia and a form of this species, or a very close relative, identified for the present as "*S. cf fuelleborni*", is found in Papua New Guinea. One biological difference between the life cycles of *S. fuelleborni* and *S. stercoralis* is that in the former, eggs rather than larvae are passed in the stools of the host. Experience of health workers in endemic areas is that infections with *Strongyloides* spp. are not easily diagnosed.

Strongyloidiasis occurs in several forms: (a) an acute, usually symptomatic *S. stercoralis* infection; (b) a chronic infection, usually in adults who have been away from an endemic area for some time; (c) an overwhelming or disseminated form of *S. stercoralis* infection (now recognized as a danger to immunocompromised patients); and (d) the swollen belly (or baby) syndrome due to "*S. cf fuelleborni*" in infants in Papua New Guinea. In the chronic form of strongyloidiasis, symptoms of hypersensitivity, such as urticaria, coughing and eosinophilia, may develop, presumably in response to the production and migration of new larvae.

Clinical studies and case histories of adults with strongyloidiasis due to *S. stercoralis* show that concomitant diarrhoea, weight loss, malabsorption, and associated lesions in the mucosa of the small intestine may occur (9). This pattern of the disease has been described frequently in members of armed forces who have served in an endemic area but have developed symptoms years after leaving that area. Many infected people appear to be asymptomatic, but if their immune status is compromised, each is potentially at risk of developing disseminated strongyloidiasis in which the larvae of *S. stercoralis* massively invade the tissues and organs (particularly the lungs), usually with fatal results. Thus, in endemic areas, patients who are to receive immunosuppressive therapy should be screened beforehand for the presence of *Strongyloides* infections. Much more work is needed at the community level to determine the public health significance not only of *S. stercoralis* but also of *S. fuelleborni*, about which little is known.

"*Strongyloides cf fuelleborni*" is now known to cause a serious and life-threatening disease called swollen belly (or baby) syndrome in infants in Papua New Guinea. The symptoms of this disease include diarrhoea and oedema, the latter perhaps developing as a result of a decline in plasma albumin owing to the effect of an enteropathy causing protein loss. It has been suggested that infants may acquire the parasite from their mothers during breast-feeding.

2.2.5 Other nematode infections

Angiostrongylus costaricensis, *Anisakis marina*, *Capillaria philippinensis*, *Enterobius vermicularis*, and *Trichinella spiralis* are species of nematodes that become established in the human gastrointestinal tract in different ways and are often associated with localized but nevertheless acute and sometimes life-threatening diseases (1, 9).

Angiostrongyliasis. *Angiostrongylus costaricensis* has an indirect life cycle and people acquire the infection by ingesting infective third-stage larvae contained in either the tissues or extruded mucus of the intermediate host, which is usually a slug. The infection is a zoonosis and the cotton rat (*Sigmodon hispidus*) and other rodents are the natural definitive hosts in Latin American countries.

After ingestion, the infective larvae develop into adult worms, which remain mainly in the ileo-caeco-colic branches of the anterior mesenteric artery. In man, as in cotton rats, the adult worms release eggs, many of which become trapped in the alimentary tract tissues causing inflammatory reactions and granuloma formation. Thrombosis and necrosis may result from the presence of adult worms in the blood vessels. Abdominal palpation may indicate the presence of a tumour-like mass. The liver and testicles may also be invaded. Until recently, the diagnosis of abdominal angiostrongyliasis was difficult and many cases may have been overlooked. In many cases, owing to the difficulties in diagnosis and often late detection of abdominal angiostrongyliasis, the disease had to be treated by extensive surgery. Thus, more research is needed to develop a simple and accurate diagnostic test so that the prevalence and distribution of this disease can be determined and monitored, and medical rather than surgical treatment used.

Anisakiasis. Occasionally, outbreaks of anisakiasis have occurred in countries where partially cooked or pickled marine fish form a substantial part of the diet. The life cycle of *Anisakis marina* is indirect and complex, with fish serving as the intermediate hosts, and predatory whales, dolphins, and sometimes seals forming the natural definitive hosts. Infection occurs when a person swallows the live infective larvae of *A. marina*, or of other closely related species. Following ingestion, the larvae penetrate into the walls of the stomach or of the small intestine, and inflammation, oedema, and tumour-like granulomas develop. Later in the course of the disease, intestinal obstruction or perforation and peritonitis, may occur, for

which surgical treatment is necessary. Anisakiasis is common in Japan.

Capillariasis. This intestinal disease, caused by *Capillaria philippinensis*, was characterized as a result of an outbreak in the Philippines in which there were about 1400 cases and more than 100 deaths. The disease occurred mainly in adults, with males appearing to be more susceptible than females.

The life cycle of *C. philippinensis* in man is still not fully understood, but it is indirect and involves a freshwater fish as the intermediate host. Eggs passed in human stools later develop into infective larvae; these become established in fish which, if eaten raw or undercooked, can pass the parasite to man. The adult worms are small and lodge in the jejunal mucosa, where a self-perpetuating, auto-infection process occurs, sometimes causing a massive worm burden to build up.

The disease causes diarrhoea, malabsorption, weight loss, enteropathy with protein loss, weakness and, in some cases, a gradual progression to death. Many cases of *C. philippinensis* infection appear to be asymptomatic, but the history of the disease shows it to have a potentially high mortality rate.

Enterobiasis. *Enterobius vermicularis* is a small nematode with a direct life cycle that normally involves only the alimentary tract; it has a high degree of specificity for man. The adult worms live in the large intestine and the mature female worms crawl out of the anus, usually at night, and deposit or burst to release sticky eggs in the peri-anal region. An infective larvae develops in each egg about 4 hours after deposition and when these are swallowed the cycle is completed.

Children throughout the world appear to be most susceptible to *E. vermicularis*. However, the disease is probably more common in the temperate regions and developed countries than in the tropics and subtropics. *E. vermicularis* is the only parasitic worm commonly encountered in developed countries. To become infected with it still carries a sense of shame and some degree of social stigma in the more affluent and sophisticated societies. The prevalence of enterobiasis may be underestimated because population surveys to detect it are uncommon, especially in developing countries.

The commonest symptoms of enterobiasis are anal pruritus accompanied by scratching which can lead to eczematous dermatitis, bleeding, and secondary bacterial infections. In some children, restlessness and insomnia are associated with enterobiasis, and these

may interfere with performance at school and learning ability. *E. vermicularis* may cause appendicitis if the worms become localized in the appendix. Invasion of the female reproductive tract by migrating worms is not uncommon.

Trichinellosis. *Trichinella spiralis* infection is a zoonosis of worldwide occurrence. It is acquired by ingesting inadequately cooked meat, especially pork. Upon entry into the body, the encysted larvae in the meat become activated and develop into adult worms which live in the epithelium of the mucosa of the small intestine. Full details of the biology of *T. spiralis* and the health hazards of trichinellosis are available in guidelines prepared by WHO (12). The parasite is mentioned here because diarrhoea, constipation, and abdominal pain have been observed to coincide with intestinal invasion by adult worms.

2.2.6 *Taeniasis*

In man, the adult *Taenia saginata* and *Taenia solium* live in the small intestine. These infections are acquired through the ingestion of infective cysticerci in undercooked beef (*T. saginata*) or pork (*T. solium*). The adults of both species of tapeworm are large and produce a variety of gastrointestinal symptoms. The most serious form of *T. solium* infection is a condition called cysticercosis (13) in which cysticerci develop in the human body. *Taenia saginata* infection seldom causes clinical problems, but in routine diagnostic procedures, it may easily be confused with the much more serious *T. solium* infection.

Taenia solium infection is endemic in many countries of Latin America, Africa, and Asia as well as in some parts of Europe and the USSR. When a person ingests infective eggs of *T. solium*, the larval stages leave the intestine via the hepatic portal system and are dispersed throughout the body where some develop to form cysticerci. Cysticerci that develop in the central nervous system (neurocysticercosis) represent a serious threat to the individual and even to the community if this condition is prevalent. For this reason, intestinal taeniasis in man cannot be ignored (13).¹

¹ *Guidelines for surveillance, prevention and control of taeniasis cysticercosis.* Unpublished WHO document, No. VPH/83.49, 1983. A limited number of copies of this document are available on request from Veterinary Public Health, World Health Organization, 1211 Geneva 27, Switzerland.

2.2.7 *Hymenolepiasis*

The adult *Hymenolepis nana* attains a length of about 40 mm and lives attached to the mucosa of the small intestine. This tapeworm has a wide distribution and is found commonly in children in the arid countries of the tropics and subtropics, mostly in Asia. The life cycle is direct and involves an internal auto-infection process. Person-to-person transmission may also occur, which may cause epidemics; indirect transmission is also possible, in which the infective cysticercoid stages are acquired by swallowing flour beetles. During auto-infection, the eggs discharged by the adult tapeworm hatch in the intestine to release larvae which penetrate the villi and develop there to form cysticercoid stages. The cysticercoids are liberated from the villi and, after activation, develop into adult tapeworms. Thus, the parasite population can increase within the body without the need for transmission across an unfavourable environment (9).

Intensive *H. nana* infection may be found in undernourished or immunocompromised children. The cysticercoid stages damage the intestinal mucosa, which might explain the observation that infected persons show signs of protein loss. Diarrhoea, abdominal pain, weakness, and weight loss have been associated with hymenolepiasis.

2.2.8 *Intestinal trematode infections*

Schistosomiasis, clonorchiasis, and opisthorchiasis are not dealt with in this report. Current knowledge on schistosomiasis was reviewed recently by a WHO Expert Committee (14) and a similar review of clonorchiasis and opisthorchiasis is planned.

The other trematode infections that present a health hazard to man include *Fasciolopsis buski*, *Heterophyes heterophyes*, and *Metagonimus yokogawai*. These are almost exclusively found in people living in South-East Asia. The life cycles of the parasites are indirect and generally similar, with man becoming infected on swallowing encysted metacercariae. The metacercariae, which develop after the parasites have undergone a phase of asexual multiplication in the tissues of snails, are found encysted on aquatic vegetation or on or in freshwater fish, crustaceans, and molluscs. All these vehicles for the transmission of trematode metacercariae are important food items for many people.

Fasciolopsiasis, caused by the adult stages of *F. buski* in the small intestine, is considered to be an important disease for man. The infection is both endemic and zoonotic and is prevalent where people

raise pigs and grow edible water plants. The adult flukes become attached to the intestinal mucosa, and heavy infections cause inflammation, ulceration, haemorrhage, persistent diarrhoea, nausea, vomiting, and abdominal pain. Malabsorption and an enteropathy causing protein loss have also been suspected.

2.3 Protozoan infections

Infections of the human intestinal tract with the pathogenic protozoa *Entamoeba histolytica*, *Giardia intestinalis*, and *Cryptosporidium* spp. are a common cause of diarrhoea and have a worldwide distribution (15, 16). The complications of invasive amoebiasis are potentially fatal and giardiasis may cause malabsorption in children.

In view of the high prevalence of protozoan intestinal infections and the morbidity they cause, measures aimed at their prevention and control should be strengthened. Although adequate treatment for amoebiasis and giardiasis is available, the diagnosis of these infections presents difficulties, particularly in epidemiological surveys, because the microscopical techniques used require highly skilled personnel seldom available where these infections are most prevalent.

2.3.1 Amoebiasis

Invasive amoebiasis is a major health and social problem in western and south-eastern Africa, South-East Asia, China, and Latin America, especially in Mexico. Inadequate sanitary conditions in these regions and the presence of highly virulent strains of *Entamoeba histolytica* may combine to sustain a high incidence of both intestinal amoebiasis and amoebic liver abscess. At present, on a global scale this infection represents one of the most common causes of death from parasitic intestinal diseases. It has been estimated (1) that, in 1981, probably 480 million people carried *E. histolytica* in their intestinal tracts and 36 million developed invasive forms of amoebiasis. A thorough review of the literature revealed that at least 40 000 died as a consequence of this infection; fatal amoebiasis is mainly due to fulminating colitis or liver abscess. The mortality from fulminating colitis is almost 70%, and that from liver abscess is up to 10%. Amoebic dysentery and amoebic appendicitis have a fatality rate of 0.5–27%, if not diagnosed properly and

treated early. For full recovery, patients with amoebic colitis, amoeboma, and amoebic abscess usually require a few weeks of hospitalization and 2–3 months of convalescence (16).

In many regions, amoebiasis is an important cause of diarrhoea and dysentery. In Mexico City, up to 15% of cases of acute diarrhoea and dysentery in children requiring hospitalization were found to be associated with *E. histolytica*. Amoebiasis may be more severe during pregnancy and lactation, and in persons with immunodeficiency; homosexuals, immigrants from certain tropical countries, and travellers are also specially liable to infection. Urban migration, the deterioration of the economies of certain developing countries, and the increasing size of urban slums with crowded, unhygienic conditions may accelerate the spread of amoebiasis and so result in even greater morbidity and mortality from this infection in the future.

2.3.2 Giardiasis

Giardia intestinalis (*G. lamblia*) infection is endemic throughout the world and epidemics of it occur sporadically. Reported prevalence rates range from less than 1% to more than 50%, depending on the geographic location of the population and the prevailing type of *Giardia* transmission (i.e., indirectly through faecally contaminated hands, water, or food or even by the direct faecal–oral route). It has been estimated (1) that about 200 million infections occur per year in Africa, Asia, and Latin America (see footnote on page 11). Surveys of giardiasis may give underestimates of prevalence or misleading results because the irregular release of cysts (the detection of which in stool is the basic test for giardiasis) may result in their not being detected when only one stool sample is examined.

In the United States of America and the United Kingdom, giardiasis is the most commonly reported intestinal parasitic infection of man. In 1983, in the USA, *Giardia* was identified as the cause of 68% of waterborne outbreaks of diarrhoea in which an etiologic agent was known. In 1984, more than 250 000 people in Pennsylvania were advised to boil drinking-water because the routine chlorination process was not effective against *Giardia* contamination. In temperate climates, giardiasis can be heavy and persistent in people with some form of immunodeficiency; in some areas even drug resistance has been suspected.

Various factors influence rates of morbidity due to *G. intestinalis* infections: primary versus secondary exposure, age, concurrent infections, nutritional and immunological status, the infecting dose of *Giardia* and, possibly, differences in *Giardia* strains. Although a substantial proportion of infections may pass unnoticed, probably about 500 000 people suffer from symptomatic giardiasis every year (see footnote page 11). Giardiasis is one of the common causes of acute or persisting diarrhoea in children in developing countries. There is some evidence from population studies that giardiasis interferes with intestinal absorption of nutrients and the growth rate of children.

2.3.3 *Cryptosporidiosis*

Since the first case of human cryptosporidiosis was reported in 1976, this infection has been frequently diagnosed in patients with the acquired immune deficiency syndrome (AIDS). In AIDS victims it causes profuse watery diarrhoea, and is considered a serious complication. In patients with normal immune function, diarrhoea associated with cryptosporidiosis may be acute, but is usually self-limiting. There are sporadic reports of *Cryptosporidium* spp. infection among the general population and particularly in those suffering from diarrhoea. In the latter group, it has been identified in 4.3% of Costa Rican children and in 10.8% of Venezuelan children. In the United Kingdom, *Cryptosporidium* spp. were the second most common enteric pathogens identified. Outbreaks of cryptosporidiosis in tourist groups and children's institutions have already been reported. It will probably take another decade or so to understand better the public health importance of this infection.

2.3.4 *Other protozoan intestinal infections*

Other protozoan intestinal infections either have a restricted geographical distribution (for example, balantidiasis, *Isospora belli* infections) or are widely distributed, but seldom pathogenic (for example, *Sarcocystis* spp., *Dientamoeba fragilis*, *Trichomonas hominis* infections) (9).

Balantidiasis occurs in populations that live in close contact with infected pigs. Waterborne epidemics of balantidiasis in man have been reported. Many human infections are self-limiting and asymptomatic but, in some cases, balantidiasis may cause an

ulcerative colitis and even a fulminating dysentery with intestinal perforation and haemorrhage.

Isospora belli infections occur in the subtropical and tropical regions and the prevalence is usually low. The clinical picture varies from asymptomatic infection to persistent severe diarrhoea with a malabsorption syndrome.

3. THE COSTS OF NOT HAVING A CONTROL PROGRAMME

Until recently, information was generally lacking about the economic and social impact of intestinal parasitic infections. The results of several new studies, brought together at a meeting in Beers, Netherlands, 1983, on the economic aspects of parasitic diseases (6) indicate that intestinal parasites, including *Ascaris* and hookworm, exert a significant and harmful effect on various aspects of the economy and quality of life of a community.

There are three major areas in which the lack of a control programme causes significant losses. These are: (a) nutrition, growth, and development; (b) work and productivity; and (c) medical care costs.

3.1 Nutrition, growth, and development

The impact of intestinal parasitic infections on nutrition, growth, and development has remained a controversial issue mainly because of shortcomings in the design and conduct of research in this area. A protocol for field studies has been elaborated by WHO and some interesting work has been done in the last decade. Evidence is accumulating from community studies that ascariasis is associated with reduced weight for age, impaired lactose digestion and decreased food consumption, lower plasma vitamin A levels, and short intestinal transit time (7). The role of hookworm infection in iron deficiency and anaemia has been confirmed by several recent studies. There are also indications from field studies in Costa Rica and Guatemala that giardiasis can interfere with linear growth and weight gain and can even cause weight loss. However, the interpretation of these studies is difficult because of the various other factors involved.

There are no reports on the impact of amoebiasis, trichuriasis, strongyloidiasis, and taeniasis on children's nutritional status and

development. Although one might expect infection with some of the intestinal parasites during pregnancy to have a negative effect on birth weight, there have been as yet no reports of such an effect.

On the basis of investigations in Kenya during the late 1970s, it was estimated that the cost to the nation of ascariasis infections in terms of wasted nutrients was approximately US\$4.4 million annually; the national prevalence for ascariasis at that time was about 25% and the mean intensity of infection about 7 worms (6, 17).

Attempts have been made to investigate the possibility that intestinal parasitic infections impair school performance in children. Although clinical reports often mention apathy, irritability, and fatigue, which suggest a reduction in intellectual performance, only few acceptable quantitative data are available that support these findings. Recently, it has been shown in central Java and in the Cairo area, both endemic for hookworm infection, not only that non-anaemic children tend to be faster and more accurate in standard achievement tests but also that anaemic children, when treated with iron, become faster and more accurate than those treated with placebo.

3.2 Work and productivity

Iron-deficiency anaemia, which is the major form of morbidity during hookworm infection, is always associated with a diminished capacity to carry out physical work. This is of great significance because in many countries hard physical work is the means by which families grow their food and by which large-scale agricultural and construction work must still be undertaken.

Studies from regions where the prevalences of hookworm infection and anaemia are almost identical strongly suggest that the infection depresses the productivity of adult workers. In Indonesia, construction workers with blood haemoglobin concentrations below 110 g/litre performed significantly less well than non-anaemic workers, when subjected to the Harvard Step Test. A similar result was obtained using the same test with agricultural workers in Guatemala. The power output of African industrial workers with moderate anaemia (approximately 90 g haemoglobin/litre) and more severe anaemia (approximately 70 g/litre) was 24% and 34% less, respectively, than that of non-anaemic workers. Similar findings emerged from investigations among sugar-cane cutters in Colombia and United Republic of Tanzania. A study of work productivity

among people constructing roads by labour-intensive methods in Kenya showed that, at one standard deviation below the mean haemoglobin level, there was an associated reduction in productivity of roughly 6% (6). Projections from this miscellany of results indicate that in some regions the costs of controlling hookworm infections and treating anaemia would be economically worth while and would benefit communities in terms of improved health, productivity, and morale.

The effect of protozoan infections on work and productivity is difficult to estimate by indicators other than absenteeism. In a study in Mexico, annual absenteeism due to amoebiasis has been calculated as being equivalent to approximately 10 000 man-years (15).

3.3 Medical care

The medical costs of dealing with intestinal parasitic infections can be calculated for governments as well as for individuals. For governments, there are expenses directly related to hospitalization, outpatient services, and drug supply. Indirect costs, which are hard to calculate, are also involved, for example those of the provision of medical facilities, training of qualified medical personnel, administration of health services, and research.

Medical costs for individuals include the retail purchase of drugs, laboratory examinations, transportation, medical fees, hospital treatment, and health insurance. There have, however, been only a few attempts to estimate these costs. In 1976, in Kenya the cost to the governmental health care system of dealing with major intestinal parasitic infections was estimated at nearly US\$340 000 and the cost to families for the purchase of anthelmintics was just over US\$199 000 (6, 17).

In 1984, in Mexico, the direct cost of invasive amoebiasis was estimated as probably equivalent to 1.6% of the entire budget of the Mexican Ministry of Health. Some 42 000 to 98 000 of the 70 million inhabitants have neurocysticercosis, a complication of *T. solium* taeniasis, and the average cost of medical care for each patient in 1982 was US\$2173 (13).¹

¹ *Guidelines for surveillance, prevention and control of taeniasis/cysticercosis*. Unpublished WHO document, No. VPH/83.49, 1983. A limited number of copies of this document are available on request from Veterinary Public Health, World Health Organization, 1211 Geneva 27, Switzerland.

Governments can evaluate the direct medical costs by calculating expenditure on antiparasitic drugs and the number of patients suffering from intestinal parasitic diseases requiring treatment or hospitalization. The following examples give an idea of the size of the problem of intestinal parasitic infections. In Bangladesh, 11.1% of patients treated in outpatient clinics were suffering from intestinal helminthiases (the second leading cause for seeking medical help) and 4.9% of inpatients (the sixth leading cause for hospitalization). In the Rangoon Children's Hospital, from 1981 to 1983, 3% of all admissions were due to ascariasis (7). In Kenya in 1976, 88 804 patients were hospitalized because of ascariasis, i.e., 2.6% of all hospital admissions (17). In Acapulco de Juárez, Mexico, intestinal obstruction due to *A. lumbricoides* ranked fifth as a cause of hospitalization in a paediatric hospital. In the Children's Hospital in Cape Town, South Africa, ascariasis is the most common cause of acute abdominal emergency. In Mexico, 2% of all adult patients admitted to general hospitals had amoebic liver abscess, which requires weeks of inpatient care (15).

4. PREVENTION AND CONTROL STRATEGIES

4.1 Epidemiological foundation

Epidemiological studies of intestinal parasitic infections have extended beyond the mere identification and counting of cases. Accurate surveys of the distribution and extent of parasitic diseases will always be essential in selecting problems for attack through prevention and control programmes and for monitoring the progress and effectiveness of the chosen strategy. Recent developments in epidemiological research, however, have led to improved understanding of how parasites are transmitted, how their numbers are regulated within the hosts (both individuals and communities), and how the population dynamics of a given parasitic infection may be disturbed for purposes of control. Mathematical models for several infections have been developed which can predict how interference with a particular aspect of a parasite's life history, with a given intervention, will affect the prevalence and intensity of the infection in the community (7, 18).

The epidemiology of amoebiasis may be investigated through a relatively simple model, originally developed by Muench (19). In

amoebiasis, prevalence rates are generated by a constant force of infection and balanced by a constant rate of loss of infection. *Entamoeba histolytica* commonly shows a prevalence of 10–45% in adults with a plateau being reached at the age of 15–20 years. The force of infection is in principle independent of age and the main routes of transmission are also independent (water, food, and flies). The mean duration of infection appears to be about 2 years. That immunological mechanisms may lead to the expulsion of amoebae from the gut is suggested by the common lack of gut infections in patients with liver abscess and the relative infrequency of parasitological relapse in patients with invasive amoebiasis treated with drugs with low efficacy against luminal parasites. These observations and assumptions indicate that the force of infection is a product of the rate of effective contact between individuals (transmission coefficient) and the number that are eventually infected. The transmission coefficient is a function of the population density and is greater in dense urban populations. So far, population density does not appear to be a major determinant in the transmission of amoebiasis, which may be high in dispersed rural communities. Thus, the force of infection depends mainly upon the local prevalence of infection. For amoebiasis, the basic reproductive rate, which is the mean total number of new infections generated by one infected person during the period of infectivity, is unlikely to exceed two, even in developing countries.

For control purposes it is important to know that incidence rates fall as the transmission coefficient declines with improvements in socioeconomic conditions, personal and environmental hygiene, and with reduction in the number of infected persons, resulting from medical treatment.

Current models may prove to be oversimplified and will probably need revision and refinement as more data are obtained. Their importance, for those responsible for the health of people in areas where intestinal parasitic infections are firmly established, is that more realistic planning for prevention and control can be undertaken and the success of the methods chosen can be assessed quantitatively.

Mathematical models for devising control strategies, planning the timing and form of interventions, and predicting the outcomes will be of little use unless they have been developed on the basis of accurate data on age-related prevalence and intensity for helminth infections and on age-related incidence rates for protozoan

infections. Data collection must be based on reliable diagnosis and correct sampling of the community and must take into account seasonal variations.

The first step in studying the epidemiology of intestinal parasitic infections is to collect existing information about the nature and extent of those infections and other diseases in the area under study. Such information may prove to be sufficient for the evaluation of the degree of priority that should be given to the prevention and control of intestinal parasitic diseases. In most cases, however, additional data will have to be obtained by special surveys in order to define and quantify the health problems, to identify the sections of the population that are particularly affected, and to assess the feasibility of control measures.

Survey data have to be supplemented by field studies on human behaviour, local practices in food hygiene, methods of faeces disposal, and the quality and accessibility of the water supply. How these may affect the pattern of intestinal parasitic infection is summarized in Table 2.

Table 2. Some patterns of infection of intestinal parasites

Defects in sanitation, water supply, and food hygiene	Most likely infection pattern
<i>Faeces disposal</i>	<i>High endemicity of</i>
Indiscriminate defecation	
—around the houses	—ascariasis in children under 5 years
—around the village	—hookworm infections and ascariasis in all age groups
—in the fields	—hookworm infections in farmers and plantation workers
Use of night-soil for market gardening	—all soil-transmitted helminthiases in all age groups
<i>Water supply</i>	<i>High endemicity or epidemics of</i>
Inadequate quantity	—all intestinal parasitic infections, especially giardiasis, amoebiasis, and hymenolepiasis
Contaminated	—epidemics of giardiasis and amoebiasis
<i>Food</i>	<i>Moderate endemicity of</i>
Contaminated with soil	—all soil-transmitted helminthiases in all age groups
Contaminated with faecal material (through flies, dirty hands, etc.)	—amoebiasis in adults and giardiasis in children
Infected meat	—taeniasis in adults

Human behaviour is of considerable importance in the transmission of intestinal parasitic infections and the success of

control programmes may eventually depend on the modification of behaviour patterns. Human behaviour may be deliberate or unintentional and can promote health or contribute to ill-health. For example, indiscriminate defecation, improper use of latrines, and the use of untreated human faeces for manure are deliberate acts that enhance transmission of infection. Good personal hygiene, the habitual use of footwear, and the avoidance of certain types of food associated with some diseases (e.g., undercooked pork), reduce the transmission and risk of infection.

Surveys undertaken as part of a planned control programme should include the collection of relevant information about the community's values and norms, its attitude to these infections, and the general response to the planned intervention. In particular, it is important to identify which types of behaviour determined by local culture and practices are adverse to health, and would need to be modified in order to reduce the risk of infection, and which are beneficial, and would need to be reinforced to enhance compliance with the control programme. Recent advances in the epidemiology of major helminthic and protozoan infections are considered below.

4.1.1 *Ascariasis*

In recent years, advances have been made in understanding the epidemiology of *A. lumbricoides* infection (7, 18). The results of horizontal, cross-sectional surveys show that most people in an infected community will have acquired the infection by the time they are a few years old. A high prevalence rate then prevails for all age groups, although sometimes the prevalence rate has been observed to decline with age, possibly as a result of the development of some immunity or because of a behavioural change leading to a reduction in exposure to infective eggs. Since adult worms only live for about a year, reinfection must be the rule. The prevalence pattern shows a striking stability. The effects of short-term mass chemotherapy, which causes a rapid fall in prevalence, have been observed to be reversed when the drug regimen is discontinued. Prevalence returns to its former level after about a year but the intensity of infection may remain lower than before for a longer period. These findings imply that feedback mechanisms and complex regulatory factors operate in the host-parasite relationship and these control the parasite population.

4.1.2 Hookworm infections

The epidemiology of *Ancylostoma duodenale* and *Necator americanus* infections has similarities with that of *Ascaris lumbricoides* infection; the prevalence rates are stable and the frequency distribution of the worms in the hosts is overdispersed, which means that most infections are light and only a small proportion of the people are heavily infected.

The experience gained from the hookworm control campaigns carried out by the Rockefeller Foundation in the 1920s and 1930s showed that hookworm infection could be best controlled by improving sanitation, health education, and the wearing of shoes, whereas the control of hookworm anaemia needed treatment with anthelmintics and iron. These community-based approaches are valid even today. For the regular standard treatment of patients with hookworm infection and anaemia, anthelmintics and iron should be available at the primary health care level; such treatment will reduce the intensity and, eventually, the prevalence of hookworm infections in the human population in a given area.

4.1.3 Taeniasis/cysticercosis

A high stability of host–parasite population dynamics has been shown in experimental field studies on the transmission of Taeniidae in dogs and sheep. The high reproductive potential of the adult tapeworms and their efficient egg dispersal mechanisms ensure a high infection pressure. On the other hand, the mammalian hosts have developed some immunological regulatory mechanisms that either protect against reinfection or lead to the development of larval infections (cysticercosis) of rather low intensity.¹ Some of these observations are relevant to taeniasis/cysticercosis occurring in man. Three common epidemiological patterns of *Taenia saginata* infections have been identified: (a) the hyperendemic pastoral type; (b) the endemic urban–rural type; (c) the epidemic cysticercosis type. Each of these patterns needs different approaches for prevention and control. *Taenia solium* infections, both taeniasis and neurocysticercosis, are endemic in several countries, but can spread even epidemically when introduced into a previously uninfected

¹ *Guidelines for surveillance, prevention and control of taeniasis/cysticercosis*. Unpublished WHO document, No. VPH/83.49, 1983. A limited number of copies of this document are available on request from Veterinary Public Health, World Health Organization, 1211 Geneva 27, Switzerland.

community (13). Control measures such as the improvement of general economic and sanitary conditions, regular inspection of meat, and indoor pig husbandry, which once helped to eradicate *T. solium* infections in Europe, are not easy to implement in the endemic areas. Thus, control projects now give emphasis to large-scale chemotherapy of taeniasis cases and to health education of people at risk.

4.1.4 Amoebiasis

The study of the epidemiology of amoebiasis suffers from several weaknesses including: (a) lack of simple and reliable diagnostic techniques; (b) variations in clinical diagnostic criteria; (c) shortage of trained personnel; and (d) reluctance of institutions and governments to provide the necessary support. In addition, anti-amoebic antibodies are relatively long-lasting and reflect only the cumulative exposure of an individual or a population to the invasive forms of amoebiasis. The recent identification of pathogenic and nonpathogenic strains of amoebae on the basis of different electrophoretic patterns may give a new dimension to future epidemiological studies, provided the technique is simplified for use in the field (15, 16).

The direct assessment of the relative importance of the known vehicles of transmission has been hindered by difficulties in: (a) evaluating the numerous variables involved; (b) analysing the interacting roles of education, socioeconomic status, type of excreta disposal, and water supply; and (c) evaluating the short- and long-term impact of changes in specific environmental factors. The role of specific immunity to amoebiasis in determining the epidemiological pattern of the disease in communities remains unexplored in practice. Despite these limitations, some useful information is available from a few countries, which can be used for planning control programmes.

Characteristically in areas where amoebiasis is endemic the prevalence rates are high, probably as a result of high levels of transmission and constant reinfection in populations living in insanitary conditions. Epidemic outbreaks are rare and are usually associated with sewage seepage into the water supply.

Amoebiasis is transmitted from person to person, and the most common vehicle of transmission is contaminated food. The greatest risk is associated with the carriers of the disease, especially when they

are engaged in the preparation and handling of food. Carriers can discharge up to 1.5×10^7 cysts daily. The infection can also be transmitted by contaminated water. It has been estimated that in some countries with a high prevalence of invasive forms there is one case of invasive amoebiasis for every four or five carriers.

Cysts have been found to remain viable for several days in faeces and for at least 8 days in soil at 28–34 °C. They also remain infective in water, sewage, and wet soil, depending on the temperature. They are easily killed by desiccation on the surface of hands and by boiling, but not by the concentration of chlorine generally used for disinfecting water.

4.1.5 *Giardiasis*

Epidemiological information on giardiasis suffers from the same limitations as that on amoebiasis. Epidemiological and laboratory evidence implicating infected animals as a source of *Giardia intestinalis* infection in man continues to increase. Beavers, dogs, and muskrats have received much attention in the USA and Canada, but other animals have not yet been systematically evaluated. Isoenzyme studies of different isolates could well provide useful information.

The limited information available from developing countries suggests that giardiasis occurs most frequently in young children; infants may become infected as early as 3 months of age. Generally, infection rates in children less than 10 years of age are 2–3 times higher than those in adults. The age at which the prevalence rates peak varies from country to country. In developed countries, the age distribution of cases usually reflects the type of exposure responsible for infection. For example, contamination of municipal drinking-water usually results in a relatively even age distribution of symptomatic cases. Person-to-person transmission of *Giardia* may occur by direct exposure to faeces but most occurs indirectly through faecal contamination of soil, food, water, or other inanimate objects, followed by contamination of fingers. Waterborne transmission of *Giardia* results from faecal contamination of water at its source, which sometimes results in epidemics. Faecal contamination of fruit and vegetables may also occur if human faeces are used as fertilizer. It has been estimated that up to 9×10^8 cysts may be excreted daily by an infected person. Cysts of *Giardia* are more resistant to chemical disinfectants and survive longer than those of *E. histolytica*.

The high prevalence of *Giardia intestinalis* in children compared with adults in endemic areas suggests that some degree of protective immunity against infection may develop. Also, adults probably have less exposure. Immunoglobulin A antibodies present in breast-milk may protect infants against infection. Several experiments and clinical observations have confirmed that spontaneous disappearance of *Giardia* is mainly the result of immunological processes.

Only rough estimates can be made of the global prevalence because the reported rates of *Giardia intestinalis* prevalence are not usually representative of the reporting country's general population. Groups that have been most frequently selected for study include international travellers, children and staff in orphanages, children in day-care centres, persons attending hospitals or clinics, women and children participating in maternal and child health programmes, homosexual men, community residents examined in the course of epidemiological investigations of waterborne outbreaks of giardiasis, and villagers. Variations in the methods used to collect, preserve, stain, and examine stool specimens, as well as differences in the training and experience of microscopists preclude valid comparisons of results obtained in different studies even when the populations studied are demographically similar.

4.1.6 *Cryptosporidiosis*

There is a dearth of information concerning the epidemiology of cryptosporidiosis. Available data suggest that all the known development stages of the parasite develop and live in the same host and are found in the brush border of the mucosal epithelium of the stomach and intestine. The oocysts are minute, usually spherical bodies of about 2–5 µm in diameter, do not stain with iodine and are acid-fast. They are excreted intermittently, sometimes in small numbers, and the number of oocytes passed in the faeces has no constant relationship with the severity of the illness. Concentration techniques are helpful in diagnosis, but caution is necessary in differentiating the oocytes from other similar bodies that may also be present in the faeces. Staining with 1% aqueous safranin or 1% methylene blue has recently been reported to be more reliable, simple, and rapid than with the modified Ziehl–Neelsen carbol-fuchsin method.

Many investigators consider cryptosporidiosis to be a zoonotic disease but it is clear that contact with animals does not account for

all cases of cryptosporidiosis. The available data indicate that the infection occurs throughout the world and that children are at greater risk. Person-to-person transmission is common and prevalence is particularly high in children attending day-care centres, and in immunodeficient male homosexuals.

The human disease appears to be more common during the warm, rainy and humid months of the year, though there are only a few epidemiological studies to support this. In rural areas, where breast-feeding is more common, cryptosporidiosis was detected less frequently in children below 1 year of age than in the urban areas. The disease has also been noted to be more severe in the urban areas.

4.2 Objectives and general approaches

4.2.1 Short-term and long-term objectives

Once the epidemiological foundation has been laid, a policy decision may be taken whether or not to initiate a large-scale programme. If the decision is affirmative, a clear statement of the specific objectives is essential for the proper planning of the programme, selection of strategies, methods for implementing strategies, setting of targets, monitoring, and evaluation. The overall long-term objective is to reduce the prevalence, intensity, and severity of intestinal parasitic infections to levels at which they cease to be of public health significance. In this context, "short-term" is envisaged to cover a few years while "long-term" refers to one or more decades (see Table 3).

The basic approach is to interrupt transmission by: (a) introduction, use, and maintenance of effective sanitation; (b) promotion of safe methods of faeces and waste disposal; (c) provision of safe water supplies; and (d) promotion of personal and food hygiene. Such measures are usually slow to take effect, require considerable investment, and need to be accompanied by social, economic, and educational development. Short-term objectives aim at bringing the disease under control quickly, which is crucial if the support and cooperation of the community are to be secured. Measures should therefore be directed at those sections of the population that are at greatest risk. For example, in the case of helminthic diseases, this means mass or selective chemotherapy with anthelmintics and, for hookworm infection, anthelmintics supplemented with iron.

Table 3. Short-term and long-term objectives and strategies for the prevention and control of various intestinal parasitic infections

	Short-term		Long-term	
	Objective	Strategy	Objective	Strategy
Ascariasis	Reduce mortality and morbidity (intestinal obstruction, malnutrition)	Individual medical care; community-oriented chemotherapy; selective chemotherapy	Reduce prevalence and intensity	Improve sanitation; health education; community-oriented chemotherapy
Hookworm infections	Reduce morbidity and mortality (hookworm anaemia)	Standard case management; community-oriented chemotherapy	Reduce prevalence and intensity	Improve sanitation; health education
Strongyloidiasis	Prevent morbidity and mortality in immunosuppressed patients	Examination and treatment of immunosuppressed patients, if infected	Reduce prevalence	Improve personal hygiene
<i>T. solium</i> taeniasis	Prevent neurocysticercosis	Diagnosis and treatment of taeniasis in individuals and communities	Reduce prevalence of <i>T. solium</i> taeniasis/cysticercosis	Chemotherapy of taeniasis; meat inspection; improve sanitation; health education
Amoebiasis	Reduce mortality and morbidity (amoebic dysentery, amoebic liver abscess)	Individual medical care; improve personal hygiene, food safety; health education	Reduce prevalence of pathogenic strains	Non-specific hygienic measures (safe water, washing hands, food safety, sanitation) As above
Giardiasis	Reduce morbidity; prevent and control epidemics	Individual medical care; improve personal hygiene and water quality; health education	Reduce prevalence	

Where intestinal parasitic infections and diseases constitute an important health problem, the prevention and control programme must have both short- and long-term components; short-term measures are needed to make an early impact and comprehensive long-term measures to reduce transmission to below the level needed to maintain the infection.

In ascariasis, the short-term objective is to reduce the intensity of infection to levels at which harmful effects on nutritional status and the occurrence of intestinal obstruction in children become uncommon. This can be achieved by chemotherapy, aimed at the most heavily infected section of the population (small children) or the most vulnerable (undernourished children). The control of biliary ascariasis and other conditions related to the migration of adult worms in the body and *Ascaris* allergy requires a substantial reduction in the general prevalence of *A. lumbricoides*, which is a long-term objective that can be achieved by improving sanitation, supplemented by large-scale chemotherapy.

In hookworm infection, the short-term objective should be to reduce morbidity and mortality due to hookworm anaemia and, in this, peripheral health centres have a crucial role to play. The long-term objective, reduction in the overall prevalence, requires a general improvement in sanitation and hygiene and can be accelerated by specific sanitary and chemotherapeutic measures.

In strongyloidiasis, the short-term objective is to prevent intensive or disseminated infection. This can be realized by the examination, and treatment if necessary, of those at special risk (i.e., individuals with malignancy or impaired immunity and patients about to receive immunosuppressive drugs for organ transplant operations. In the case of "*S. cf. fuelleborni*" infection (e.g., in Papua New Guinea), prophylactic chemotherapy and well-organized standard case management should help to save the lives of infants unless a survey suggests that better control measures are needed. Improvement of general living standards will reduce the prevalence of strongyloidiasis but will not eradicate it because the infection is easily transmitted from person to person and is of extremely long duration.

In *T. solium* taeniasis, the short-term objective is to reduce the mortality and morbidity due to *T. solium* neurocysticercosis, which can probably be achieved by large-scale chemotherapy in hyperendemic areas. The long-term objective should be an overall reduction in the prevalence of taeniasis by proper case management,

early detection and treatment, regular meat inspection, and improvement of sanitation and veterinary hygiene. Health education and community participation are of particular importance in *T. solium* control programmes.

In hymenolepiasis, the main emphasis should be on the prevention and control of *H. nana* epidemics in children's institutions and hospitals. Long-term reduction in prevalence requires improvement of personal hygiene rather than general sanitary measures.

In amoebiasis, the short-term objective is to reduce mortality and morbidity due to amoebic dysentery and extra-intestinal amoebiasis. This can be achieved by improving sanitation, personal and food hygiene, and quality and supply of water, as well as through the proper diagnosis and treatment of individual cases. A reduction in prevalence rates can be achieved by the non-specific hygienic measures mentioned above, which are generally essential for the prevention and control of most intestinal infections and diarrhoeas of viral, bacterial, or parasitic origin.

In giardiasis, the short-term objective is to prevent and control epidemics in populations sharing water sources, or in institutions (such as day-care centres, orphanages, and mental hospitals). Wherever the overall prevalence rate exceeds 10%, an attempt should be made to reduce the number of cases by non-specific hygienic measures.

4.2.2 *Evaluation of priorities, costs, and benefits*

The decision to establish a control programme for intestinal parasitic diseases may depend on an evaluation of the advantages of control (6). In other words, it has to be decided whether the benefits that will result from control are likely to justify fully the costs of the measures required, particularly when resources are likely to be limited and there are other health problems.

There are three good reasons for the current interest in controlling intestinal parasitic infections:

(a) There is increasing evidence that intestinal parasitic infections are of great public health importance because of their direct impact on health and because they contribute to other pathological conditions.

(b) Experience in the correct use of modern drugs has made the control of these infections both feasible and effective.

(c) The application of control measures against intestinal parasites promotes the development of integrated health programmes at the community level. Such control measures are welcomed by communities and have a beneficial psychological impact, leading to better compliance with other parts of an integrated health and development programme.

The planning process should include analytical approaches to estimate the comparative costs and benefits of different health programmes. In addition, assessments should be made of the potential impact of different strategies and policies on not only the health status of the population to be covered, but also the changes in knowledge, attitudes, and behaviour of the people.

A comparison of the impact and benefits of different health programmes may be made by measuring the potential gain in healthy life-days through each of those programmes. However, it should be borne in mind that this approach allows the comparison of only direct benefits (e.g., reduction in mortality). For many health programmes (e.g., ascariasis control programmes) there may be considerable indirect benefits (e.g., increased community cooperation in health and development efforts). Thus, indirect benefits must also be considered in deciding which health programmes should receive priority.

For example, in a health assessment project in Ghana, hookworm anaemia was ranked only 36th in importance among 55 diseases for which days of healthy life lost were calculated (insufficient data made the evaluation of days lost due to ascariasis impossible). The reason for the low ranking of hookworm anaemia was that the method for measuring healthy days of life lost is strongly influenced by the "mortality effect". In other words, the case fatality rate of a disease strongly affects the calculation of healthy days of life lost due to it (6). And in the case of hookworm and many other intestinal parasitic infections, mortality is generally low.

The experience of health workers throughout the world is that people have a general abhorrence of large intestinal worms such as *Ascaris lumbricoides* (7). There is widespread desire at the community level to be rid of roundworms and no doubt this would apply to other intestinal parasites if they were as visible and repulsive. Policy decisions to establish prevention and control programmes generate good will and support in the community and in this respect also there is a cost, albeit unmeasurable, of not controlling intestinal

parasitic infections. For example, in Kenya, the cost of medicaments for the treatment of ascariasis in schoolchildren was US\$0.30 per head per year and this was calculated to bring about US\$2.50 worth of direct benefit per head per year (17). Other advantages such as increased community cooperation in health matters and the higher credibility of local health personnel are frequently much more important than direct public health benefits, though these are difficult to measure in terms of money. In lower Zaire, for example, community participation in a programme combining helminth control with sanitation has increased the utilization of the health services. The number of consultations for malaria attacks rose by 81% and compliance with the immunization programme improved from 69% to 83%; at the same time there was a significant reduction in the incidence of dermatoses, indicating increased interest in personal cleanliness.

The activities of the Japanese Organization for International Cooperation in Family Planning (JOICFP) in South-East Asia offer many more examples of how ascariasis control programmes can serve as entry points for community cooperation on other health matters. In conclusion, wherever the prevalence of intestinal helminthiasis, including ascariasis, is high and greater community cooperation with the health authorities is needed, then the control of ascariasis may be a good investment, provided that it is effective and leads to general health programme development including sanitation. It is also useful to remember that deworming campaigns have a high potential for attracting non-governmental funds.

4.3 Implementation strategies

There are three main types of prevention and control measures: epidemic control, case management, and community-oriented programmes.

4.3.1 Control of epidemics

Epidemic outbreaks and the very rapid spread of intestinal parasitic infections require immediate action by the health authorities in the form of epidemiological investigation and appropriate intervention. Following are some examples of appropriate interventions:

(a) In the case of waterborne outbreaks of amoebiasis or giardiasis the source of infection may need to be determined, followed by sanitary measures to stop the further spread of infection.

(b) Intensive hookworm infections among plantation workers may indicate the need for better sanitary facilities on plantations and more effective health education, as well as specific treatment of those heavily infected.

(c) Foci of *T. solium* taeniasis and cysticercosis, created by the sale of infected pork products or the importation of infected pigs, may need the coordinated intervention of medical and veterinary services.

(d) Outbreaks of hymenolepiasis in children's institutions can be controlled by chemotherapy and prevented by improvement of hygiene.

(e) The control of outbreaks of ascariasis caused by agricultural use of inadequately treated faecal wastes (night-soil) requires chemotherapy for those affected and improvements in excreta disposal methods.

4.3.2 Case management

Case management, which is concerned with the medical care of individuals, may have a role in the prevention and control of amoebiasis, giardiasis, *T. solium* taeniasis, and hookworm infection, but probably not of ascariasis and trichuriasis. Proper individual case management requires suitable laboratory facilities for diagnosis, effective drugs, and health education of individuals.

The diagnosis of the major intestinal parasitic infections is mainly based on macroscopical examination of expelled worms or microscopical examination of faeces, duodenal contents, etc. Facilities for microscopical diagnosis are normally available at least in hospitals and parasitological laboratory diagnosis should be an essential part of the training of laboratory technicians. In reality, at the periphery of the health services, the availability and quality of diagnostic facilities and expertise are frequently severely limited.

However, individual diagnosis can, and nowadays should, be partly replaced by population-based surveys, undertaken by national or regional reference centres. The results of such a survey can be used as a basis for standard case management, agreed at the national level by health administrators, parasitologists, epidemiologists, and clinicians.

Two examples of standard management which can be used at the primary health care level where laboratory diagnosis facilities are limited are:

(a) treatment with anthelmintics of persons with ascariasis or taeniasis (diagnosis by macroscopic examination of the worms or proglottids);

(b) anthelmintic (one dose) and oral iron treatment (for at least two months) of any anaemic person, in regions endemic for hookworm infections.

Standard case management for other common conditions, such as persistent diarrhoea, should be elaborated at the local level.

4.3.3 *Community-oriented projects*

Since the treatment of individuals with intestinal parasitic diseases is likely to have only a limited effect on the transmission of those diseases in the entire community, community-oriented projects have an essential role to play in the prevention and control of intestinal parasitic infections. The aim of community-oriented projects may be twofold: (a) to control locally prevalent intestinal parasitic infections themselves, or (b) to promote community cooperation in health matters by using such a control programme as a means of achieving general development. The practicability of intestinal parasite control programmes as "entry points" to the development of community cooperation in other sectors has been well established (see the last paragraph of section 4.2.2).

Community-oriented projects may vary in the attention they give to the various components of prevention and control activities (mass chemotherapy, sanitation or health education) but in principle they should not be limited to one activity only, e.g., chemotherapy. A close association between the programme and the whole range of health services available to a particular community will improve the effectiveness of the programme.

Since its establishment in 1974, the Asian Parasite Control Organization has recognized the importance of intestinal parasite control for the promotion of community cooperation in health matters. This idea has been developed further by JOICFP's integrated health programme which includes parasite control, improvement of nutrition, and promotion of family planning.

During the past few years, encouraging results and valuable experience have been gained from the villages of Panchkhal, a remote and poor area of Nepal, where initially an intestinal parasite control programme was offered to the communities to see whether people would later accept an integrated health programme after seeing for themselves the benefits of chemotherapy (in terms of expelled worms). Not only was the intestinal parasite control programme successful, but soon a local committee was formed and within 3 years several additional programmes, including nutrition, education, immunization, and maternal and child care, had been added to the original programme. Moreover, the original parasite control programme had such an impact that within a few years almost all families in the communities had a latrine of their own (3).

Integrated health programmes, with parasite control as one of the first components, have been in operation in Sri Lanka for some time. Local programmes rely greatly on women in the communities for the planning and implementation of activities. Experience shows that the inclusion of parasite control has been extremely beneficial. During the 5 years before the project was started in Nakulugamuwa-Kudawella, some 11 latrines were being constructed annually, while 73 were built within the first year of the programme.

In the coal-mining town of Swahlunto, Sumatra, Indonesia, an integrated programme, including parasite control, was started in 1976. By 1981, the prevalence of hookworm among coal miners had fallen from 79.8% to 21.2%, of *Ascaris lumbricoides* from 39.8% to 7.3%, and of *Trichuris trichiura* from 14.1% to 6.1%. The prevalence of anaemia declined as did absenteeism. For more details of these and other successes the reader is referred to the various issues of *JOICFP review*.

4.3.4 *Implementation within other programmes*

Activities concerning the prevention and control of intestinal parasitic infections will generally have to be implemented through other major health programmes, namely: water supply and sanitation, diarrhoeal disease control, maternal and child health, feeding programmes, food safety, health education, and occupational health (3).

Well-designed anthelmintic programmes, constituting a substantial part of a whole package of health-promoting activities, may help to increase community cooperation and interest in the

various aspects of primary health care. The control of intestinal parasitic infections can also be included in those schistosomiasis control programmes in which stool examination is routinely carried out before chemotherapy.

Recently, a number of countries in the Western Pacific Region of WHO have launched control programmes for intestinal parasitic diseases in conjunction with other priority health programmes. For example, in the Philippines deworming is being done along with a schistosomiasis control programme; in Samoa, it is part of filariasis control activities. In Vanuatu, parasite control is being integrated with the promotion of family planning, and in Kiribati with a nutrition improvement programme. In Tonga, Tuvalu, and Vietnam, deworming is integrated into environmental hygiene and sanitation programmes. In Singapore, a programme on parasite control forms part of a programme for the promotion of personal hygiene.

4.4 Costs and financing

The cost of prevention and control of intestinal parasitic infections is minimal when the programme is so designed that its various components are made a part of the established routine of community health work, such as maternal and child health care, care of schoolchildren, health education, and environmental sanitation. The additional costs of helminthiasis control to established programmes are then largely those of diagnostic laboratories and anthelmintics, with a relatively minor cost of staff and transportation. Thus, such integration is desirable wherever it can be achieved.

Experience in South-East Asia has already shown that many prevention and control activities against intestinal parasites can be effected with voluntary help from the communities and with financial support from non-governmental organizations. In any case, investment in microscopy laboratories is extremely worth while as they may also be used for the diagnosis and prevention of other diseases, for example, malaria, tuberculosis, leprosy, and certain sexually transmitted or neoplastic diseases.

In certain situations, it may be necessary to have a "vertical" type of programme, at least in the initial stages, in which the costs per case will be relatively high. Where the problem is acute and there is no adequate infrastructure, this approach may be unavoidable.

There are several examples (USSR, Japan) to prove that health teams, once organized for a particular vertical type of control programme, can be used later on for other health programmes if priorities change. Furthermore, the community cooperation in health matters gained by an effective intestinal parasite control programme may be used for other health programmes.

4.5 Methodologies and tools

In practice, the prevention and control of intestinal parasitic infections depend on accurate and reliable initial surveys, and proper monitoring of the progress of intervention programmes. Particular attention must be given to diagnostic tools, drug delivery and use, choice of sanitary technology, and health education for individuals and the community.

4.5.1 Survey methodologies¹

Epidemiological work, conducted through population surveillance, forms an essential component of any prevention and control programme. Primarily, it provides the information necessary for the identification of problems and forms the basis for decisions about appropriate actions. Also, surveillance enables health officials to monitor the progress of control programmes and to modify them as and when necessary. Finally, epidemiological surveillance serves as a system for the long-term monitoring of the prevalence of infections in relation to established control measures.

4.5.1.1 Surveillance. In surveillance work, factors that determine the occurrence and distribution of an intestinal parasitic infection must be carefully scrutinized. The following is a summary of the types of data needed for surveillance and considerations in their assessment.

It is important to collect and analyse data on the prevalence and intensity of infection by age, sex, socioeconomic status of the

¹ Important survey methods and the factors to be considered in surveillance work are presented in detail along with practical information on the control of intestinal parasitic infections within the primary health care system in various unpublished WHO documents (PDP/85.1-4). A limited number of copies of these documents are available on request from the Parasitic Diseases Programme, World Health Organization, 1211 Geneva 27, Switzerland.

population, geographical location of the area covered, and seasonal variations in the area.

The public health significance of intestinal parasitic diseases is, for the most part, concerned with morbidity rates. One of the difficulties frequently encountered with intestinal helminthic infections is that of making a reliable assessment of the intensity of infection; this assessment is important because in helminthic infections morbidity usually increases with the intensity of the infection. Mortality rates, however, should not be ignored. Except for giardiasis, most of the major intestinal parasitic infections may be life-threatening conditions under certain circumstances.

In practice, the methods adopted for the surveillance of one intestinal parasitic infection provide data about others. Although this is convenient and cost-effective, it may tend to mislead some planners into assuming that there may be a prevention and control programme that can tackle all intestinal parasitic infections *en masse* and simultaneously. However, this is not the case because the biology of each parasite, the course of each host-parasite relationship, and the modes of transmission of the parasites in the human environment are generally different.

The choice of the surveillance strategy will depend to some extent on the types of intestinal infection prevalent in the area under consideration. For example, common experience shows that there is little to be gained by spending resources on surveys of animal reservoirs if ascariasis is the disease of concern. In taeniasis, however, human involvement is closely linked to domesticated (farm) animals.

The main elements of a surveillance strategy are likely to be: (a) epidemiological surveys of the population to determine prevalence, distribution, and intensity of infection, where applicable; (b) mortality registration; and (c) morbidity reporting. Demographic data are necessary as they contribute to the interpretation of the results of epidemiological surveys and allow estimates to be made of the supplies needed for the conduct of prevention and control programmes.

An additional element of surveillance is a mechanism for the reporting of epidemics. This is particularly important in the case of protozoan intestinal infections and those helminth parasites that may undergo auto-infection or multiplicative processes within the host (*Capillaria philippinensis*, *Hymenolepis nana*, *Strongyloides stercoralis*, *S. fuelleborni*, and "*S. cf fuelleborni*").

4.5.1.2 *Survey methods.* Methods for the establishment and conduct of surveys to cover intestinal parasitic infections have been recently reviewed by WHO, with reference to work on ascariasis and hookworm disease. The two main elements are the recruitment and training of survey personnel for the different forms of surveillance to be used and the problem of how to sample the population under surveillance.

The quality and reliability of survey data will depend on the sampling techniques chosen and the size and representativeness of the sample selected. Most of the routine techniques for sampling populations in epidemiological surveys have probably evolved from investigations in developed countries and therefore they may have to be adapted for use in developing countries. Further thought should, perhaps, be given to the particular population dynamics of helminth infections in human communities before decisions are made about how to sample the population for surveillance.

The choice of the sampling method will depend to some extent on the type of demographic and census information already available. Sometimes the available demographic data may need to be updated or expanded before a survey sample is selected. Also, a decision will have to be taken whether to use random or purposeful samples and whether the samples should include individuals, selected age groups or social groups, nuclear or extended families, households, entire villages, etc.

Once the decision is taken about the composition of the sample, its size must be calculated. Calculation of the sample size is often not straightforward and it is advisable to consult a qualified statistician. Sometimes it may be appropriate to start with a pilot survey to verify the suitability of the selected sampling methodology. Finally, it should be noted that the sampling methods and size of the sample may vary depending on the amount of money available.

4.5.2 *Data management*

It is essential that in all programmes quantitative information be collected and analysed by statistical methods. In surveys of intestinal parasitic infections, which constitute a very heterogeneous group, the variables have to be carefully selected, according to the rule that there should be as many as necessary, but as few as possible.

In order to characterize and monitor intestinal parasitic infections, data are needed on prevalence rates along with

information on the intensity of infection and recurrence of infection after treatment; this will allow calculations to be made of reinfection and/or parasite reproduction rates. In order to understand the transmission patterns of different infections, the basic demographic data must be known by age, sex, occupation, family size, and place of residence (urban, suburban, rural) of the affected population.

To evaluate the effectiveness of a control programme, data on mortality due to intestinal parasitic infections must be analysed and compared annually; more frequent analysis would be inappropriate because there are usually only a few such deaths reported. Morbidity data may be obtained readily from data collected in certain hospitals or health centres that are representative for an area. The basic information required for such comparisons is the number of patients hospitalized each year for ascariasis, hookworm anaemia, neurocysticercosis, strongyloidiasis, and amoebiasis, as well as the number of surgical interventions for intestinal obstruction due to ascariasis and for amoebic liver abscess. Changes in morbidity may also be detected by comparing annually the proportion of outpatients seeking medical help because of "worms" or "persistent diarrhoea" (most likely related to parasitic protozoa).

In a large-scale control programme, the geographical area to be covered, the segment of the population to be examined, the methods of examination, the frequency of treatment and re-examination, and typical case descriptions should be established before statisticians design the necessary sampling procedures and specify how data should be collected, analysed, and evaluated at a central statistical unit. Moreover, modern surveys generate a mass of data which must nowadays be handled by a computer, as it allows easy storage, retrieval, duplication, updating of files, integration with other data banks and, above all, rapid analysis. In addition to this central data evaluation, each operational unit involved in large-scale projects should be capable of making its own specific judgements on the progress of the project.

4.5.3 *Diagnostic tools*

4.5.3.1 *Planning for diagnosis.* At present, the diagnosis of intestinal parasitic infections largely depends on the microscopical examination of stool specimens. WHO has recently reviewed the available diagnostic tools from the point of view of use in primary

health care services.¹ The following considerations are important in the diagnosis of intestinal parasite infections:

(a) More than one infection may be present in an individual at the same time and protozoan and helminth parasites may coexist. Therefore, the diagnostic procedures must be able to detect mixed infections.

(b) There are three levels of diagnosis, depending on the objectives of the examination. (i) Research will probably require quantitative diagnostic work to give some measure of the intensity of the infection, particularly if helminth infections are under study. (ii) Community surveys require quick and accurate qualitative diagnosis and methods designed to process large numbers of stool samples. (iii) In the individual patient, diagnosis requires a combination of clinical judgement and specific laboratory investigation.

(c) Laboratory facilities are needed for diagnosis, and some additional training of technical staff is usually necessary. Diagnostic tests and the methods of recording and interpreting results need to be standardized to improve communication within the control programme.

(d) Human faeces are potentially dangerous and represent a health hazard for all those who come into contact with them because they may be a source of various bacterial, viral, and parasitic infections. Therefore, steps must be taken to ensure the health and safety of all personnel involved.

(e) Recent research shows that some parasites exist as distinct strains, which can be characterized according to differences in their pathogenicity, immunology, biochemistry, and even resistance and susceptibility to chemotherapeutic agents but not on the basis of their morphology. Recently, specific DNA characteristics, monoclonal antibodies, and isoenzymes have been used successfully to identify different strains within a species or within an assemblage of parasite species. There is a need to apply this type of research by developing highly sensitive, simple diagnostic tests for use at the community level. For the moment, however, morphological examination will continue to offer the best form of practical

¹ *Diagnostic techniques for intestinal parasitic infections (IPI) applicable to primary health care (PHC) services.* Unpublished WHO document, No. PDP/85.2. A limited number of copies of this document are available on request from the Parasitic Diseases Programme, World Health Organization, 1211 Geneva 27, Switzerland.

diagnosis for prevention and control programmes and standard epidemiological surveys.

4.5.3.2 *Brief review of simple diagnostic techniques.* The selection of appropriate diagnostic techniques is of the utmost importance. However, there is no substitute for experience; only a lot of practice and a good knowledge of the morphological features of the different stages of the parasites can lead to reliable diagnosis. Also, no amount of laboratory expertise and equipment is worth while unless locally acceptable procedures are developed for the collection of stool samples. Two important smear techniques used in laboratory diagnosis are described below:

Direct thin smear. A smear is simple and quick to prepare and requires little equipment. It is useful for the detection of trophozoites and cysts of *Entamoeba histolytica* and *Giardia intestinalis*. Helminth eggs and larvae can be recognized and roughly quantified if present in sufficient numbers.

MIF (Merthiolate, iodine, and formalin) procedure. Several variations of staining techniques for direct thin smears are available. The MIF procedure is one of the most useful methods for the diagnosis of protozoan parasites. It both fixes and stains the parasites through the action of Merthiolate, iodine, and formalin (MIF).

Cellophane thick smear. The original version is the Kato cellophane thick smear technique which is a simple, cheap, and effective method for the qualitative and quantitative diagnosis of helminth infections. Although the modified Kato-Katz method needs more preparation, it gives more precise results. Cellophane smears can be stored and re-examined.

Other methods are also available for preparing and processing stool samples before microscopic examination. Some of these methods include the concentration of parasitic stages by sedimentation, flotation or ether-extraction. They are probably better suited to research studies or diagnosis of infection in individual patients than to diagnosis in communities, and certainly need more equipment than do the different smear techniques.

Hookworms cannot be identified to the species level on the basis of eggs detected in stool samples. If adult worms passed in stool samples are not available for identification, coproculture techniques using fresh, unfixed stool specimens will be needed, from several

positive stool specimens, to provide larval stages for further diagnosis (2). Specific identification of *Ancylostoma duodenale* and *Necator americanus* is important because their life cycles are different and therefore they require different treatment methods.

4.5.3.3 *Immunodiagnostic techniques.* The fact that antigen-antibody reactions occur between parasites and hosts offers another approach to diagnosis, by the detection of parasite antigens, even if the nature of the host response has immunopathological rather than protective consequences. Serological diagnostic results can be difficult to interpret because the tests are often indirect and cross-reactivity may occur. Furthermore, antibodies against an infection may remain in the serum long after the parasite itself has disappeared. These difficulties could be overcome if the serological procedures were directed at antigens. Antigen detection tests would be more sensitive and more likely to detect the presence not only of living parasites but even of specific stages. This particular approach to diagnosis needs more research for the development of suitable tests. For example, population screening for the prevalence of *T. solium* taeniasis might be facilitated if a reliable faecal antigen test could be developed for field use.

Some work aimed at developing immunodiagnostic techniques for intestinal parasitic infections is in progress but needs encouragement and support. For example, coproantigens can be exploited for diagnostic purposes and immunofluorescent staining might be combined with faecal smear techniques to increase the chances of detecting *G. intestinalis* and other infections. This approach might be used in the future to decide whether *A. lumbricoides* or *A. suum* is present in a person or whether a hookworm infection is of a single or mixed species. In theory, serological techniques might be used to measure the intensity of established parasitic infections and to provide some insight into the degree of polyparasitism. Perhaps, most importantly, an immunodiagnostic approach could lead to the detection of parasites before the release of cysts, eggs or other dispersion stages. With the exception of thick cellophane smears, nematode larvae cultures, and some staining techniques for protozoa, the diagnostic procedures for intestinal parasitic infections have remained unchanged in principle for over 50 years.

4.5.4 Chemotherapy: drug delivery and use

With the introduction of new, safe, and efficient drugs, chemotherapy has become a potent tool for controlling severe intestinal helminthiases; however, its effectiveness in controlling intestinal protozoan infections is less evident. Although community-oriented chemotherapy gives immediate results, the effect may be transient if the treatment is not repeated at appropriate intervals for some time or if it is not supported by sanitary measures and health education programmes.

4.5.4.1 *Individual treatment.* Chemotherapy is used both in the medical care of individuals and in population-based projects. Although the treatment of individuals with intestinal parasitic infections reduces morbidity rates, it does not contribute much to the overall prevention and control of infections such as ascariasis, giardiasis, and hymenolepiasis, all of which spread easily or directly. However, if cases of amoebiasis, intensive hookworm infections, and taeniasis are treated promptly with effective chemotherapy, such individual treatment may substantially decrease the parasite population and lower the infection pressure in the area.

4.5.4.2 *Large-scale chemotherapy.* Any decision to use chemotherapy on a large scale must be based on the results of a survey of the distribution and transmission of intestinal parasites in a given area and on clearly defined objectives. The programme should include arrangements necessary for the integration of chemotherapeutic interventions with other activities of the local health services.

4.5.4.3 *Drug selection.* The important criteria in the selection of the drug are: dosage regimen, ease of administration, and absence of side-effects. These factors contribute to ensuring maximum efficacy and compliance (5). Other criteria for drug selection, such as availability and cost, depend much on the national drug policy. Criteria for efficacy, spectrum of activity, safety, and acceptability usually differ only slightly between countries. Delays in the delivery of the drugs and/or their improper use may decrease the impact of chemotherapy.

4.5.4.4 *Efficacy.* Estimates of "cure rates" for selected anthelmintic drugs that are in frequent use at the community level

are given in Table 4. The estimates assume that the drugs, when used in population-based chemotherapeutic programmes, are given in a *single oral dose*.

The terms “cure rate” or “parasitological cure” have a time-honoured and specific meaning in clinical usage and refer to the termination of an existing parasitic infection with permanent cessation of excretion of trophozoites or cysts in the case of protozoan infections, or eggs, larvae, or proglottids in the case of helminthic infections. This state can be confirmed only after repeated parasitological examinations, often using concentration techniques, plus other essential post-treatment ancillary examinations, which are often specific for different parasites. Such examinations are carried out over an extended period, which again is specific for each parasite. In community-based programmes, however, it is not possible to undertake repeated stool examinations for logistic reasons, and estimates of “cure rates” are thus usually based on the findings of a single post-treatment examination. In this context, the term “cure rate” must be interpreted with caution — in other words, as a guide and not as an absolute statistic.

An alternative technical term used in the assessment of drug efficacy in helminthic infections, which may be seen in reports of population-based chemotherapy programmes, is the “egg-reduction rate”. This is simply the calculation of the post-treatment egg count of either a population or a specific age-group and its comparison with the pre-treatment egg load per common unit weight of faecal material.

The calculation of “egg-reduction rate” is now quite common, but compared to the calculation of “cure rate”, has several disadvantages as a measure of drug efficacy, principally because numerous factors influence egg production and excretion, as well as the accuracy of measurement of production and excretion rates. Neither index can be regarded as totally satisfactory.

In amoebiasis and giardiasis the efficacy of the various 5-nitroimidazoles is broadly similar but ornidazole and tinidazole are slightly better than metronidazole. The recently developed secnidazole has shown a higher cysticidal activity than the others, but experience with this drug is still limited.

4.5.4.5 *Safety*. Nitroimidazoles are generally considered safe drugs although minor side-effects have been observed in 15–30% of patients. A WHO Scientific Group investigated this question in

Table 4. Anthelmintic activity of selected drugs in frequent use at the community level^a

Drug ^b	Therapeutic activity ^c against:				
	Ascaris <i>lumbricoides</i>	Hookworms (<i>A. duodenale</i> and <i>N. americanus</i>)	<i>Trichuris</i> <i>trichiura</i>	<i>Strongyloides</i> <i>stercoralis</i>	<i>Enterobius</i> <i>vermicularis</i>
Albendazole	4	3	2-3	2-3 ^d	4
Levamisole hydrochloride	4	2-3 ^d	2	2	2
Mebendazole	4	2-3 ^e	2-3 ^e	2 ^e	3-4
Piperazine salts	3-4	1 ^f	1 ^f	1 ^f	3 ^g
Pyrantel embonate	4	2-3 ^d	1 ^f	1 ^f	3-4

^a Adapted from: DAVIS, A. Ascariasis: drugs and drug policy. In: Crompton, D.W.T. et al, ed. *Ascariasis and its public health significance*. Basingstoke, Taylor & Francis, 1985.

^b No attempt has been made to include all the drugs or drug combinations used in the treatment of intestinal parasitic infections.

^c Key: 1 = 0-19% cure rate; 2 = 20-59% cure rate—moderate activity; 3 = 60-89% cure rate—good activity; 4 = ≥ 90% cure rate—very good activity. In these studies cure rate refers to the proportion of patients treated who are egg-negative on one follow-up examination on a single stool sample. (See also section 4.5.4.4).

^d Higher ranges of cure rates are seen after an increased total dose is given, either once, or over a period of 2-3 days.

^e Mebendazole is usually given 100 mg, twice daily for 3 days, irrespective of age or in a single dose of 500 mg.

^f 0-19% "cure" is inseparable from the technical errors associated with the techniques of examination.

^g Piperazine is usually given daily for 7 days in enterobiasis.

1980 and concluded: "The question of carcinogenicity of metronidazole was reviewed in depth by the International Agency for Research on Cancer. It was found to be carcinogenic in mice after oral administration; the incidence of lung tumours in both sexes and of lymphomas in females was significantly increased. Its oral administration to rats increased the incidence and multiplicity of mammary fibroadenomas. The drug has been widely used throughout the world for the last 20 years. No case reports or epidemiological studies in man are available for assessing the human risk of teratogenicity or cancer, which is almost certainly not large and may be negligible" (2). This position remains unchanged.

In the doses administered against intestinal nematode infections, both the widely used benzimidazoles (mebendazole and albendazole) are well tolerated, causing transient side-effects in only about 6% of patients. In a few studies, an increased rate of *A. lumbricoides* migration has been observed during mebendazole therapy. Cyclic amines, such as pyrantel and oxantel, are neither teratogenic nor embryotoxic and are well tolerated, causing transient side-effects in 4–20% of patients. Levamisole is well tolerated in the low doses used against ascariasis. Piperazine and tetrachloroethylene are not tolerated well, but are the cheapest anthelmintics available. Praziquantel and niclosamide, both very effective taenicides, are generally accepted as safe drugs.

4.5.4.6 *Coverage, frequency, and timing.* In large-scale chemotherapeutic interventions against intestinal nematodes, the decision about the extent of coverage must be taken on the basis of prevalence data, reinfection rates, the level of community cooperation, and the coverage of the available laboratory facilities. For example, mass treatment is suggested if the prevalence and reinfection rates are high and community cooperation is good even if the laboratory base is inadequate. In highly endemic areas, chemotherapy may start with one or a few mass treatments followed by selective treatment. Selective treatment of specific groups in the population is recommended when the prevalence and reinfection rates are moderate but community cooperation and the laboratory base are weak. Populations for selective treatment may be stratified by age (schoolchildren), profession (plantation workers), place of residence (rural or shanty-town areas), and level of prevalence (localities with higher prevalences than the others). However, the

selective treatment approach may not be well understood and accepted by communities; if the aim of intervention is to strengthen community cooperation, this approach may not be the best. It has been shown in Japan and South Korea that selective treatment of only those who are infected needs a good laboratory base and a high degree of community cooperation.

To control ascariasis effectively, the whole community may need to be treated every 2–4 months for some years, depending on the prevailing epidemiological conditions. Similarly, in the case of hookworm infections a community may need treatment at least once or twice a year. For taeniasis, one or two treatments may be sufficient. The timing of treatment is important where transmission is seasonal; treatment should be scheduled before and after the period of intensive transmission, i. e., at the end of the dry season and shortly after the rainy season.

4.5.4.7 Monitoring and evaluation. The monitoring of large-scale chemotherapeutic interventions requires the measurement of: (a) effective coverage; (b) drug efficacy, (i. e., the ratios of prevalence and intensity before and shortly after treatment); and (c) drug tolerance (in subsamples). Treatment activities should be evaluated at periodic intervals, either with every treatment cycle or every other treatment cycle. The evaluation process should include a calculation of the actual (current) transmission rate (reinfection rate, basic reproduction rate).

If neither the prevalence nor the intensity of infection is reduced, the intervention programme should be carefully evaluated to determine if there is any evidence of: (a) drug failure; (b) lack of compliance; (c) drug resistance or (d) operational failure. The evaluation process, just like survey design, usually requires the assistance of an experienced statistician and parasitologist.

4.5.5 Sanitation technology

Intestinal parasitic infections will remain prevalent as long as people have no easy and convenient access to clean water supplies and acceptable and hygienic facilities for the disposal of human excreta. The provision of clean water supplies and better sanitation and their use would make a major contribution to the prevention and control of diarrhoeal diseases (including amoebiasis

and giardiasis) (16, 20) and other intestinal parasitic infections (2, 21).

The 10 years from 1981 to 1990 have been declared as the "International Drinking Water Supply and Sanitation Decade", and during this period great emphasis is being placed on the improvement of water supply and sanitation services to the rural and poor periurban areas of developing countries. This segment of the human community, which makes up over 70% of the total world population, is the most deprived group in terms of access to water supply and sanitation and also experiences the most hardship from the various intestinal parasitic infections. According to a 1984 WHO estimate, at least 1200 million people in the rural areas of the world in some 90 developing countries (excluding China) are still without access to safe drinking-water. Also, close to 1600 million inhabitants in the same rural communities lack safe sanitation. Although in recent years there have been improvements, these have been mainly in water supplies; sanitation is still lagging seriously behind, and thus grave problems concerning the transmission of intestinal parasites will continue for several years.

Planned urbanization and a high standard of living in developed countries have resulted in reduced prevalences of intestinal parasites. On the other hand, uncontrolled migration of the rural poor to already overcrowded urban areas in developing countries has resulted in the spread of shanty towns, in which poor sanitation facilities have caused heavy contamination of the environment and high prevalences of intestinal parasites.

The provision of sanitary facilities for excreta disposal and their proper use are necessary components of any programme aimed at controlling intestinal parasites (7, 16, 21). In many areas, sanitation is the most urgent health need and those concerned with the control of intestinal parasitic infections are urged to promote intersectoral collaboration between health care authorities and those responsible for the provision of sanitation facilities and water supply at the community level. Studies assessing the impact of improved sanitation show that the benefits expected from sanitation are maximized when such programmes are complemented with the provision of safe water and health education.

However, sanitation alone cannot eliminate the transmission of intestinal parasites because ideal sanitation is seldom achieved. The most frequent shortcomings are the following (see also Table 2, page 33):

- lack of strict hygienic practices (hand washing after defecating and before eating), resulting in auto-infection and transmission through person-to-person contact;
- use of contaminated water for personal hygiene and, more important, for dishwashing and for cleaning, refreshing and irrigating vegetables eaten raw;
- indiscriminate defecation (rather than using latrines) by certain groups, especially young children, which spreads parasite cysts and eggs in the immediate environment (soil, courtyard); and
- lack of personal hygiene among those who have close contact with domestic animals.

In addition, sanitation efforts can be jeopardized by the contamination of the environment with excreta through open sewers, the flow of untreated sewage into rivers, canals and ponds, and the use of inadequately treated sewage in agriculture, either as fertilizer or for irrigation. The direct use of night-soil is always associated with high prevalences of *Ascaris*, *Trichuris* and amoebiasis and sometimes of *Taenia*. The presence of *Ascaris* eggs in the environment constitutes a sensitive indicator of the effectiveness of the treatment of faeces, and, more generally, of the effectiveness of sanitary measures in a community.

In relation to the wide differences in the observable levels of sanitation, intestinal parasite surveys sometimes reveal surprisingly high, or low, rates of infection, strikingly high prevalences of soil-transmitted helminths in areas where the water supply is assumed to be safe and where the latrines are used regularly and universally, or strikingly low prevalences of *E. histolytica* and other intestinal protozoa in areas where little or no provision has been made for safe water or the disposal of human excreta. *Ascaris lumbricoides* and *Trichuris trichiura* usually occur together in the same geographic areas but one of the two may be present where the other is absent or rare. These findings are unexplained. In some instances the accuracy of diagnostic methods or the reliability of technicians can be doubted, especially with regard to intestinal amoebiasis, but in many instances, low prevalence of amoebiasis in highly unsanitary areas is well documented. It is possible that viruses and coccus-like organisms, known to occur in amoebae, are largely responsible for spontaneous loss of infection. Similarly, diseases and predators of eggs and larvae of soil-transmitted helminths, causing high mortality among the parasites, may significantly influence the rates of infection

in people. Various factors influence the survival of eggs of helminths and cysts of protozoa in the soil. Eggs of *Ascaris* can survive for years under favourable conditions of moisture and temperature. Other factors influencing survival are not well known. There is a great need for more studies on parasite egg survival in different countries and ecological settings.

4.5.5.1 *Choice of technology.* Improvements in community water supply and sanitation in developing countries, have, over the past 20 years, been mainly in the form of refinements of existing equipment or methods, without any major breakthroughs (21). Such developments are especially noticeable in the improved designs of hand-pumps, on-site excreta disposal facilities through ventilated pit latrines, pour-flush latrines, and compost latrines. Experience acquired in the use of new techniques, for example small-bore shallow sewers, has increased the confidence of designers in applying such techniques in appropriate situations. Although only very limited epidemiological knowledge on the health impact of these improvements has been obtained, it is generally accepted that they have contributed considerably to reducing the risk of infection from parasitic diseases.

The principles and criteria involved in the selection of appropriate methods of providing a clean water supply and hygienic sanitation facilities stipulate that those chosen should be: (a) technically and environmentally sound; (b) financially affordable; (c) socially and culturally acceptable; (d) simple to install, operate and maintain; and (e) beneficial to public health.

There is indirect evidence suggesting that water supplies through house connections result in maximum health benefits; this is especially true for infections with parasitic cysts and eggs that are infective immediately after excretion (e.g., *Enterobius vermicularis*, *Balantidium coli*, *Giardia intestinalis*, and *Entamoeba histolytica*). These infections may also be reduced by having a water stand-pipe (hand-pump) in the yard, which would encourage personal hygiene. Where only communal water supplies can be made available, the provision of separate areas for laundry and washing and for the collection of water for drinking may reduce the transmission of these infections.

Among the various sources of water, shallow wells are the cheapest and easiest to develop. Unfortunately, they are not usually safe, as they are exposed to contamination. Preferred alternatives to

shallow groundwaters, if available and economical to develop, include, in decreasing order of safety, spring water supplied from an uncontaminated source by gravity and requiring no treatment; deep groundwater requiring simple treatment; rain water; spring water, lake water, irrigation water, and run-off water requiring simple treatment; and river water requiring extensive treatment. To ensure the removal of protozoan cysts and helminth eggs all surface water must be filtered; reliance on chlorine alone is inadequate.

For economic and sociocultural reasons, on-site excreta disposal facilities including pit latrines, compost latrines, aquaprivies, septic tanks, and leaching fields will remain the most appropriate sanitation systems in rural and poor periurban areas. The use of these sanitation facilities is not entirely without risk of contaminating groundwater and therefore appropriate safeguards must be introduced in their design and construction.

If built or used improperly, pit latrines may not be safe; there may be risk of contamination from squatting slabs or pollution of groundwater. Nevertheless, they substantially reduce the transmission of soil-transmitted infections. The continuous type of compost latrine is not safe. On the other hand, most parasitic cysts and eggs do not survive in the discontinuous type of latrines with two chambers. However, the proper use and maintenance of compost latrines demands high user compliance.

Aquaprivies are generally safe, but have no advantage over the pour-flush latrine, which is more economical. The efficacy of aquaprivies depends much on their design and retention time. The sludge from an aquaprivy, septic tank, or soakaway may contain infective parasites; soakaways are likely to contain the lowest number of infective parasites. Although bucket latrines are still used in some communities, they are extremely dangerous and a grave health hazard to the night-soil collectors and the general public.

For very large congested urban communities with high population densities conventional flush toilets and sewers are appropriate for protecting public health. Some disadvantages inherent in this method of excreta disposal include: (a) wastage of large volumes of water; (b) very high capital and recurrent costs; (c) need for sophisticated skills for installation, operation, and maintenance; and (d) need to treat huge volumes of waste water to render it innocuous.

4.5.5.2 *Treatment and reuse of excreta.* With the exception of stabilization ponds, which may fully eliminate intestinal parasites under ideal conditions, all other traditional treatment methods (primary sedimentation and biological treatment) are insufficient for removing all *Ascaris*, hookworm, and *Taenia* eggs and protozoan cysts. The best method of recycling human excreta is by composting night-soil and sludge, provided that a temperature of 60°C is reached and sustained throughout the compost for over 5 days. The use of untreated sewage or faeces for aquaculture is not safe and favours the spread of some trematode infections. The slurry from biogas plants may also contain viable pathogens, especially the hardy *Ascaris* eggs. The discharge of effluents into rivers, lakes, or sea is always risky, as most of the helminthic eggs and protozoan cysts survive for a long time in fresh or sea water.

There is a tendency, especially in certain developing countries that experience water shortages, to use untreated raw sewage for irrigation. This practice has tremendously increased intestinal parasitic infections in populations consuming the irrigated agricultural produce. In these areas, international guidelines on the use of effluent for irrigation and other purposes must be followed.

4.5.6 *Health education and community involvement*

The collaboration of the health education services should be sought early in the planning process for a prevention and control programme so as to identify the target groups, decide on the educational objectives for each group, and draw up a detailed and comprehensive programme of health education adapted to the needs of each section of the community involved (4). A health education programme should include the following components:

(a) *Preparatory phase*

- development of community cooperation
- orientation of health staff
- securing the collaboration of education authorities and other influential local organizations
- obtaining the support of the mass media
- collection or preparation of appropriate educational materials

(b) *Implementation phase*

- training schoolteachers in the prevention and control of intestinal parasitic infections

- inclusion of similar instruction in school curricula
- health education of other target groups
- keeping the community informed about the progress of the programme

There are some principles to follow in gaining community cooperation. Opinion leaders (village chiefs, politicians, teachers, church leaders, or other influential persons) should be contacted first. The purposes of the programme should be clearly and convincingly explained to the people. The schedule of the programme should be kept flexible so that it can be adjusted to the convenience of the target group. The organizers of the programme should also talk to the people about their interests before finalizing the plans.

As many people as possible should be involved in the planning process (women and youth groups, schoolteachers, religious leaders, and village council). Activities requiring community participation should be made as interesting, informative, and entertaining as possible.

Special attention should be given to schools because schoolchildren are very receptive and will easily follow the teacher's direction. A model of a clean latrine and a demonstration of the proper use of the water supply will always prove useful.

The achievements and successes of the health programme should be given publicity so that the participants are encouraged to continue to improve personal, family, and community health.

4.6 Strategy for prevention and control

The approaches for prevention and control of the major intestinal parasitic infections (see Table 3, page 40) differ for each infection and for each area, depending on:

- (a) the local public health importance of a particular infection;
- (b) local health priorities;
- (c) political will;
- (d) manpower and economic resources; and
- (e) the potential for achieving coordination between intestinal parasite control programmes and other major health programmes (diarrhoeal disease control, sanitation, maternal and child care, etc.).

4.6.1 *Ascariasis*

Ascariasis prevention and control programmes can reduce morbidity and mortality caused by the parasite within a few years. In addition to sanitary measures and health education, large-scale chemotherapy can effectively lower the population of worms in a given area. Selective treatment given to the most heavily infected section of the population (e.g., schoolchildren or preschoolchildren) is probably the best option in most countries. Mass treatment is justified when the prevalence in all age-groups is high, while selective chemotherapy is appropriate when adequate laboratory facilities are available. Unorganized treatment of individual cases does not contribute much to the control of ascariasis in communities.

4.6.2 *Hookworm infections*

Morbidity and mortality from hookworm infection depend much on the worm load. Therefore, the control of light infections and the reduction of local prevalence may be achieved by sanitary measures and better health education alone. Intensive infections, which cause hookworm anaemia, have to be treated regularly by the peripheral health services. The treatment of the most heavily infected people, if regular, will gradually lead to a substantial decrease in the hookworm population. Then, if a survey confirms that anaemia is of hookworm origin, standard case management of anaemic people at the primary health care level is the most suitable approach. In areas where hookworm anaemia is an occupational disease, control measures should be oriented towards those at special risk (e.g., plantation labourers and mine workers). In areas where heavy hookworm infections are prevalent, community-oriented chemotherapy may be necessary.

4.6.3 *Trichuriasis*

A programme aiming at the control of *T. trichiura* infections is justified only in areas where intensive infections are common and actually cause symptoms. It may be expected that the intensity and the prevalence of trichuriasis will decrease with the improvement of general sanitation and as ascariasis control programmes take effect.

4.6.4 *Strongyloidiasis*

Prevention and control activities should be directed against only intensive or disseminated strongyloidiasis and should include the diagnosis and treatment of individual patients with immunosuppression. Further work is needed before any realistic and specific control measures can be suggested. This is also true for "*S. cf. fuelleborni*" infection, which is endemic in some parts of Papua New Guinea.

4.6.5 *Taeniasis*

Taenia solium taeniasis could be better controlled if attention was focused not only on pig cysticercosis but also on infections in man. There are three options for prevention and control programmes: (a) the traditional approach of improvement of general sanitation, health education, pig husbandry, and meat inspection; (b) short-term mass chemotherapy against taeniasis to protect the community against neurocysticercosis, which is now possible owing to the development of safe drugs; and (c) long-term control of human taeniasis by health education and by making diagnosis and treatment of taeniasis free and easily accessible (which is now being done in some countries).

4.6.6 *Amoebiasis*

Amoebiasis can be prevented and controlled by both non-specific and specific measures. Non-specific measures include: (a) improved water supply, excreta disposal, and food safety; (b) health education; and (c) general social and economic development.

In areas where invasive amoebiasis is endemic, all activities at the country, district, or community level related to intestinal infections should include amoebiasis. The implementation of individual and community preventive measures (e.g., washing hands, proper excreta disposal) should be an essential part of these activities. However, measures such as the improvement of water supplies and sanitation are cost-intensive and are likely to be a long-term undertaking.

Specific measures that should be taken whenever possible are: (a) local epidemiological surveys of amoebiasis; (b) steps to improve case management (i.e., rapid diagnosis and adequate treatment of patients with invasive amoebiasis) at all levels of the health services

including in the community and at health centres; and (c) surveillance and control of situations that may favour widespread amoebiasis.

4.6.7 *Giardiasis*

Approaches to the prevention and control of giardiasis are basically the same as those for amoebiasis. The differences in giardiasis are that: (a) waterborne epidemics are common; (b) animal reservoirs may be important; and (c) outbreaks occur in children's institutions. These differences reinforce the importance of water supply and hygiene in institutions.

5. NATIONAL PROGRAMMES

Countries in which intestinal parasitic infections and diseases constitute a significant health problem should consider adopting a national policy for their prevention and control. Where there is political will on the part of the government to respond to the people's expressed need to be rid of their worms, considerable success and benefit to the population can be confidently expected.

5.1 Justification

Intestinal parasitic infections are widespread and cause considerable morbidity. Although mortality from such infections is low, some intestinal parasitic infections interfere with the nutrition, growth, and development of children, as well as with the work and productivity of adults. Furthermore, expenditure on medical care of the infected people may use up a considerable proportion of the funds available in the national health budget. Substantial social benefit can therefore be derived from the control of these diseases. In addition, there is evidence that the control of ascariasis, which gives measurable results, is a good entry point for initiating other health programmes, encouraging community cooperation and promoting intersectoral collaboration.

Recent experience in various countries has demonstrated the effectiveness of periodic deworming and standard case management at the primary health care level in reducing most of the problems associated with intestinal parasitic infections.

Considerable biomedical and operational research is in progress which is likely to produce new methods for incorporation into national control programmes. Furthermore, current global efforts to improve maternal and child care, water supplies, and sanitation, and to develop new techniques of health education and communication will help in improving the effectiveness of such programmes. As national health authorities are committed to the goal of health for all by the year 2000, the need to control intestinal parasitic infections as a part of other primary health care activities cannot be over-emphasized.

5.2 Objectives and strategies

The overall objective of control programmes is to reduce mortality, morbidity, and other related ill-effects. The aims and the means of prevention and control differ according to the parasite concerned (see Table 3, page 40).

5.3 Planning

National control programmes should be planned on the basis of existing health statistics and/or data from special surveys, and should have well-defined objectives and targets. Provision should be made for programme support with appropriate budgetary allocation, including the identification of the sources of such support. The plan should also take into consideration the required infrastructure and logistics, training of health personnel, and education of the community.

The national plan should encourage action at all levels to identify reasonable and measurable targets for the programmes. For example, an objective such as reduction in prevalence could be measured by the number of hospital admissions for the treatment of intestinal parasitic diseases during a given time period.

In functional terms, there need to be three levels of operational responsibility in a national programme:

<i>Level</i>	<i>Responsibilities</i>
Central	Overall planning and coordination Technical guidance, education and training Surveying, monitoring, and evaluation
Regional	Joint programming with all concerned

	Technical supervision, laboratory support Drug supplies, transport and logistics Information and health education
District	Implementation with full community participation in villages, schools, health centres, and hospitals

At the central, ministerial level, the programme would come under a department or division of communicable diseases control. At the regional level, it would probably be the responsibility of the provincial or state health office. At the district level, there may be several options depending on the structure of national administration; the programme might be coordinated and supervised by the district health officer, by the district hospital superintendent, or directly by a community development authority, responsible for all administration and services in the area. The aim should be to have intestinal parasitic infection and disease control well integrated with the major components of primary health care—maternal and child health, diarrhoeal disease control, nutrition, health education, water supply and sanitation.

5.4 Programme implementation

In implementing the programme, it is essential to use all available means of reaching the target groups of the population and to make the prevention and control of intestinal parasitic infections a part of the existing activities, without creating unnecessary additional services with their own staff and hierarchies.

A high degree of decentralization is necessary in order for the programme to operate through the health care system, schools, community development projects, and voluntary associations. Great care must be taken to see that all interested parties are consulted from the beginning. Therefore, their views must be sought, their support enlisted, and their continuing involvement ensured.

The mechanism envisaged for the implementation of a national programme is that WHO and national health authorities should work as partners in all stages of programme development. It is anticipated that the basic approach to be adopted by national health authorities for implementing the programme will be through their existing infrastructures, particularly through primary health care programmes for maternal and child health, environmental health, nutrition promotion, and diarrhoeal disease control, as they are available at the community level and focus on the rural and

periurban areas. A national programme would usually evolve from pre-existing activities aimed at dealing with specific problems. For a new control programme the health authorities would have to identify national personnel with the necessary competence and then motivate them appropriately. Strong national commitment and active participation of the health staff and communities concerned are important for the programme to succeed in the long run.

National and/or local conditions must be the principal determinants of the nature, scope, and elements of the programme. In other words, control programmes must be adapted to local conditions and gradually integrated into the activities of the existing health and social services at the local and national levels.

Countries may find it desirable to implement the control programme on a limited basis at first in a state, region or other subdivision, before embarking on a countrywide programme. Experience from the pilot programme will facilitate the planning of a national programme. Moreover, the planner will have a better idea of the costs involved, and there will be a cadre of experienced health workers available to train more staff.

5.5 Training, education, and dissemination of information

High priority has to be given to the training and education of national health workers. The following specific training needs are recognized:

- intercountry/interregional seminars for the motivation of senior public health and hospital administrators responsible for policy-making and of other staff;
- national/intercountry training courses for professional and auxiliary health personnel and community workers on the managerial aspects of community-oriented treatment, surveillance, water supply, sanitation, and personal and food hygiene;
- development of educational and training materials, communication equipment, and manuals for the training of health personnel in the application of control strategies and simple measures for community hygiene and sanitation;
- organization of training courses to teach laboratory workers well-established and newly devised simple, reliable, and rapid laboratory techniques;

- training of personnel in the procurement, installation, operation, maintenance, and surveillance of water supply and sanitation facilities (local expertise is needed because frequent breakdowns considerably reduce the health benefits derived from these installations); and
- development of suitable training and educational material for use at the community level and in schools.

Information and experience on the effectiveness of different strategies, especially for the delivery of chemotherapy, should be systematically collected and widely disseminated.

5.6 Programme monitoring and evaluation

The monitoring and evaluation of national control programmes should be encouraged and supported by WHO in order to ensure the progress and effectiveness of the activities that have been selected and undertaken. In evaluation, two aspects have to be considered: (a) operation, and (b) impact.

Operational evaluation is used to measure the progress of programmes against pre-established targets (e.g., for the procurement, manufacture, or distribution of drugs). Similarly, targets should be established for the installation of water supply and sanitation facilities and these should be evaluated at appropriate intervals.

Whenever possible, time schedules for the completion of parts of the programme should be established; such time schedules allow periodic evaluation of the progress of the programme and facilitate timely remedial action if problems are detected. The programme coordinator is usually responsible for evaluation.

Evaluation can be made on such operational indicators as the following:

- quality of drugs manufactured or procured, distributed, and consumed;
- number of personnel trained in the administration of the drugs;
- utilization and functioning of sanitary facilities provided or improved; and
- production of supplies and equipment (e.g., for laboratory examinations or sanitation).

Impact evaluation is important for assessing the benefits of the programme from reductions in the ill-effects of the intestinal

parasitic infections. The ultimate objective is to reduce mortality and morbidity. These may be difficult to measure because of the unavailability or unreliability of vital statistics, the need for a large population base to obtain a reliable measure of the impact of the control programme on mortality, and the tendency for aberrant increases in incidence rates to appear as surveillance is improved. Impact indicators may include:

- number of cases identified by a survey, with age-specific data, if possible;
- number of cases in hospitals, health centres, or outpatient departments;
- acceptance of community-oriented treatment by the population;
- nutritional status surveys;
- health education status at schools; and
- other parameters of local importance.

It may be possible to select representative areas of a country or region to measure the impact of the programme by collecting data before, during, and after intervention. However, it should be stressed that other variables, which cannot be easily controlled or recognized, often influence the findings. Whenever possible, neighbouring countries with common problems should share information and cooperate with each other in carrying out control measures.

These evaluation techniques complemented by surveillance information can facilitate the early recognition of problems, permitting timely corrective actions. They may also indicate a need to modify goals and objectives, to obtain additional resources, or to request technical guidance from within the country or from WHO.

5.7 Technical guidance

A national programme can and should bring together the best expertise in the country, from university departments and research institutes as well as from the health services. To do so is important, for it ensures that high standards are set and maintained not only in the parasitological, scientific, and medical work of the programme, but also in the development of educational and training material, in the conduct of social research, and in other related fields. In parasitology, the strengthening of suitable institutions may be necessary so that they can serve as reference centres.

6. PROGRAMME SUPPORT

Prevention and control programmes need support not only from national authorities but also from outside the country. This section deals only with the latter, taking it for granted that the possibilities of local support are already known. Support from outside may be available in the areas of: (a) management; (b) technical expertise (which includes research); (c) funding; and (d) exchange of relevant information.

6.1 Role of WHO

The World Health Organization can provide both technical and managerial expertise in the design and conduct of national programmes.

Technical collaboration includes: (a) provision of technical expertise; (b) organization of training programmes for staff who will implement the national programmes; (c) transfer of modern technology and up-to-date strategies; and (d) promotion and support of basic and operational research.

Managerial assistance includes: (a) promotion of functional integration of prevention and control programmes for intestinal parasitic infection into other activities; (b) encouragement of closer cooperation between countries having similar intestinal parasitic infection problems (e.g., through regional seminars); and (c) training of basic manpower (health administrators, parasitologists oriented towards public health, epidemiologists, district officers, microscopists).

In addition to this, WHO can play an important role in coordinating the activities of other agencies (e.g., UNICEF) and non-governmental organizations (e.g., JOICFP, industry) in the area of prevention and control of intestinal parasitic infections.

6.2 Technical and research organizations

A wealth of academic and practical expertise relevant to every aspect of programmes designed to prevent and control intestinal parasitic infections is available in the universities, medical schools, research institutions, and industrial companies of the world. Many

of these organizations may be persuaded to release staff for limited periods to help with particular aspects of control programmes, including:

- the development of technical training courses for programme staff;
- the design and testing of diagnostic kits;
- methods of data recording, statistical procedures, and development of computer software;
- collaboration on research projects aimed at solving specific problems linked to the programme.

Access to such experts is not straightforward and is at present likely to be based on long-standing personal contacts. Consideration might be given to the establishment of a register of organizations and their expertise for use when consultation would be beneficial. A possible mechanism for the establishment of such a register would be through the World Federation of Parasitologists, which represents most of the national parasitological societies.

6.3 Funding agencies

In addition to national research councils, which have been established in many countries, a great variety of funding agencies exist which can be approached for support of the type of research needed to sustain prevention and control programmes.

Some major agencies are:

- (a) those associated with the United Nations system, e.g., UNICEF, UNDP, WHO, and World Bank;
- (b) national agencies with international roles, e.g., Danish International Development Agency, International Development Research Centre (Canada), Overseas Development Administration (United Kingdom), Swedish International Development Authority, and United States Agency for International Development;
- (c) private foundations, e.g., the Rockefeller Foundation, the McArthur Foundation, the Wellcome Trust, the Sasakawa Foundation;
- (d) privately financed non-governmental organizations in official relationship with WHO or non-governmental organizations that operate entirely independently, e.g., JOICFP and Arab Gulf Programme for United Nations Development Organizations;

- (e) organizations based on political or regional grouping, e.g., the European Economic Community or the South-East Asian Ministry of Education Organization; and
- (f) agencies based on religious or other humanitarian groupings.

UNICEF should be particularly interested in parasitic disease control programmes in view of the high percentage of children infected with intestinal parasites throughout the developing world.

Persons concerned with parasitic infection control programmes should learn how to explain to funding agencies the nature of the disease, its harmful effect on the development of children and on the working capacity of adults, and the disability and discomfort it causes. Programme organizers should be ready to present their proposals in terms of suggested action, target population, methods of control, estimated costs, and expected results.

6.4 Industry

Large prevention and control programmes are likely to need quantities of supplies on a scale that can be provided only by industrial companies dealing in pharmaceutical products and laboratory equipment and supplies, or those having the capacity to produce and install sanitation equipment.

The research and development already undertaken by the international pharmaceutical industry have produced a range of effective and safe chemotherapeutic preparations for the treatment of ten parasitic infections, and satisfactory preparations for providing some relief against a further six infections; many of these preparations are against intestinal parasites. The impact of many prevention and control programmes will probably be increased if a manufacturer of the anthelmintic or antiprotozoal drugs of choice for a particular programme is invited to participate in planning at an early stage. The pharmaceutical industry can contribute to the programme by:

- providing guidance on the tactical use of the drug in the community in relation to the objectives of the programme;
- providing full information about the mechanism of action of the drugs, their safety record, their side-effects, and the possibility of the development of drug resistance in the parasites;
- preparing literature for the staff of the programme explaining how to use the drug;

- reviewing climatic conditions and providing information on storage conditions for the drugs;
- packaging drugs specifically for the programme with instructions for use in the appropriate form and language;
- coordinating the delivery of batches of drugs to distribution points;
- reducing the price of the drugs and providing them in the desired form and quantity throughout the programme (based on guaranteed orders);
- obtaining the necessary licences and permissions, and complying with legislation for the import of drugs and other products.

Some of the countries wishing to establish prevention and control programmes for intestinal parasitic infections may already possess dynamic pharmaceutical industries, while others may need to obtain the necessary products from the international market. It is of paramount importance, however, that any chemotherapeutic agent used in a prevention and control programme should be manufactured to the highest standards of purity and safety. Packaging can be simplified for a drug that is no longer offered through a competitive market, and this can reduce costs substantially, but savings cannot be made by compromising the safety of drugs.

The type of cooperation proposed here between programme planners and pharmaceutical manufacturers could also be extended to the companies that manufacture diagnostic kits, laboratory supplies, and other equipment needed for a prevention and control programme. Early exchange of views between the planners and industry is likely to facilitate programme planning and implementation and can prevent wastage of precious resources.

The pharmaceutical industry can contribute in many cases to the support of programmes by providing medicaments for treatment of parasitic diseases at prices affordable by health services of developing countries, as well as by individuals purchasing anthelmintic drugs for their own treatment. The question whether generic drugs can be produced locally or imported for control programmes should always be examined in view of the substantial price difference between generic drugs and those sold under brand names. The pharmacy units of ministries of health need to be well informed on these issues and should be consulted when control programmes are established or expanded.

6.5 Information flow

The success of the programme will depend on the smooth flow of information between the various levels of the health services. Statistical information on cases of intestinal parasitic infections treated in government health services is in many countries already a part of routine reporting; the countries that do not as yet report such data should be encouraged to do so. Information collected by special surveys or as a part of broader health surveys, also covering the private sector, should be published regularly, e.g., in yearly reports of the ministry of health.

The establishment of a special mechanism for making information available to the managers of control programmes is necessary. In the meantime, existing outlets for information flow and exchange such as scientific journals and national and international scientific conferences should be used. The administrators of prevention and control programmes could assist with information flow by: (a) encouraging their programme staff to publish the results of their activities; and (b) enabling them to attend relevant scientific meetings. In turn, the editorial boards of journals and the organizing committees of scientific meetings should adopt policies that encourage the submission of reports on the state of prevention and control programmes and should set aside sessions for the discussion of results.

7. CONCLUSIONS

The Committee has considered the global magnitude and the public health importance of intestinal parasitic infections and the measures available for their control. In view of the widespread and harmful effects of these infections on large sections of the world's population, the Committee concludes that the problems call for effective action to prevent and control intestinal parasitic infections at the community level through active and well-designed national programmes.

8. RECOMMENDATIONS

The Committee considers that the time is appropriate for taking action to control intestinal parasitic infections. This is now feasible at reasonable cost as a result of the development of primary health

care, based on community support and cooperation and intersectoral collaboration. The wider use of modern methods has led to a deeper understanding of the public health significance of intestinal parasitic disease, and new epidemiological insight has been gained. Moreover, more effective drugs are available and there is every chance of improving diagnostic methods through the application of molecular biological techniques.

The Committee, therefore, makes the following recommendations:

Prevention and control

1. National control programmes should be developed and linked to existing programmes in primary health care (e. g., nutrition, water supply and sanitation, maternal and child health, control of diarrhoeal diseases, school health programmes, family planning). The control of intestinal parasitic infections may also be linked to other special programmes (e. g., schistosomiasis control) where these exist.

2. National reference centres for intestinal parasitic infections should be established, designated, or strengthened. They should provide staff and facilities for the development of improved survey and control methods and, where necessary, for the precise identification of intestinal protozoan and helminth species.

3. While it may be useful to achieve short-term control of intestinal parasitic infections by individual and community-oriented treatment, short-term policies should not be used as a substitute for the provision of environmental sanitation and a clean water supply, and promotion of personal hygiene. The non-chemotherapeutic strategies, especially water supply and sanitation, should be promoted to ensure sustained long-term control.

4. It is essential to demonstrate and document the local consequences of intestinal parasitic infections on nutrition, growth, development, work output, and medical costs so as to be able to convince policy-makers and administrators of the advantages of control programmes.

5. WHO should attempt to develop standardized forms for record-keeping, which is an essential component of control programmes at all levels of implementation.

6. Since the transmission and persistence of intestinal parasitic infections are influenced by human behaviour and culture,

appropriate health education measures should be applied at all levels of programme implementation.

7. In view of the profound impact of these infections on the health of children and the family, the special role of women in the control of intestinal parasitic infections should be recognized and enhanced.

Technical guidance

8. Before diagnostic techniques are selected, the relative reliability of the various diagnostic methods should be tested and assessed by those who will use them.

9. Microscopes and other equipment necessary for reliable and accurate diagnosis should be made available and should be of adequate quality.

10. New methods of stool preservation and examination should be investigated and tested under local conditions in order to improve the accuracy of parasite identification in population surveys. Methods of stool collection should provide for the culture of hookworm larvae when species identification is needed.

11. A quantitative diagnosis, using egg counts by an appropriate method, should be regarded as essential for the interpretation of prevalence data on helminthic infections. Such data on egg counts should be regarded as relative measures of intensity of infection, in terms of light, moderate, and heavy parasite loads.

Training

12. Training programmes, such as those developed by WHO, need to be continued and extended; success in prevention and control in Member States will not be achieved without adequately trained public health workers.

13. Parasitologists, especially protozoologists, and epidemiologists should be trained specially for public health programmes.

14. Laboratory technicians should be trained to identify all major intestinal protozoan and helminth parasites. During their training, laboratory technicians should also be instructed in the biology, pathology, and prevention and control of intestinal parasitic infections.

15. Appropriate systems of quality control and retraining in microscopical diagnosis should be developed. Microscopical

diagnosis deserves more attention in the training of general laboratory technicians, and whenever possible, microscopy should be a recognized specialty in their careers.

16. Better teaching and learning aids need to be developed in parasitology and made available in medical schools and other training institutions for health staff.

Field and clinical investigations

17. A special effort should be made to identify and support research workers and institutions in developing countries that could carry out operational and biomedical research on intestinal parasitic infections.

18. Research funding agencies should support more operational research in order to help design the most efficient and feasible control programmes.

19. In addition to research on ways of improving the cost-effectiveness of prevention and control programmes, the following issues should be studied further:

- methods of selecting target groups for chemotherapy;
- the effects on local transmission of measures to control intensive infections;
- the identification and testing of transmission breakpoints in urban and rural areas; and
- the economics of alternative control programmes and delivery systems.

20. Control strategies should be based on the most appropriate form of chemotherapy for each epidemiological situation. This involves selecting the appropriate drug, dosage and regimen, and considering the availability of manpower and funds.

21. Epidemiological investigations of amoebiasis, giardiasis, and cryptosporidiosis are needed in order to prevent and control these infections better.

22. Environmental studies on the transmission of helminths, especially egg survival times and the distribution of invasive stages in the environment, should be encouraged and intensified.

23. In cases of mixed helminth infections the efficacy of broad-spectrum anthelmintics needs to be evaluated further.

24. The efficacy of praziquantel in the control of fasciolopsiasis and of taeniasis and cysticercosis caused by *Taenia solium* should be assessed in community-oriented projects.

25. The dynamics of *Strongyloides* multiplication in the human intestine and the development of the hyperinfective syndrome should be investigated further; studies should also be carried out on the effectiveness of the diagnostic and treatment methods used for strongyloidiasis in different parts of the world.

26. The pathology of fasciolopsiasis requires further investigation.

Laboratory research

27. Improved diagnostic techniques are needed for strongyloidiasis, taeniasis and cysticercosis caused by *Taenia solium*, and cryptosporidiosis. Improvements need to be made in the techniques of selective staining of protozoa, and methods for the detection of faecally eliminated antigens need to be made available for field use.

28. Methods should be developed for the detection of parasite antigens in stool and serum through the use of monoclonal antibodies and recombinant DNA techniques. The sensitivity, specificity, and feasibility of different biotechnical procedures should be compared.

29. Simplified techniques need to be developed for analysing strain differences of pathogenic intestinal protozoa for use in epidemiological work.

30. The development of safe, more effective, and less expensive drugs, ideally for use in single-dose regimens, should be encouraged.

31. Better *in vitro* systems and animal models for intestinal parasitic infections should be developed for immunological and pathological studies and for trials of drug efficacy.

32. The encystation and excystation processes of *Entamoeba* and *Giardia* should be studied to facilitate the development of chemical and physical cysticides.

33. Studies should be carried out on the nature of immunity, particularly gut-associated immunity, against intestinal parasitic infections and on ways of enhancing the immune response against them.

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