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The Challenge of Parasitic Worms

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THE CHALLENGE OF PARASITIC WORMS

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INTRODUCTION

The bequest from James Henry Montgomery to the University of Nebraska invites the Montgomery Lecturer to stimulate constructive thought on contemporary problems. Endangered species, AIDS, pollution, population growth, rain forests, nuclear power, cycles of famine, surrogate motherhood, global warming, greenhouse effects, drug addiction and the use of human embryos *in vitro* are some of the contemporary problems for a biologist to tackle. Each topic understandably has a high profile and a lecturer can expect a well-informed audience.

A strong case can be made for adding the scourge of parasitic disease to this catalogue. Half the world's population endures a massive burden of illness described by Myron Schultz as the forgotten problems of forgotten people. It seems almost unbelievable, but our best estimates indicate that over half the world's population is plagued by four species of parasitic worm. Millions of poor people harbor two or even three species of worms simultaneously. Who are these people? Where do they live? How much do they suffer? Is their suffering necessary? Can they be helped to control and prevent these infections? How can we help from our situation in the developed countries? Can we meet the challenge of parasitic worms?

SOIL-TRANSMITTED HELMINTHIASES

Three hundred forty-two species of worms have been found living in the human host and 197 are known from the human gastrointestinal tract (Coombs and Crompton, 1991). Of the commonly occurring intestinal species, *Ascaris lumbricoides* (roundworm), *Ancylostoma duodenale* and *Necator americanus* (hookworms) and *Trichuris trichiura* (whipworm) are exceedingly abundant (Table I). These parasites are rarities nowadays in the industrialized countries of the developed world like the U.K. and U.S.A. For example, in the U.K. about 1000 cases of *Ascaris lumbricoides* infection are reported annually from a population of 56 million (Owen, 1986), but three hundred years ago a London physician wrote about "that common roundworm with which children are usually troubled" (Tyson, 1683). In developed countries, access to supplies of clean drinking water, the availability of health services, effective health education, the safe disposal and treatment of sewage and refuse, the relative conquest of poverty and the release of the population from dependence on subsistence farming have steadily brought the soil-transmitted helminthiases under control. In developing countries the situation recorded by Tyson for 17th-century London is part of everyday life. Parasitic worms flourish wherever poverty, malnutrition and socio-economic deficiencies are deeply rooted.

Roundworms, hookworms and whipworms are known as soil-transmitted or geohelminths because each species must spend an obligatory period of development on the soil, free from its host (Table I).

Table I. Common endoparasitic helminths from the human gastrointestinal tract.

Parasite	Life history	Transmission[a]	Infective stage	Cases (millions)[b]	General reference
Platyhelminthes (flatworms)					
Digenea (flukes)					
Fasciolopsis buski	Indirect	Or	Metacercaria	15	Chandra (1976)
Eucestoda (tapeworms)					
Diphyllobothrium latum	Indirect	Or	Plerocercoid	16	von Bonsdorff (1978)
Taeniarhynchus saginatus (= *Taenia saginata*)	Indirect	Or	Cysticercus	76	Pawlowski and Schultz (1972)
Vampirolepis nana (= *Hymenolepis nana*)	Direct	Au/Or	Egg (oncosphere)	29	Sahba et al. (1967)
Nematoda (roundworms)					
Ascaris lumbricoides	Direct	Or	Egg (2nd larva)	1000	Crompton (1989a)
Enterobius vermicularis	Direct	Or	Egg (1st larva)	360	Marcus (1982)
Necator americanus (and *Ancylostoma duodenale*)	Direct	Cu (Cu, Or, TM, TP)	3rd larva (3rd larva)	700-900	Schad and Warren (1990)
Strongyloides stercoralis	Direct	Au/Cu	1st/2nd larva	70	Grove (1989)
Trichinella spiralis	Direct	Or	2nd larva	49	Steele (1982)
Trichuris trichiura	Direct	Or	Egg (1st larva)	500-800	Bundy and Cooper (1989)

[a]Au, autoinfection; Cu, cutaneous; Or, oral; TM, transmammary; TP, transplacental.
[b]Estimates obtained from Bruer (1982), Cooper and Bundy (1988b), Crompton (1988a), Peters and Gilles (1989), Walsh and Warren (1979).

Each species has a direct life-history pattern, each is dioecious, no asexual phase of reproduction is known and each appears to be highly host specific for humans (Table I); there are no known reservoir hosts of any importance.

PUBLIC-HEALTH SIGNIFICANCE

Even in the world's prosperous communities and countries resources for health care are limited (UNICEF, 1990); there is competition to meet needs and priorities for action have to be set. The quality of the information available to policy makers is variable; in the U.S.A. efficient standards of reporting have been established and the data are readily available for discussion (Table II). These facilities are not available in every country, but progress can be achieved in making an assessment of the public-health significance of parasitic disease by use of a scheme proposed by Walsh and Warren (1979) with modifications based on the ideas of Jancloes (1989) and Trainer (1989) (Table III).

Information about (1) the epidemiology of soil-transmitted helminths, including parasite population biology, (2) the nature and severity of disease and (3) the prospects and benefits of control formed the main body of the lectures. The economic costs of disease and control measures have been largely ignored although these aspects are becoming a matter of debate despite the difficulties that have been encountered in their investigation (Morrow, 1984).

Table II. The burden of circulatory disease in U.S.A. 1977: an example of health information that can be used in assessing public-health significance and setting priorities. Statistical data obtained from U.S. National Center for Health Statistics. (Reproduced from Walsh, 1984).

Potential years of life lost	11,678,000
Number of deaths	978,343
Days short-stay in patient care	49,007,000
Number of physician-office visits	54,202,000
Number of work-loss days	40,006,000

Table III. A framework for assessing the public-health significance of intestinal helminth infections [Developed from the schemes proposed by Walsh and Warren (1979), Jancloes (1989) and Trainer (1989).].

1. EPIDEMIOLOGICAL ASPECTS
Estimates of numbers of cases
Distribution of numbers of cases
Estimates of infection intensities
(Helminth population biology)

2. DISEASE ASPECTS
Pathology
Morbidity rates
Mortality rates
(Social and economic consequences)

3. CONTROL ASPECTS
Available measures and feasibility
Costs
Direct and indirect benefits
(Costs of not controlling)

Epidemiological aspects

Although counting cases is the basic function of epidemiology (Schultz, 1985), estimates like those shown in Table I do little more than draw attention to the existence of a potential problem. It is more useful to describe the geographical distribution and related abundance of an infection. In the case of *A. lumbricoides,* there is evidence to show that humans are infected in 151 of the world's 208 countries (CDC, 1985; Crompton, 1988b) and a similar distribution probably exists for hookworms and *T. trichiura.*

The distribution of soil-transmitted helminths is often discussed in terms of prevalence which is the proportion (percentage) of hosts found to be infected at the time of the survey. Diagnosis is usually made by the detection of helminth eggs in stool samples (Theinpont et al., 1986) and the results can be displayed graphically to illustrate the relationship between prevalence and host age (Fig. 1). Typically, *A. lumbricoides* and *T. trichiura* are assumed to be acquired by young infants with peak prevalence values being observed by the time children are aged 10 years whereas hookworm infections tend to be acquired more gradually with peak prevalence values being observed later (Fig. 1). Hookworm species cannot reliably be distinguished by conventional microscopic examination of eggs (W.H.O., 1981), but in most regions *N. americanus* is much commoner than *A. duodenale* although mixed infections and single infections with *A. duodenale* occur not infrequently (Schad, 1990).

The study of prevalence data shows that soil-transmitted helminths have a patchy distribution within countries and within districts of a country. *Ascaris lumbricoides* is endemic in Nigeria, but prevalence values vary from 0.9 to 98.2% (Crompton, 1988b). In a study of four similar villages in Ghana, Annan et al. (1986) found the prevalence values for *A. lumbricoides* infection in preschool children to be 76, 42, 33 and 0% in the four villages. Goldsmid et al. (1976) could not detect *A. lumbricoides* in a sample of 595 people in Zimbabwe although *T. trichiura* was present. Climate (Carrie, 1982), season (Gelphi and Mustafa, 1967), housing (Holland et al., 1988), social status (Chiwuzie, 1986), ethnicity (Pampiglione and Ricciardi, 1974), altitude (Meakins et al., 1981) and family (Williams et al., 1974) are factors that can be correlated with the distribution and prevalence of *A. lumbricoides* infection. These points about prevalence illustrate the need to obtain detailed epidemiological data before establishing programs for the prevention and control of soil-transmitted helminthiases in a region (W.H.O., 1987).

The application of mathematical techniques to studying the population biology, epidemiology, immunity and control of soil-transmitted helminthiases has demonstrated that the intensity of the infection is the most important variable to measure and monitor (Anderson 1982, 1986). Intensity is defined, depending on the objectives of the investigation, as either the number of worms per person or the number per infected person and it is measured directly by counting the number of worms expelled in the stools following anthelmintic chemotherapy or indirectly by counting the number of eggs per gram (e.p.g.) of stool. Generally, the higher the e.p.g., the greater will be the number of adult female worms present,

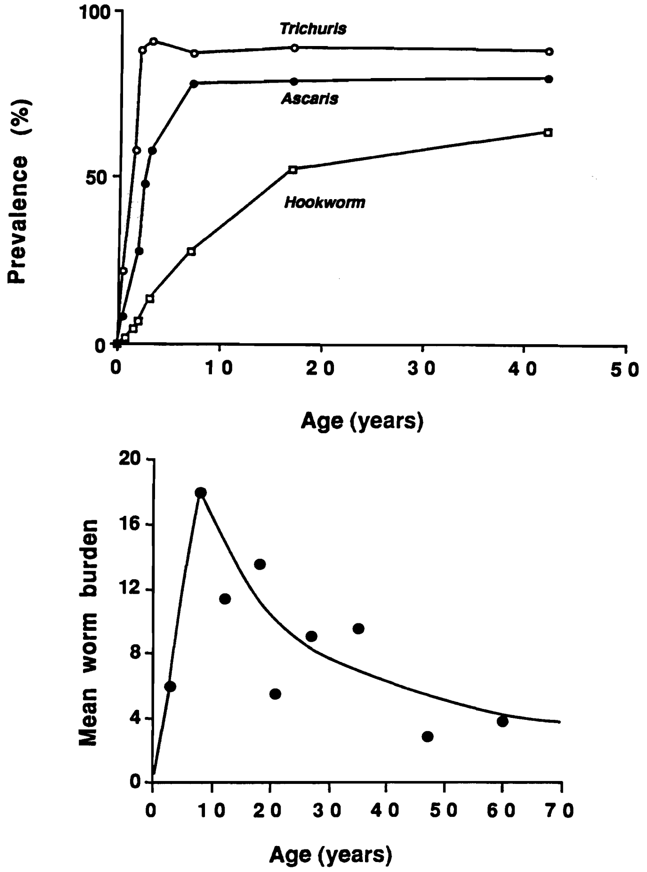

Figure 1–2: 1. Relationship between host age and the prevalence of infections of *Ascaris lumbricoides*, hookworms and *Trichuris trichiura*. These data represent the findings from a cross-sectional survey in which the results are arranged by age class. (From Bundy, 1990, Fig. 10.1). 2. Relationship between host age and the intensity of *Ascaris lumbricoides* infection measured as the number of worms passed following effective chemotherapy. (Redrawn from Thein Hlaing, 1985, Fig. 6).

although this relationship may be upset by density dependent effects (Thein Hlaing et al., 1984). Intensity affects transmission and parasite survival and also human health since the severity of disease tends to increase as the number of worms present increases. The objective of programs for the control of soil-transmitted helminthiases must be the lowering of the intensity of infection (see Davis, 1989).

Typical relationships between host age and the intensity of infection of *A. lumbricoides*, hookworms and *T. trichiura* are shown in Figures 2, 3, and 4. Apparently children require considerably higher burdens of *A. lumbricoides* and *T. trichiura* than adults (Figs. 2 and 4) whereas adults will usually carry more hookworms. There are exceptions to these generalizations, notably in the case of *A. lumbricoides* which has occasionally been observed to infect adults more heavily than children (Arfaa and Ghadirian, 1977; Beattie et al., 1990).

Studies of the intensity of soil-transmitted helminthiases have shown that the numbers of worms per host are not distributed at random in the infected population. Usually, many individuals in the community harbor a few worms each while a few people are found to be heavily infected (see Crompton, 1988a). The worms are overdispersed or aggregated and their observed distribution is best described by the negative binominal distribution (Anderson, 1986). Furthermore, reinfection studies following chemotherapy have provided statistical evidence to show that individuals are, in some as yet unexplained manner, predisposed to particular infection intensities (Schad and Anderson, 1985; Bundy,1986; Thein Hlaing et al., 1987, Holland et al., 1989).

Disease aspects

Common clinical features and health consequences of ascariasis, hookworm disease and trichuriasis are summarized in Tables IV, V and VI. The major impact of chronic ascariasis and trichuriasis is some degree of impairment of childhood nutritional status (ACC/SCN, 1989) since children harbor most worms (Figs. 2 and 4). Acute ascariasis is a significant public health matter for children because of abdominal complications requiring hospital admission and surgery (Pinus, 1985; Pawlowski and Davis, 1989).

Hookworm infections cause or exacerbate iron-deficiency anemia (Crompton and Stephenson, 1990) with individual *A. duodenale* causing greater blood loss than individual *N. americanus*. The public-health significance of hookworm disease and

Table IV. Features of *Ascaris lumbricoides* infection (ascariasis). (Based on Stephenson, 1987, Table 4.1).

Life history events	Clinical features	Effects on health[a]
1. Larval migration through liver and lungs	Pneumonitis, eosinophilia, fever, skin rash, range of allergic reactions	Decrease food intake, increase nitrogen loss
2. Adult worms in small intestine (chronic)[b]	Abdominal pain, colic, nausea, disordered small bowel pattern, mucosal abnormalities	Decrease food intake, malabsorption, temporary lactose intolerance, increase nutrient excretion
3. Aggregations and migrations of adult worms (acute)	Biliary obstruction, hepatic abscess, intestinal obstruction, intussusception, pancreatitis, perforation and peritonitis, volvulus, worms in ectopic sites (ear, heart, thorax, vagina)	Life-threatening complications, often needing hospital admission: mortality rate unknown, perhaps 100,000 per annum (Pawlowski and Davis, 1989)

[a]See also reviews by Crompton (1985, 1986), Holland (1989), Stephenson (1984), Taren and Crompton (1989).

[b]There is considerable evidence to show that chronic ascariasis contributes to the development and persistence of some degree of malnutrition and reduced growth rate in children (Willett et al., 1979; Stephenson et al., 1980a; Thein Hlaing, 1989; ACC/SCN, 1989).

the associated iron deficiency anemia can be put into an economic perspective because reduced worker productivity (Basta et al., 1979; Wolgemuth et al., 1982; Crompton, 1986) can be measured and quantified and healthy days of life lost can be estimated (Morrow, 1984). Results of attempts to calculate the value of nutrients lost and the cost to the population of health care for childhood ascariasis in Kenya were published by Stephenson et al. (1980b) who concluded that the disease cost that country about 5 million U.S. dollars in 1979.

Control aspects

The availability of safe, effective and affordable control measures must be considered when public health priorities are identified. A range of control measures for soil-transmitted helminthiases is available based on chemotherapy, sanitation, and health education.

Chemotherapy. The World Health Organization regularly issues a list of essential drugs (W.H.O., 1990a) and prescribing instructions (W.H.O., 1990b). These publications include information about the proper use of a selection of anthelmintic drugs that have been developed by the research-based pharmaceutical industry. In addition to having an impressive safety record and a low incidence of reports of side effects, a single oral dose of an ideal anthelmintic drug should expel all the intestinal stages of *A. lumbricoides*, hookworms and *T. trichiura*. Nor surprisingly, the manufacturers' promotion-literature often describes a drug as having broad spectrum activity and impressive egg reduction and cure rates are presented. Scrutiny of the vast literature on anthelmintic drug trials (see Janssens, 1985) shows that genuine broad spectrum activity is rarely observed. However, all WHO-recommended, modern anthelmintic drugs are highly efficacious for the treatment of ascariasis and each has a differing level of effectiveness against *A. duodenale*, *N. americanus* and *T. trichiura*.

Anthelmintic drugs offer a means of making rapid progress in the control of soil-transmitted helminthiases in the community. In addition to the treatment of individual cases who may report to clinics and dispensaries, communities may receive anthelmintic drug by means of mass, targeted or selective treatment (Fig. 5). These forms of drug application have emerged from the mathematical approach developed by Anderson (1989) to plan for the disruption of helminth transmission. Given that epidemiological data have been obtained and interpreted (W.H.O., 1987), mass treatment ought to incur low technical costs since the drug is made available to any member of the community irrespective of age, sex, infection status or social situation. Targeted treatment indicates that the drug is offered to a group within the community. In areas endemic for soil-transmitted helminthiases, children of

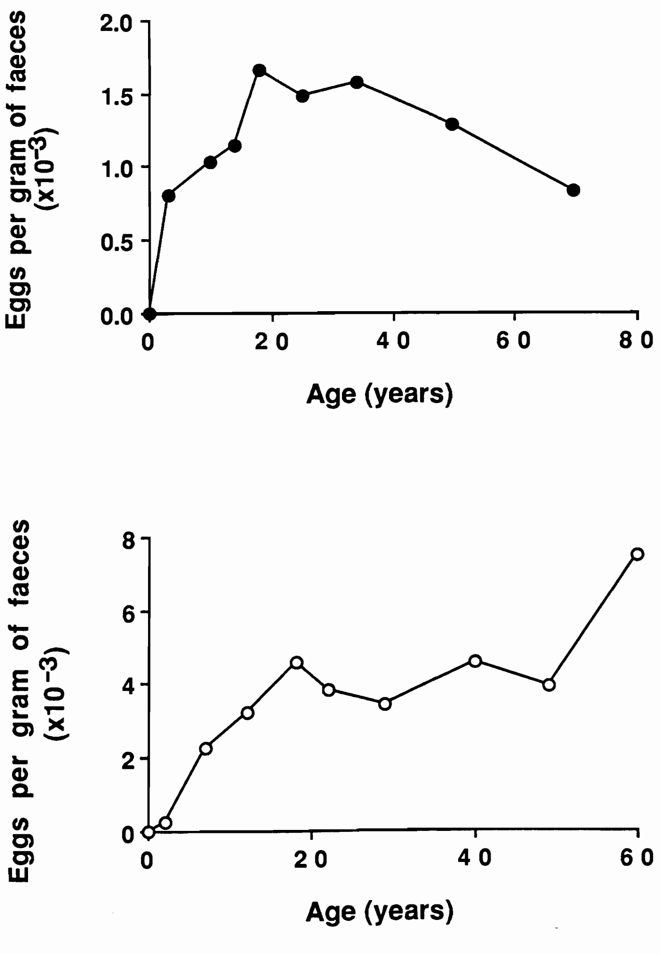

Figure 3. Two forms of the relationship between host age and the intensity of hookworm infections measured as eggs per gram feces (e.p.g.). (From Bundy 1990, Fig. 10.4).

primary-school age form an important target group, especially for the control of ascariasis and trichuriasis (Figs. 2 and 4, Tables IV and VI) and schools may be used as drug delivery centers (Stephenson et al., 1983; Bundy et al., 1990). Selective treatment involves giving the drug to the relatively few individuals known to be heavily infected or to have a history of heavy infection. Selective treatment is likely to incur high technical costs because the heavily infected individuals must be identified initially and sought out when each dose of drug is due. The intervals between doses and the period over which the chemotherapy should be applied to achieve desired low levels of infection intensity can be calculated on the basis of the mathematical framework (Anderson, 1989).

A recent study by Asaolu and colleagues in rural Nigeria compared the effectiveness of mass, targeted and selective chemotherapy in lowering the intensity of soil-transmitted helminth infections (see Crompton, 1990). The results for the effects of these treatments on the intensity of *A. lumbricoides* infections are shown in Table VII. Mass treatment appeared to have the greatest effect while selective treatment, although highly beneficial for the treated individuals, had little overall effect. In fact, considerable difficulty was encountered in explaining to untreated villagers the rationale of selective treatment. Targeted treatment provided the most interesting results (Table VII). Intensity fell significantly not only in the high-risk group of primary-school age children (Fig. 2), but also in other inhabitants of the village who made up about 60% of the community and did not receive treatment. The fall in intensity in the untreated villagers may be explained by assuming either a genuine disruption in transmission of *A. lumbricoides* or a stimulation in the community to seek help and medication on seeing the beneficial effects in the children. There was no evidence in support of the latter explanation, although self-help for any health care must always be encouraged.

The possibility of using multi-drug chemotherapy against parasites is under discussion. Millions of people are concurrently infected with the debilating blood flukes or schistosomes, with filarial worms including *Onchocerca volvulus* which causes river blindness, as well as with soil-transmitted helminths (Warren et al., 1990). This attractive scheme requires further research to discover whether 3 different types of drug can be given simultaneously and to investigate how the various combinations of candidate drugs and their metabolites might interact after absorption into the body (W.H.O., 1990c).

Sanitation and hygiene. General experience shows that all the advantages gained by the use of anthelmintic chemotherapy against soil-transmitted helminthiases can be reversed within about a year due to the reinfection that occurs once drug treatment is stopped. Recent evidence suggests that even higher infection intensities may develop following cessation of chemotherapy as a result of reinfection (Thein Hlaing et al., 1987). There will be no permanent respite from the burden of intestinal diseases be they due to viruses, bacteria, protozoa or helminths, until culturally acceptable, functional and affordable sanitation systems are provided for the collection, treatment and disposal of human excreta (Kilama, 1985; Cairncross, 1990; Pickford, 1991). Furthermore, the treatment of "night soil" to destroy parasite stages before use as agricultural fertilizer must be encouraged (Kagei, 1986); hygiene at work in the community and home must be improved (Sridhar, 1991); and the supply and management of water resources must be developed (W.H.O., 1987). These measures, which are expensive and slow to take effect, provide the means for sustaining the effects of anthelmintic chemotherapy and ultimately of preventing the persistence of intestinal infections in the environment.

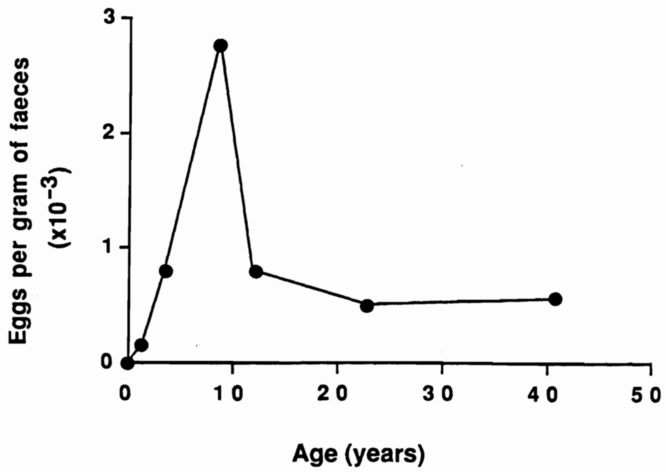

Figure 4. Relationship between host age and the intensity of *Trichuris trichiura* infection measured as eggs per gram feces (e.p.g.). (From Bundy and Cooper 1989, Fig. 7).

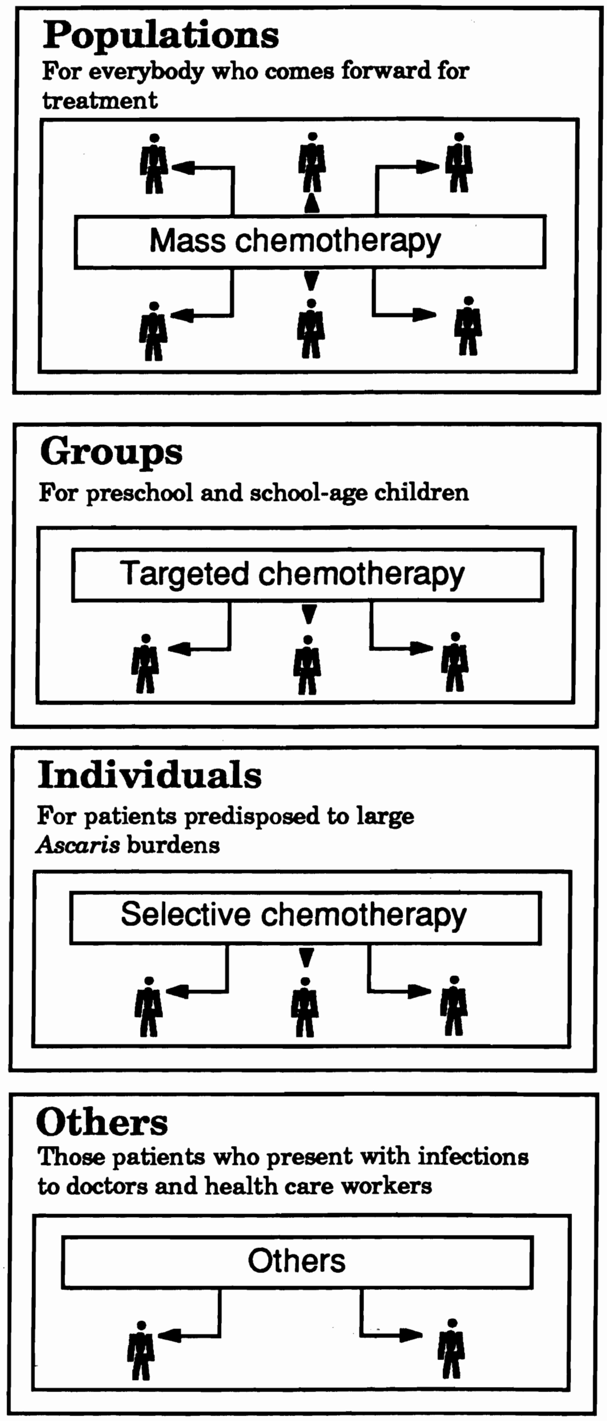

Figure 5. Diagrammatic representation of different methods of using drugs in the community for the control of soil-transmitted helminthiases. (Developed from definitions offered by Anderson [1989] and reproduced in Parasitology News, I.C.I. Pharmaceuticals).

Table V. Features of *Ancylostoma duodenale* and *Necator americanus* infections (hookworm disease). (Based on Crompton and Stephenson, 1990, Table 15.2)

Life history events	Clinical features	Nutritional consequence
Cutaneous invasion and subcutaneous migration of filariform larvae	Ground itch: dermatitis, blisters, macules, papules	? Decrease food intake
Migration of the larvae through the lungs, bronchi and trachea to esophagus	Coughing, wheezing, bronchitis, pneumonitis, eosinophilia	? Decrease food intake
	Wakana disease associated with nausea, vomiting	Decrease food intake Increase nutrient excretion
Attachment of adult worms to the upper intestinal mucosa	Epigastric pain and tenderness	Decrease food intake
	Peptic symptoms: anorexia pica	Decrease food intake; Decrease nutrient absorption (if clays with calcium are eaten)
Acute infection	Nausea, vomiting, diarrhea, occasionally massive intestinal-haemorrhage	Decrease food intake Increase nutrient excretion Increase nutrient loss (iron, vitamin B12, folic acid, protein)
Chronic infection[a]	Chronic intestinal blood-loss and chronic iron-deficiency anemia leading to high-output, cardiac failure, excretional dyspnoea, apathy	Increased nutrient loss (iron, vitamin B12, folic acid, protein) ? Decrease food intake
	Protein-losing enteropathy: hypopoteinaemia oedema	? Increased nutrient loss

[a]Chronic intestinal blood loss leads to iron deficiency anemia (Roche and Layrisse, 1966; Crompton and Stephenson, 1990) which, together with nutritional problems, may affect childhood cognitive performance (Pollitt et al., 1985), human reproductive capacity (Yusufji et al., 1973), childhood physical fitness (Stephenson et al. 1990) and adult worker productivity (Basta et al., 1979; Wolgemuth et al., 1982).

Health education. Even if chemotherapy is available and even if appropriate sanitation has been provided, the successful control and eventual prevention of soil-transmitted helminthiases will require more support for health education (W.H.O., 1983). People need to know how infections become established, how they can be avoided, how to cope with an infection and how to construct, maintain and use latrines properly. Changes in behavior patterns that have emerged over centuries may be required. Although given little space in this discussion, the provision of conditions for the attainment of health education and knowledge represents a major action for the control of soil-transmitted helminthiases. In 1978, the Alma-Ata Declaration identified education concerning prevailing health problems and the methods of preventing and controlling them as the first essential activity of primary health care.

RECENT APPROACHES TO THE CONTROL OF SOIL-TRANSMITTED HELMINTHIASES

Ascariasis has been brought under control in Japan (Yokogawa, 1985) and progress has been made in Israel, South Korea and Taiwan (Schultz, 1985; Shuval et al., 1985). During a period of 75 years, the Rockefeller Foundation has funded and directed work around the world in an attempt initially to eradicate hookworms and later to under-

Table VI Features of *Trichuris trichuria* infection (trichuriasis). (Based on Holland, 1987, Table 6.1).

Type of infection	Clinical features	Nutritional consequence[a]
Sensitized individuals	Non-specific allergic responses such as: nervousness, anorexia, urticaria	Decrease food intake
Light infection	Not well documented	Unknown
Moderate infection	Allergic symptoms	? Decrease food intake
	Epigastric and lower abdominal pain	Decrease food intake
	Diarrhea (rarely bloody)	Decrease food intake
	Vomiting	Increase nutrient loss
	Flatulence and distention	? Decrease food intake
	Headache	
	Weight loss	Decrease food intake
	Anemia in malnourished children	Increase blood loss and iron loss
	Blood diarrhea with profuse mucus	Increase blood, iron and other nutrient losses
Heavy infection (usually children)	Abdominal pain and tenesmus	Decrease food intake
	Weight loss leading to cachexia	Decrease food intake
	Severe anemia	Increase blood loss and iron loss
	Clubbing of fingers	? Decrease food intake
	Moderate eosinophilia	

[a]For a detailed discussion of all clinical aspects of trichuriasis, the reader should consult Bundy and Cooper (1989).

Table VII. General effects of chemotherapy strategies on the intensity of *Ascaris lumbricoides* in rural communities in Oyo State, Nigeria[a]

Village	Participants[b]	Chemotherapy[c]	Mean e.p.g.[g] Before	After	Significance[h]
1	288	Control	7500	4700	N.S.
2	185	Selective[d]	6800	4250	N.S.
3	211	Targeted[e]	9000	2600	P<0.0001
4	224	Mass[f]	12000	1500	P<0.0001

[a]Study carried out by S.O. Asaolu, D.W.T. Crompton and C.V. Holland.

[b]Number of subjects providing stools before and after treatment

[c]Chemotherapy consisted of four doses of levamisole (Ketrax, I.C.I. Pharmaceuticals) given at 3-monthly intervals according to the strategies shown in Figure 5.

[d]Treatment provided for the individuals making up the 20% with the heaviest infections.

[e]Treatment provided for children aged from 2–15 years.

[f]Treatment provided for any willing individual, but not for pregnant women or children under 2 years of age.

[g]Intensity was measured indirectly by egg counts; the values have been rounded up or down and standard deviations omitted for clarity.

[h]N.S., not significant, p >> 0.05.

Table VIII. Some indicators of the effects of integrated programs (after Trainer, 1989).

DIRECT EFFECTS

- Quantitative
  - Increase in family planning acceptance rates
  - Decline in intestinal parasite infection rates
  - Increased number of nutrition activities
  - Increase in contributions from government
  - Increase in number of volunteers for health programs
  - Increased construction and usage of latrines
- Qualitative
  - Increase in people's interest in project
  - Increase in people's demand for services
  - Increase in worker's credibility
  - Increase in community participation

INDIRECT EFFECTS

- Quantitative
  - Increased practice of breast feeding
  - Increased construction of safe water systems
  - Increased usage of regular health facilities
  - Reduced malnutrition levels
  - Reduced absenteeism in schools
  - Increased labor productivity
- Qualitative
  - Development of income generating activities
  - Increased skills of community in care of own health

stand how better to control hookworm disease (Crompton, 1989b; Ettling, 1990). There is little likelihood that developing countries will be able to afford large-scale public-health programs directed solely at controlling soil-transmitted helminthiases. There may be opportunities, however, to develop integrated programs and to use the control of soil-transmitted helminthiases, especially ascariasis, as a means of introducing and strengthening primary health care.

The Japanese Organization for International Cooperation in Family Planning (JOICFP) has organized a series of integrated programs combining family planning with nutrition and parasite control (Kunii, 1983). JOICFP projects have been organized in Africa, Asia, and Latin America and in each case the availability of parasite control serves to draw the community into the program (see Trainer, 1985). The same basic strategy is being used to promote primary health care programs. Measures for ascariasis control have strong direct links with most of the essential elements of primary health care which include health education, sanitation, proper nutrition, maternal and child health, appropriate medical care, approved available drugs and community preventive activities. Operational research has shown that the establishment of ascariasis control within either integrated programs or the primary health care system is accompanied by a range of other health benefits (Table VIII; Jancloes, 1989). Communities may not enjoy these benefits if the control of soil-transmitted helminthiases is ignored.

CONCLUSION

No one need doubt that intestinal-parasitic worms are widespread agents of disease Decisions about implementing available control measures depend on the policies and priorities of the governments concerned. We may be concerned and saddened to know that so much suffering exists while opportunities to respond seem so remote. The University of Nebraska and other institutions can help now to meet the challenge of parasitic disease. The University of Nebraska has an established tradition and international reputation for first-class work in the subject of parasitology. This body of knowledge needs to be extended, shared, and applied not only through the books and articles of its staff and researchers, but also through courses of instruction for students from both developed and developing countries who will go to use their knowledge where parasitic disease is entrenched. Short courses in parasite diagnosis, computing, project administration and survey design will enhance the skill, status and morale of medical and paramedical professionals from Africa, Asia and Central and South America. Members of the faculty can collaborate with institutions and agencies in developing countries in applied research projects and in the design and presentation of training courses. Funds for these activities will have to be identified; equipment, books, living and travel expenses, and tuition fees require financial support. Nevertheless, this is one approach to meet the challenge of the parasitic worms.

It is with very much pleasure that I thank the University of Nebraska for inviting me to visit the Campus and give the Montgomery Lectures for 1990. The friendship and warm hospitality of the staff and students at UNL will always be remembered.

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