ABSTRACT

The control of parasitic diseases of humans has been undertaken since the aetiology and natural history of the infections was recognized and the deleterious effects on human health and well-being appreciated by policy makers, medical practitioners and public health specialists. However, while some parasitic infections such as malaria...
have proved difficult to control, as defined by a sustained reduction in incidence, others, particularly helminth infections can be effectively controlled. The different approaches to control from diagnosis, to treatment and cure of the clinically sick patient, to control the transmission within the community by preventative chemotherapy and vector control are outlined. The concepts of eradication, elimination and control are defined and examples of success summarized. Overviews of the health policy and financing environment in which programmes to control or eliminate parasitic diseases are positioned and the development of public–private partnerships as vehicles for product development or access to drugs for parasite disease control are discussed. Failure to sustain control of parasites may be due to development of drug resistance or the failure to implement proven strategies as a result of decreased resources within the health system, decentralization of health management through health-sector reform and the lack of financial and human resources in settings where per capita government expenditure on health may be less than $US 5 per year. However, success has been achieved in several large-scale programmes through sustained national government investment and/or committed donor support. It is also widely accepted that the level of investment in drug development for the parasitic diseases of poor populations is an unattractive option for pharmaceutical companies. The development of partnerships to specifically address this need provides some hope that the intractable problems of the treatment regimens for the trypanosomiases and leishmaniases can be solved in the not too distant future. However, it will be difficult to implement and sustain such interventions in fragile health services often in settings where resources are limited but also in unstable, conflict-affected or post-conflict countries. Emphasis is placed on the importance of co-endemicity and poly parasitism and the opportunity to control parasites susceptible to cost-effective and proven chemotherapeutic interventions for a package of diseases which can be implemented at low cost and which would benefit the poorest and most marginalized groups. The ecology of parasitic diseases is discussed in the context of changing ecology, environment, sociopolitical developments and climate change. These drivers of global change will affect the epidemiology of parasites over the coming decades, while in
many of the most endemic and impoverished countries parasitic infections will be accorded lower priority as resourced stressed health systems cope with the burden of the higher-profile killing diseases viz., HIV/AIDS, TB and malaria. There is a need for more holistic thinking about the interactions between parasites and other infections. It is clear that as the prevalence and awareness of HIV has increased, there is a growing recognition of a host of complex interactions that determine disease outcome in individual patients. The competition for resources in the health as well as other social sectors will be a continuing challenge; effective parasite control will be dependent on how such resources are accessed and deployed to effectively address well-defined problems some of which are readily amenable to successful interventions with proven methods. In the health sector, the problems of the HIV/AIDS and TB pandemics and the problem of the emerging burden of chronic non-communicable diseases will be significant competitors for these limited resources as parasitic infections aside from malaria tend to be chronic disabling problems of the poorest who have limited access to scarce health services and are representative of the poorest quintile. Prioritization and advocacy for parasite control in the national and international political environments is the challenge.

1. CONTROL OF PARASITIC DISEASES

1.1. Concepts of Control, Elimination and Eradication

A distinction must be made between the terms ‘control’, ‘elimination’ and ‘eradication’; the latter term is often used inappropriately and it should be employed with caution. The International Task Force for Disease Eradication (ITFDE) was established in 1988 to evaluate systematically the potential for eradication of candidate diseases and to identify specific barriers to eradication. The criteria used to assess the feasibility of eradication are provided in Table 1. The Task Force was reconstituted in 2001 to evaluate the current situation. The ITFDE defined eradication as ‘reduction of the world-wide incidence of a disease to zero as a result of deliberate efforts obviating the
necessity for further control measures’. The original ITFDE reviewed more than 90 diseases, 30 of them in depth, and concluded that dracunculiasis, rubella, poliomyelitis, mumps, lymphatic filariasis and cysticercosis could probably be eradicated using existing technology. The term ‘elimination’ is increasingly being used to replace the term ‘eradication’, which should be only used in Global terms. The Dahlem conference held in Berlin in 1997 (Dowdle and Hopkins, 1998) also considered these issues in some detail and introduced the term extinction to classify an organism that did not exist on the planet contrasting with smallpox, which had been eradicated as a cause of disease but stocks had been retained in secure laboratories. The use of the term elimination is now regarded as referring to the removal of the organism from a defined geographical region (“local eradication”), which creates problems for quantification of achievement towards the goal. The accepted position being that the disease is not eradicated but no longer requires ongoing investment in control and is maintained at a level when the problem is no longer a significant health burden. A new concept has also been introduced through World Assembly Resolutions of the “Elimination of a disease as a Public Health problem”. The definitions which will be used

Table 1 Criteria for assessing eradicability of diseases or conditions (Dowdle and Hopkins, 1998)

<table>
<thead>
<tr>
<th>Scientific feasibility</th>
<th>Epidemiologic vulnerability (e.g. absence of non-human reservoir; ease of spread; natural cyclical decline in prevalence; naturally induced immunity; ease of diagnosis; and duration of any relapse potential)</th>
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<td></td>
<td>Effective, practical intervention available (e.g. vaccine or other primary preventive, curative treatment, and means of eliminating vector). Ideally, intervention should be effective, safe, inexpensive, long lasting and easily deployed</td>
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<td>Demonstrated feasibility of elimination (e.g. documented elimination from island or other geographic unit)</td>
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<td>Political will/popular support</td>
<td>Perceived burden of the disease (e.g. extent, deaths, other effects; true burden may not be perceived; the reverse of benefits expected to accrue from eradication; relevance to rich and poor countries)</td>
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<td>Expected cost of elimination or eradication (especially in relation to perceived burden from the disease)</td>
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<td></td>
<td>Synergy of eradication efforts with other interventions (e.g. potential for added benefits or savings or spin-off effects)</td>
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</tbody>
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in this chapter are from Dowdle and Hopkins (1998), WHO (1998) and Molyneux *et al.* (2004):

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Control</td>
<td>Reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level as a result of deliberate efforts; continued intervention measures are required to maintain the reduction.</td>
</tr>
<tr>
<td>Elimination of disease</td>
<td>Reduction to zero of the incidence of a specified disease in a defined geographical area as a result of deliberate efforts; continued intervention measures are required.</td>
</tr>
<tr>
<td>Elimination of infection</td>
<td>Reduction to zero of the incidence of infection caused by a specified agent in a defined geographical area as a result of deliberate efforts; continued measures to prevent the re-establishment of transmission are required.</td>
</tr>
<tr>
<td>Eradication</td>
<td>Permanent reduction to zero of the worldwide incidence of infection caused by a specific agent as a result of deliberate efforts; intervention measures are no longer needed.</td>
</tr>
<tr>
<td>Extinction</td>
<td>The specific infectious agent no longer exists in nature or the laboratory</td>
</tr>
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1.2. Examples of Parasite Elimination and Vector “Eradication”

The classic eradication programme was that of smallpox which achieved its target in 1977. To date, no parasitic disease has been eradicated, although attempts to eradicate Guinea worm are under-way (Hopkins *et al.*, 2002; Ruiz-Tiben and Hopkins, 2006). Nevertheless, successful “local eradication” (correctly elimination) has been achieved in some restricted geographical or epidemiological situations. For example, onchocerciasis has been eliminated from several parts of Kenya and from the Nile at Jinja in Uganda, by using DDT to remove the local vectors (*Simulium neavei* and *S. damnosum,*
respectively) (Davies, 1994). The Onchocerciasis Control Programme (OCP) in West Africa has achieved the same goal eliminating particular cytoforms of the *S. damnosum* complex using aerial application of insecticides. Local elimination has also been achieved; the malaria vector *Anopheles gambiae* from Brazil in the late 1930s using larviciding measures and house spraying with pyrethrum, a success repeated in early 1940s after the same species had been introduced into Egypt; *Glossina palpalis*, the tsetse fly, the vector of human trypanosomiasis was eliminated from the Island of Principe in 1905 by trapping out flies using sticky back packs on plantation workers; animal trypanosomiasis from parts of North-East Nigeria by ground spraying of tsetse resting sites with persistent doses of DDT; *Aedes aegypti*, the vector of yellow fever, in parts of Central and South America. Local anti-mosquito spraying has eliminated lymphatic filariasis from the Solomon Islands with no evidence that over a 20-year period there has been any resurgence; filariasis due to *Brugia malayi* was eliminated from Sri Lanka through selective treatment with DEC, anti-larval measures (host plants killed by herbiciding), house spraying with DDT as part of the malaria eradication programme and environmental improvements. Chemotherapeutic approaches have eliminated filariasis (due to *Wuchereria bancrofti*) from Japan, South Korea and Taiwan in Asia and Suriname and Trinidad and Tobago in the Americas (WHO, 1992, 1994). Filariasis has also been eliminated as a public health problem in large areas of China where it seems transmission has been stopped for a period of over 10 years (WHO, 2003). Long-term “elimination” programmes have been successful against hydatid disease in Iceland, New Zealand and Cyprus; and malaria was eliminated from Sardinia by DDT spraying as well as in other marginal areas of distribution such as North Africa, Greece and parts of Turkey and the Middle East.

One noticeable feature of these successes is that many examples refer to islands or isolated populations or areas where the parasite is at the edge of its geographical range. Clearly, the advantages of isolation and a greater ability to control animal or human population movements are important. Elimination or global eradication of any disease is difficult to achieve and costs increase per case detected, controlled or averted as the end point is reached.
However, the high cost of eradication or local elimination programmes may be justified as they are time limited, whereas disease control implies a long-term commitment. Any control programme must be cost effective and should reduce the target disease to a level at which costs are sustainable by the local community or by public or private healthcare systems. Control seeks to bring the problems to a level at which the disease is no longer of public health importance with morbidity at an acceptable level within the community, an absence of mortality and, if appropriate, greatly reduced levels of disability. To translate the level of control achieved to eradication or elimination status requires a vastly increased cost per case treated or prevented which, for financial and ecological reasons, may never be feasible or the development of a more effective intervention.

1.3. Components of Control

1.3.1. The Range of Interventions

The spectrum of interventions against parasitic diseases, currently used against parasitic diseases, is summarized in Figure 1 and discussed in detail in the accompanying chapters in the volume.

1.3.2. Control of Animal Reservoir Hosts

Many parasitic diseases are zoonoses, defined as ‘those diseases and infections (the agents of) which are naturally transmitted between (other) vertebrate animals and man’ (WHO, 1979). A list of recognized parasitic zoonoses is provided by the WHO (1979). Ostfeld and Keesing (2000) provide an up-dated list of vector-borne infections of potential public health importance, while a recent analysis of all emergent and re-emergent infections (Taylor et al., 2001) has identified that 75% of emerging pathogens are zoonotic and that such organisms are more than twice as likely to emerge as non-zoonotic ones. However, viruses and protozoa are more likely to emerge than the macroparasites such as helminths. The important zoonoses for which reservoir host control can have a cost-effective impact are
leishmaniasis, echinococcosis and cysticercosis; while treatment of cattle with trypanocides in Uganda is a strategy used to reduce the role of cattle as a reservoir of *Trypanosoma rhodesiense* sleeping sickness (Fèvre *et al.*, 2005). However, the presence of an animal reservoir host may be a major impediment to control a disease particularly if the habits and habitats of the animal host prevent the intervention either on the grounds of practicality or for reasons such as protected status of host species e.g. primates or endangered species status. The ITFDE recognizes that the existence of an animal reservoir precludes the likelihood of the eradication of the infection.

1.3.3. Community Participation in Parasitic Disease Control

The drive towards primary healthcare following the Alma-Ata declaration of 1978 provoked a greater degree of involvement of
communities in healthcare through (1) the use of community leaders to support various programmes; (2) the identification of personnel to undertake health activities on a voluntary basis; and (3) emphasizing the importance of such activities in community well-being. The topic of community participation has been reviewed by Curtis (1991) who provides a series of examples in vector-borne disease control. MacCormack (1991) provides an insight into the underlying principles of sustainable vector control in a community context emphasizing that success in small pilot projects depends on particular characteristics such as leadership; a responsive, well-motivated and well-educated community support; incentives from agencies and insecticide manufacturers; and ease of communication. Following initial success, there is a danger that a ‘hot’ project will fall into a steady state as enthusiasm and donor support wane while the project life cycle faces inevitable problems. The scaling up of pilot projects to national ones within a primary healthcare context presents additional challenges. For instance, the community may be affected by the replacement of local leaders with national bureaucracy. In establishing a functional link between the communities and the health systems, each group must be trained to understand the social role on the one hand and technical skills on the other. Communities’ local knowledge about insects should be exploited to aid in vector control. Appropriate control methods, and the importance of maintaining them, must then be clearly explained to all those involved at the local level.

It must also be established whether unpaid community labour can be sustained over time; although it has been achieved in pilot programmes, doubts exist about longer-term sustainability (Walt, 1988). Much is likely to depend on the community structure and its relationship with those in authority, who are perceived as those most likely to benefit. If, for example, a cost recovery system operates, the volunteers are less able to collect fees from their social superiors. Professional interaction between technicians and volunteers can also fuel conflicts based on perceptions about status.

The outcome of community participation in any project will depend on the numerous complex social interactions existing within the community environment. The interaction between weak and strong groups, and the impact of participation on such group relationships,
are of critical importance (Antia, 1988). It is valuable to define the boundaries of the community involved, as individuals tend to identify with a particular locale; this is despite the risk of inherent social instability of villages, resulting from factors such as migration, schooling and marriage. For practical reasons the community is usually defined by a geographical boundary such as an urban neighbourhood or an agricultural village while nomadic groups themselves represent a mobile community.

Communities differ in how they function and are stratified; for example, they may be democratic, autocratic or under military control. In a democratic environment, obtaining consensus may be a slow process, but the likelihood of sustainability will be high. MacCormack concludes that community participation in vector control will be sustainable only if the assessment of the costs to benefits ratio takes account of ‘opportunity costs’ (the value of activities people would undertake if they had not committed themselves to a particular control activity). Sustainability will be enhanced if activities are linked to the communities’ priorities; skills training enhances the communities’ well-being; and preventative work links to curative or care outcomes that increase income (Rajagopalan et al., 1987).

Community-based treatments are usually better targeted and tend to involve volunteers, traditional birth attendants (TBAs) and primary healthcare workers. Increasingly, other types of groups are also becoming involved, such as women’s groups, faith groups, civil society organizations (CSO) and non-governmental developmental organizations (NGDOs). The NGDO community has become increasingly involved in onchocerciasis control as the programmes in Africa and the Americas have expanded using the donated drug Mectizan® (ivermectin). The momentum for NDGO involvement came from the organizations committed to blindness control who recognized the value of ivermectin as a tool for reducing morbidity associated with onchocercal eye disease (Drameh et al., 2002). NGDOs provide some 25% of the resources required for National Onchocerciasis programmes and 12 international as well as some local NGDOs are active in some 20 countries in Africa through the African Programme for Onchocerciasis Control (APOC) and the countries from the former OCP. The key element of the approach to
control is community directed treatment with ivermectin (CDTI), which is regarded as the key driver in ensuring sustainability of this programme. The progress of the APOC programme is documented in a publication, which highlights the status of these programmes *(Annals of Tropical Medicine and Parasitology, 2002)*. Amazigo *et al.* (2002) review the challenges presented by CDTI strategies with an approach based on the principle of community participation but also ensuring empowerment; allowing communities to decide on who should be distributors (CDDs) allowing the planning of ivermectin distribution to be decided by communities e.g. dates, location model of distribution. The replacement of the “Community-directed” approach from a “Community-based” treatment system has been encouraged as the former is likely to be more sustainable, provides community ownership and empowerment and reduces costs to the health system. CDTI enables communities to organize distribution in line with cultural norms and organizational structures—such as kinship and clan structures in Uganda (Katabarwa *et al.*, 2000) while stimulating basic healthcare infrastructure in remote areas (Hopkins, 1998). The experience of the Guinea Worm Eradication programme has led Seim (2005) to identify 10 components to bridge the divide between the systems approach and the disease-specific intervention. He also identifies the criteria for the effective use of volunteers, an approach described as the community-based catalyst to public health. The 10 elements can be summarized as the requirement for a few dedicated individuals, a data manager and a programme manager in each country, the role of a fast non-bureaucratic organization, resident technical advisers, international meetings, regular programme reviews, annual training and retraining of volunteers, network of supervisors, adequate transportation and continuous research for course correction.

**1.3.4. Steps in a Control Programme**

Components of control are listed under the following headings: (1) situation analysis; (2) definition of objectives and strategy; (3) roles and responsibilities at different levels of health system; (4) planning
and resourcing; (5) monitoring and evaluation; and (6) implementa-
tion and integration of selected methods of control.

(1) Situation analysis

**Stratification of parasitic diseases**

Control programmes often involve specific approaches to arrest the
transmission of infection (e.g. via vector control) or to prevent or cure
a disease. Although such programmes have been successful in the past,
integrated approaches are now recognized as being more appropriate
for reducing prevalence and incidence. This is important if the strategy
is aimed at alleviation of a disease problem in a community or pop-
ulation rather than in an individual. Integrated control is based on
coordinated planning and detailed knowledge from many different
areas: scientific, technical, inter-sectoral, financing and managerial. An
approach termed ‘stratification’ has been used in malaria control; this
means that the strategy is modified according to different epidemi-
ological situations (WHO, 1993). Malaria stratification has been taken a
step further by those with particular interests in different environments
and geographical regions, a process known as ‘microstratification’
(Rubio-Palis and Zimmerman, 1997). While stratification has been
most widely used in malaria control the concept is equally applicable to
other parasitic diseases, for example leishmaniasis (WHO, 1990), onco-
hocerciasis (Boatin *et al.*, 1997), filariasis (WHO, 1992), schist-
osomiasis and African trypanosomiasis. Molyneux (2005) details in a
series of tables, examples of stratification of the epidemiology and its
relevance to the planning of control in selected parasitic diseases.

**Planning for Control**

- Desk study of published and unpublished reports to assess prob-
  lems in the context of country, region and district.
- Acquisition of information on prevalence and incidence.
- Appraisal of the validity of information.
- Evaluation of current epidemiological situation by passive sur-
  veillance at health centers or by use of questionnaires of health
  workers—for example using the postal system.
- Observation of changes over time and prediction of future
  change.
• Definition of the structure of health services and their existing capacity, human resources available and needs for training and capacity building.
• The priority afforded to the disease by the government, the MOH, the district management teams and the communities themselves.
• Establishment of linkages to other sectors or organizations in planning for control (e.g. other ministries, development organizations, NGOs).
• The influence of other activities such as development projects on planned programmes.
• Spot surveillance of local prevalence, vectors and, if applicable, animal reservoirs.
• Use of rapid assessment methodologies e.g. for schistosomiasis, onchocerciasis, filariasis or loiasis.
• Assess the available methods for prediction of epidemics using remote sensing or climate prediction available to other sectors, e.g. agriculture, natural resources, environment.
• Establishment of a National Task Force composed of various stakeholder groups to address the problem.

(2) Definition of objectives and strategy

• Analysis of cost effectiveness of different control approaches and options.
• Selection of appropriate methodology and definition of control requirements.
• Establishment of an inventory of personnel and facilities (including estimation of training needs and requirements for equipment and drugs).
• Establishment of feasibility in the context of other health needs.
• Contrasting epidemic (‘firefighting’) problems when rapid action is required to prevent further transmission (e.g. establish emergency response capacity to address predicted epidemic risk) compared with endemic situations for which a long-term approach and integration are required (Table 2).

(3) Roles and responsibilities of different levels of the health service
Table 2 Role of different levels of the health system in parasitic disease control

Community
Identification of suspects/patients
Follow-up of patients
Coordination of any appropriate vector control activities, e.g. bednet distribution to vulnerable groups/re-impregnation
Facilitation of cooperation, local logistics for community-directed treatment schemes, e.g. drug distribution of ivermectin and albendazole
Communication by Village Health Committees

District
Passive detection and treatment
Parasitological/serological diagnosis
Treatment and clinical care
Follow-up of microscopy

Regional
Active surveillance
Confirmatory diagnosis
Data collection
Technical supervision of vector control
Distribution of reagents and materials for vector control

Ministry and country level
Situation analysis/policy position
National strategy and plan
Establish stakeholder group/National Task Force
Financing
Training needs and responsibility
Health education
Distribution of technical information, equipment, drugs and materials
Purchase of equipment and supplies
Human resource management

(4) Planning and resourcing

- Define the expected contribution from the government.
- Develop national plan.
- Evaluate targeted approaches to donors in the context of donor priorities and prevailing national policy.
- Define appropriate timeframes for implementation of plans.
- Define the relationship of the action to overall health plans and budgets.
- Establishment of linkages with appropriate international reference centres for technical support; control of an epidemic may merit application for emergency status to provide rapid funding
(e.g. requests for therapeutic drugs and insecticides from international aid agencies and NGDOs).

- Establishment of drug supply line following identification of sources, initiate quality assurance mechanisms, define tax status of drugs (e.g. donated products).
- Definition of the role of the non-government sector (e.g. private providers, NGOs) in control policy.
- Ensure adequate information exchange about control policy between different bodies and individuals involved in healthcare provision.
- Undertake knowledge, attitudes and practice (KAP) studies as a basis to inform approaches to social mobilization strategies.
- Training (including management training) through courses, instruction of trainers, educational materials and health education programmes.
- Assessment of community acceptability and the perceived priority of any involvement that will require resource input from the communities (e.g. role and views of village health workers (VHWs), volunteers, TBAs, community leaders, school teachers).
- Definition of the management structure of the programme and its relationship with existing management structures.
- Assess capacity available (managerial, financial, technical) and ensure capacity building is embedded in planning.

(5) Monitoring and evaluation

- Assessment of progress towards objectives (prevalence distribution, vector status).
- Establish Sentinel site/baseline data in defined units.
- Definition of appropriate methods for epidemiological evaluation, e.g. parasitological, serological and vector-sampling methods.
- Longitudinal surveys or spot surveys at indicator villages.
- Adjustment of the programme in the light of results.
- Establish process indicators at national and sub-national level.

(6) Implementation and integration of selected methods of control
Chemotherapy and chemoprophylaxis

- Assessment of the availability and quality of drugs and the distribution system.
• Establish relationship between national bodies, donation programmes and NGDO community to define operational relationships, e.g. onchocerciasis, lymphatic filariasis, African trypanosomiasis, schistosomiasis, Trachoma programmes.
• Assessment of, or monitoring for, drug resistance (e.g. East-African network for antimalarial drug resistance).
• Assessment of the role of private providers and control of quality and price (e.g. malaria drug policy).
• Utilization of other systems for distribution (e.g. schools, agricultural extension workers, other health or government workers, NGOs, committees).

**Vector and reservoir control**

• Availability, cost and appropriateness of insecticides.
• Availability of skills to monitor insecticide resistance.
• Availability and effectiveness of alternative chemicals.
• Capacity for management of the control programme.
• Relationship to other sectors in providing support for environmental control measures.
• Acceptability and feasibility of reservoir control.
• Environmental acceptability of interventions.
• Personal protection, e.g. bednets, sustainability of a bednet programme/retreatment modalities.
• Policy in relation to bednet distribution—vulnerable groups, social marketing.
• Investigate opportunities for integration if appropriate, e.g. malaria and lymphatic filariasis in Africa; dengue and filariasis in the Pacific; leishmaniasis, Chagas disease and malaria via bednets in Latin America.

**Environmental management**

• Ensuring effective linkages between health and other sectors.
• Assessment of potential impact on other diseases.
Health education, information education communication (IEC), social mobilization

- Media resources, including radio, television and videos.
- Posters and drama sessions oriented around the local environment and traditions.
- Participation of teachers, local leaders, health workers, local medical practitioners, religious leaders.
- Ensure linkage to KAP studies to inform social mobilization strategies.

1.4. Scaling up Control Programmes

Control of a parasitic infection can be focused on the individual, with a view to alleviating pain, reducing disability or avoiding death, while at the same time reducing the parasite load and transmission within a community. Such an approach will be less cost effective than larger-scale control programmes that employ methods such as vector control, reservoir host control or mass drug distribution. Large-scale measures have a public health objective but also provide socioeconomic benefits through improved agricultural productivity, improved cognitive function improved educational prospects, and better nutrition. These benefits accrue as a result of increased and more varied agricultural output and hence diet and enhanced food security. Large scale control will alleviate individual suffering and reduce the community morbidity and mortality thereby providing additional economic opportunities. Control of animal parasitic diseases also has benefits for human populations through increased protein availability and higher income from the sale of higher-quality livestock enhancing both local and national economies. Parasitic disease control programmes vary in scale, but they have generally been targeted at two different types of disease situations: (1) the alleviation of an endemic disease in which long-term chronic infections have persisted in communities, e.g. river blindness (onchocerciasis), hydatid disease (Echinococcus), schistosomiasis, Guinea worm (dracunculiasis), Chagas disease and filariasis; and (2) the contrasting epidemic situation where rapid intervention is required to prevent widespread
morbidity and mortality. Epidemics are frequently predictable, but if health facilities are ill equipped or non-existent, high mortality may occur before control can be instigated despite the technological capacity to predict epidemics of malaria using climate models and remote sensing data (WHO/RBM, 2001).

1.5. Strengthening the Evidence Base

The use of reliable, systematic reviews of evidence of effectiveness to inform policy is becoming recognized as an important contribution to enable resources to be used appropriately. A scientific approach has been developed by systematic reviews of randomized control trials, which provide reliable assessment of the effectiveness of various healthcare interventions. This approach has been promoted, as traditional reviews are unsystematic and do not respect scientific principles or control for biases and random errors. The Cochrane Collaboration approach involves world-wide partners, designed to build on enthusiasm for the process, to minimize duplication, to avoid bias, to maintain an electronic database and to ensure wide access in order to make the information available to decision makers (www.cochrane.org). Molyneux (2005) lists the Cochrane reviews relevant to the control and elimination of parasitic diseases.

2. THE HEALTH POLICY ENVIRONMENT

Disease control, elimination or eradication activities must be implemented in the context of broader health policy issues and the requirements for prioritization, which confront resource constrained health systems. There has been an increased political awareness of health issues in poor populations over the past decade with an increasing commitment to poverty alleviation as the core component of agreed international development targets and millennium development goals (MDGs) (WHO, 2005a). The publication of the report of the Millennium project provided a detailed analysis of the progress towards the attainment of the MDGs (Sachs, 2004; Haines and
Cassels, 2004; Sachs and MacArthur, 2005). In addition, there have also been changes in international organization policy and focus generated by changed leadership. There have been a series of initiatives of the World Health Organization (WHO) which recognize the need for broadly based partnerships for health development such as Roll Back Malaria (RBM), Stop TB (2002) and the $3 \times 5$ initiative to respond to the problems of HIV/AIDS and in the NCDs the Tobacco-Free Initiative. The establishment of the Global Fund to specifically address the problems of HIV/AIDS, TB and Malaria (Global Fund to fight AIDS, TB and malaria (GFATM)) following the initiative of the UN Secretary General has raised awareness of the relentless problems of these diseases. However, even the Global Fund resources will have limited impact against the estimated needs of HIV/AIDS, TB and malaria control which is an annual figure of around US$10 billion (www.theglobalfund.org). This is also an open-ended commitment as there is currently little impact on transmission of these diseases (Molyneux et al., 2005); without an impact on incidence these diseases will continue to increase as public health problems, hence the need for efficacious preventative interventions such as stable, easy-to-administer vaccines.

### 2.1. Health Financing and Sector-Wide Approaches

New approaches to donor funding of health in poor countries the “sector wide approach to financing” (sector-wide approaches (SWAPs)) (Cassels, 1997) has been instituted particularly in African countries to enable a more coordinated approach to financing; this prevents donors from influencing, via special projects, overall national health policy and plans. SWAPs should provide for increased coordination in the health sector, stronger leadership and improved management and delivery systems. As Hutton and Tanner (2004) assert this should reduce duplication, lower transaction costs, increase equity and sustainability and improve effectiveness and efficiency of health-targeted aid. This approach-so-called “basket” funding recognizes that ownership rests with the country, that donors all contribute to the “basket”, that, once committed, control of
resources is lost, that priorities are established through policy dialogue and that partnership relations are strengthened. The SWAPs approach is also layered onto the increasing decentralization of national budgets to district-level management in many countries. However, the approaches of SWAPs to discourage project or disease-specific funding appears at odds with the approaches of the Global Fund where disease-specific projects and programmes are part of the application process. In addition, Hutton and Tanner (2004) have pointed that there is a limited evidence base, despite some 10 years experience, that SWAP support has impacted on improved health outcomes; such evidence is urgently required. In contrast to disease-specific interventions where strategies are based on effective monitoring of scientific information, to guide the interventions the policies which are designed to strengthen the health system may not achieve the desired outcomes in ever-changing political, social, economic and environmental settings.

Over recent years, large international NGDOs have become increasingly active in disease-control implementation and policy. Medecins Sans Frontieres (MSF), Save the Children (SCF), Oxfam and others have been vociferous on issues of equity and access to drugs often criticizing “vertical” programmes and drug donations. Notwithstanding policy papers introduced by NGDOs, MSF for example has driven the establishment of the Drugs for Neglected Disease initiative (DNDi) which should recognize that in many circumstances drugs for the diseases DNDi targets—the trypanosomiases, and leishmaniases require delivery through disease-specific treatments based on the availability of the necessary medical knowledge and with the requirement for clinical management. While over the last three decades the UNDP/World Bank/World Health Organisation Special Programme for Research in Tropical Diseases (TDR) has played a prominent role with many partners in bringing new drugs into widespread use. Such treatment-based interventions respond to clinical need but have a limited impact on transmission-approaches which do not fit easily into the SWAPs, decentralization and health sector reform for diseases such as trypanosomiasis or leishmaniasis.

In attempts to increase resources for health, models have emerged such as the “Bamako Initiative” to raise money through imposing
user fees to create revolving funds at the periphery of the health system, insurance systems have been introduced, while macrofinancing to provide overall budget support for the social sector has been promoted through policies such as the Heavily Indebted Poor Countries (HIPC) initiative, Poverty Reduction Strategy Papers (PSRP) and more recently by debt cancellation agreements.

There has been increasing recognition that infectious diseases are more prevalent and inflict a greater burden of disease on the poorest quintile of the population. The poorest 20% however would benefit proportionately more if there was a pro-poor focus in tackling infectious diseases compared with other health interventions (Gwatkin et al., 1999).

2.2. Public–Private Partnerships

There has been a dramatic expansion of the number PPPs in health over the last decade. These developments are summarized by Widdus (2001, 2005) who identifies around 100 such initiatives. The diversity of objectives, financing, governance, legal status and management of these alliances prevents significant generalizations about best practice and how lessons can be learned as most of the alliances/partnerships are disease or product development specific. Widdus (2005) recognizes two main groups of PPPs, those dealing with product development and those concerned with access to medicines or drugs for mass distribution to target populations (Access PPPs). Some partnerships also act as global coordinating mechanisms. Croft (2005) provides case studies of the most prominent product development PPPs. These partnerships have often been funded by long-term commitments from donors, through drug donations, from the private sector and by a recognition that relatively cheap interventions can be sustained by health systems and bring long-term health benefits. Analysis of these partnerships have also been carried out by Buse and Walt (2000a, b) and Buse and Waxman (2001). Table 3 lists partnerships relevant to parasitic disease control. The major characteristic of most PPPs is the interaction between the public, private and civil society (NGDOs, academia) sectors. The establishment of the Bill and
Melinda Gates Foundation as a key player in Global Health has also greatly enhanced the opportunities for research and partnership interaction and development. However, an often understated factor in these relationships is the time required specifically for partnership management to ensure regular communication between partners and enhance the added value of the whole as opposed to the component entities.

2.3. The Global Burden of Parasitic Diseases

The World Development Report (World Bank, 1993), introduced the concept of the Global Burden of Disease expressed as the Disability Adjusted Life Years (DALYs) lost. This measure has been expanded enabling an assessment of likely change in global disease burden between 1990 and 2020 (Murray and Lopez, 1996). These projections suggest that as a proportion of global disease burden only malaria remains a significant burden as a parasitic infection. Malaria falls in Global Burden importance from a ranking of 11th to a predicted 26th over this period. The majority of the projected change in Global burden is in the increased burden of NCDs such as cerebrovascular events, depressive illness, conflict-related conditions, road traffic
accidents and cancers (WHO, 2005b). The DALY burden of parasitic disease is projected to remain largely stable, while the surge of NCD burden due to the epidemiological transition, diet and life style change associated with urbanization, substance abuse, environmental degradation, population growth and increased conflict are projected to be proportionally greater contributions. The DALYs burden and overall public health importance of major parasitic disease is given in Table 4. However, a recent meta analysis of disability due to schistosomiasis has demonstrated there is a significant and underestimated burden of subtle morbidity due to anaemia, chronic pain, diarrhoea, reduced exercise tolerance and malnutrition (King et al., 2005). This subtle morbidity is likely to apply to other diseases in the neglected cluster as pointed out by Savioli et al. (2005) who call for the reassessment of the overall burden in view of potential gains which can be achieved by reducing this burden through cheap regular delivery of anthelmintics.

The impact of financing and policies in public sectors of developing country economies such as education, agriculture, transport, natural resources has a significant impact on health outcomes; of particular importance will be levels of investment and achievement of education targets in an attempt to provide universal primary education by 2015 in the context of the Millennium Development Goals (WHO, 2005a); the importance of increasing the proportion of females in primary education will be of particular significance in achieving targets of reducing maternal, child and infant mortality. In the agricultural sector productivity, efficiency and diversity will have a major impact on nutrition and food security particularly in regions dependent on rain-fed agriculture at a time of increasingly unpredictable weather patterns and climate uncertainty (Patz et al., 2005).

2.4. “Neglected” Tropical Disease Initiatives and the Integration of Control

2.4.1. Integrated Control

Recent publications argue for the integration of vertical control activities into a more integrated approach (Molyneux and
<table>
<thead>
<tr>
<th>Condition</th>
<th>Population at risk (m)</th>
<th>No. of endemic countries</th>
<th>No. of infected/prevalence (m)</th>
<th>Estimated deaths mortality/y humans × 1000</th>
<th>Total DALYs (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>2000</td>
<td>90</td>
<td>300–500</td>
<td>1080</td>
<td>46.5</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>350</td>
<td>82</td>
<td>12</td>
<td>41</td>
<td>2.1</td>
</tr>
<tr>
<td>Lymphatic filariasis</td>
<td>750</td>
<td>65</td>
<td>119</td>
<td>No direct mortality</td>
<td>5.8</td>
</tr>
<tr>
<td>Guinea worm</td>
<td>140</td>
<td>18</td>
<td>c. 120 000</td>
<td>No direct mortality</td>
<td></td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td>122</td>
<td>34</td>
<td>17.6</td>
<td>No direct mortality</td>
<td>0.5</td>
</tr>
<tr>
<td>African trypanosomiasis</td>
<td>50</td>
<td>36</td>
<td>20 000–300 000</td>
<td>50</td>
<td>1.5</td>
</tr>
<tr>
<td>Chagas disease</td>
<td>90</td>
<td>19</td>
<td>16</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>500–600</td>
<td>74</td>
<td>200</td>
<td>11</td>
<td>4.5</td>
</tr>
<tr>
<td>Ascaris</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td>10.5</td>
</tr>
<tr>
<td>Trichuris</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
<td>6.4</td>
</tr>
<tr>
<td>Hookworm</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td>22.1</td>
</tr>
<tr>
<td>Entamoeba</td>
<td>500</td>
<td></td>
<td></td>
<td>40–100</td>
<td>NA</td>
</tr>
<tr>
<td>Giardia</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Taeniasis</td>
<td>40</td>
<td></td>
<td>15</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Neurocystocercosis</td>
<td>50</td>
<td></td>
<td></td>
<td>50</td>
<td>NA</td>
</tr>
<tr>
<td>Food-borne trematodes</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Fasciolias</td>
<td>180.25</td>
<td>8</td>
<td></td>
<td>2.39</td>
<td>NA</td>
</tr>
<tr>
<td>Clonorchiasis</td>
<td>289.26</td>
<td>6</td>
<td></td>
<td>7.0</td>
<td>NA</td>
</tr>
<tr>
<td>Opisthorchiasis</td>
<td>63.6</td>
<td>5</td>
<td></td>
<td>10.3</td>
<td>NA</td>
</tr>
<tr>
<td>Paragonimiasis</td>
<td>194.8</td>
<td>5</td>
<td></td>
<td>20.6</td>
<td>NA</td>
</tr>
<tr>
<td>Other intestinal flukes</td>
<td>6</td>
<td></td>
<td></td>
<td>1.28</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA = not available
Nantulya, 2004). Four drugs, albendazole, Mectizan®, azithromax and praziquantel, if given to communities once a year would have a significant impact on lymphatic filariasis, onchocerciasis, hookworm, trichuriasis, ascariasis, schistosomiasis and trachoma in areas where the diseases are co-endemic particularly in sub-Saharan Africa and focal regions of the Americas. In much of Africa individuals are polyparasitized; with three gastrointestinal worms, filarial parasites in the skin and/or blood, malaria and intestinal protozoan parasites (Raso et al., 2004; Hotez et al., 2006). These four drugs can be delivered through existing mechanisms and such integrated control approaches have the potential to eliminate morbidity and blindness from these diseases at a fraction of the cost needed to control other diseases (Molyneux et al., 2005).

The Commission for Africa (www.commissionforafrica.org) and the Millennium Project reporting on the progress towards the achievement of the Millennium Development Goals recognized the importance of these neglected infections in their 2005 report. Fenwick et al. (2005) calculated that some 500 million people living in communities endemic for these diseases in Africa could be treated with all the four drugs at a cost of $200 million annually, or $0.40 per patient if these resources were allocated as a package, particularly as multinational corporations like Merck Co. Inc., GSK and Pfizer are committed to long-term donations of three of the four drugs, Mectizan®, albendazole and azithromax, respectively. Molyneux et al. (2005) have compared these costs with the published costs of treatment of HIV/AIDS, tuberculosis and malaria per person annually. Figures for antiretrovirals alone reach $200, TB costs around the same figure in Africa while malaria can cost the poorest families some 30% of the annual household expenditure in Malawi imposing a huge burden on the poorest families (Ettling et al., 1994). Despite high unit costs, the current curative approaches to the big three diseases are “reactive” strategies. The treatment of individuals infected with HIV/AIDS, TB and malaria fails to significantly reduce transmission while there is significant interaction between the diseases themselves in co-infected patients. In seeking to combat the big three diseases, decision makers, policy makers and donors should consider supporting a programme of “rapid impact interventions”, an approach that would
bring real benefit to millions suffering disablement, poverty and ill health. This would enable the treatment of poor people more equitably, by providing such polyparasitized populations with effective and cheap interventions that would reduce stigma and disability, as well as reduce morbidity and mortality, thus reaching the MDGs quickly and cost effectively.

2.4.2. Evidence for the Value of Integrated Control

As noted elsewhere there are several major PPPs committed in Africa to elimination or control programme addressing a specific tropical disease. These PPPs often operate in parallel, using drugs deployed over wide areas and among large populations. Currently, four drugs, albendazole, ivermectin (Mectizan), praziquantel and azithromycin (Zithromax) are being used to target more than one hundred million people in around 30 countries (Hotez et al., 2006). Such partnerships have a role in strengthening health systems (Amazigo et al., 2002). The most prominent example being APOC which has established a successful community-directed treatment initiative, providing an entry point for other community-directed health interventions in regions where there is little access to traditional health services (Homeida et al., 2002).

The tropical diseases in Africa exhibit considerable geographical overlap and hence, in many cases, show extensive co-endemicity (Molyneux et al., 2005). There is significant value in exploring whether a drug employed by a vertical programme that targets one condition could also be used to simultaneously impact on some of the others. A significant number of school-aged children in Africa are polyparasitized with three different soil-transmitted helminths (STHs) (Ascaris, Trichuris and hookworm), early filarial infections and schistosomes, who could be simultaneously treated with three drugs, Mectizan, albendazole and praziquantel (Loukas and Hotez, 2006; Raso et al., 2004). In 2001, the 54th World Health Assembly urged its member states to undertake frequent and periodic deworming with praziquantel together with either albendazole or mebendazole as a means to control and reduce the morbidity in this
paediatric age group (www.who.int/wormcontrol) while more recently an editorial highlighted the opportunities of deworming for development (Lancet, 2004), the Millennium project listed regular deworming as one of the quick wins towards the MDGs, while the Commission for Africa recommended “donors should ensure that there is adequate funding for the treatment of parasitic diseases and micronutrient deficiency. Governments and global health partnerships should ensure that this is integrated into public health campaigns by 2006”.

The Schistosomiasis Control Initiative, a PPP based in London supporting control in Uganda, Tanzania, Zambia, Mali, Niger and Burkina Faso, adds albendazole to its praziquantel regimen (www.schisto.org). Similarly, the major drugs used for lymphatic filariasis and onchocerciasis control, ivermectin and albendazole (www.filariasis.org), have significant impact on the STH where albendazole is the drug of choice. Ivermectin also has a significant anthelmintic effect on Ascaris and Trichuris infections, and is the drug of choice for the treatment of human strongyloidiasis.

More recently, selective mass treatment with ivermectin has been shown to also reduce the prevalence of ectoparasitic skin infections such as pediculosis, scabies and tungiasis as well as cutaneous larva migrans (Heukelbach et al., 2004).

2.4.3. The Cost-Effectiveness of Parasite Control

The economic rates of return (ERR) when they have been calculated suggest investment in control/elimination of these diseases produces an ERR of between 15–30%, and are capable of delivery on a large scale (Molyneux, 2004). The potential synergies in collateral benefits delivered using the four drugs as mentioned in Section 1.3.1 is appropriate as they often have compatible approaches to delivery. The numbers requiring treatment for each of these infections, the unit drug price (if applicable) and the estimated total delivery costs of treating these chronic-disabling conditions in sub-Saharan Africa. Such interventions, are pro-poor, are based on safe, efficacious drugs that reach a high coverage of the target population, are known to be
cost effective, and do not, as yet, have any associated drug resistance (Albonico et al., 2004). They can be delivered through community directed approaches, school health programmes, the World Food Programme, school feeding programme, or NGDO supplementary feeding and nutrition programmes usually on an annual basis (www.wfp.org).

2.4.4. Scaling Up Integrated Control

A number of issues require to be addressed before integrated control of neglected tropical diseases can be implemented on a large scale. For example, the final costs of an integrated package may need to include the costs of drug use monitoring and of developing new tools for neglected disease control. In some areas neither mebendazole nor ivermectin are highly effective against hookworm, the most common STH in Africa, especially when these drugs are used in a single dose (Loukas and Hotez, 2006). Moreover, the rate of post-treatment hookworm infection is high, and there is additional evidence that the efficacy of benzimidazole anthelmintics diminishes even further with frequent and periodic use—there are therefore some concerns about the possibility of emerging resistance, which is now common for STHs that infect livestock (Albonico et al., 2004). Therefore, additional costs must be considered in order to promote ongoing research and development for new neglected diseases control tools.

An equally important challenge will be to determine the actual feasibility of integrating six different vertical control programmes. There are currently disparities between the groups targeted for lymphatic filariasis and onchocerciasis control (treatment is excluded for children under 90 cm and pregnant women in 2nd and 3rd trimester) and the groups targeted for STH and schistosome control (control is primarily aimed at school-aged children, but WHO encourages treatment of pregnant women and children above the age of 12 months). Pilot studies will be necessary to identify common age groups for integrated control. While the partnerships themselves require to cooperate on disease control efforts and integrate their activities to reduce costs and enhance efficiency.
2.4.5. Defining End Points for Integrated Control

In the case of Ascaris, Trichuris and schistosome infections, the major goal is a sustainable reduction in worm burden and control of morbidity, while for lymphatic filariasis, onchocerciasis and trachoma, the major goals are to reduce or eliminate transmission resulting in much reduced morbidity in future generations. The externalities of these two goals are considerable and include improved education, and economic productivity. The calculated annual loss of US $1 billion from lymphatic filariasis in India (Ramiah et al., 2000) and $5.3 billion from blinding trachoma while substantial reductions in future wage-earning capacity as a result of chronic hookworm infection in childhood, illustrates the burden and costs of these diseases to poor individuals and communities. An added externality emphasizes the immunosuppressive effects of helminths, and their possible impact on promoting susceptibility to HIV-AIDS, tuberculosis and malaria (Fincham et al., 2003). The control of helminth infections has been suggested as a means to reduce the burden of malaria by reducing the frequency of malaria fevers, the frequency of severe and cerebral malaria, and the prevalence of anaemia (Speigel et al., 2003; Le Hesran et al., 2004; Sockna et al., 2004; Druilhe et al., 2005), although a recent study concludes S. haematobium infections are protective against P. falciparum in children in Mali (Lyke et al., 2005).

3. PARASITIC DISEASES: NEW AND OLD CHALLENGES

3.1. Emerging Diseases

The problem of emerging diseases (defined by either new infections of humans or re-emerging ones where a rapid increase in incidence of an existing infection or in a new geographical area) has been a significant concern as new viruses such as SARS, Avian influenza and Ebola virus have been identified. In the USA, potential epidemics of West Nile Fever and the recognition of Lyme Disease and Hanta virus have alerted authorities to previously unidentified threats. As a result,
considerable additional resources have become available for research on such emerging agents. Recent quantitative analysis of the risk of emergence allied to the nature of the organisms, their mode of transmission and source have been provided by Taylor et al. (2001). They note that viruses, bacteria and protozoa are more likely to emerge than macroparasites (e.g. helminths), that around 75% of emergent organisms are from zoonotic sources and that emergences are independent of the mode of transmission. It should be noted however that despite the emphasis in some circles of the importance of such agents they are not predicted to play a significant role in the Global Burden of Disease estimates as a proportion of Global DALYs.

Such conclusions are based on the current definition of species. However, the capacity to identify “species complexes/groups” and the level of intraspecies variation is becoming apparent as a result of molecular analyses. The development of the discipline of molecular epidemiology, which has been applied to vectors and causative parasites, clearly suggests that the absolute numbers of genetically distinct parasites and vectors irrespective of sub-specific variation is much greater than hitherto recognized emphasizing the degree of biodiversity in microorganisms and its importance in the strategies of parasite and vector control (Yameogo et al., 2004).

3.2. Climate Change

The suggestions that Global Climate Change will have a widespread impact on health as mean temperatures rise over the next decades have provoked studies on the projected change in distribution of vector-borne infections (Patz et al., 2005). It is generally agreed from different climate models that the mean rise of temperature over the next 100 years will be of the order of 2–4°C. The impact of these changes particularly on the distribution of Plasmodium falciparum malaria has been projected by various groups (IPCC, 2001; Rogers and Randolph, 2000; Hay et al., 2002) although little consensus is available (Patz et al., 2002; McMichael and Le Sueur, 2002). In addition, the role of El-Niño events have been studied which have been identified with a change in epidemic patterns in different regions
of several vector-borne infections (dengue in Indonesia; malaria in most of Africa, Colombia and India) (Bouma et al., 1997).

3.3. Epidemics of Parasitic Diseases

Anthropogenic and environmental changes frequently result in epidemics of parasitic disease. Several reviews have identified the primary drivers of these changes (Molyneux, 1997, 2003; Patz et al., 2004). These are

1. Movements of non-immune populations in areas where transmission occurs; such movements may be of an organized nature, e.g. mobilization of the workforce in Brazil to exploit forest resources has resulted in malaria epidemics. Alternatively, they may occur without formal organization, e.g. movements of workers involved in mining for gold or gems in the Amazon and South East Asia.

2. Climatic changes, e.g. temperature change is considered to be a cause of highland malaria in Kenya and Ethiopia. Unusual levels of rainfall following periods of drought result in epidemics of malaria in East and South Africa.

3. Urbanization results in populations being exposed to new organisms, vectors establish in new habitats and peri-domestic reservoirs act as the source of infection. Health services are grossly inadequate or non-existent and service providers are often only NGDOs or faith groups.

4. Change in vegetation such as the growth of thickets of the plant *Lantana* in Uganda, which provided a habitat for *Glossina fuscipes*, provoking epidemics of Rhodesian sleeping sickness. Another example is deforestation, which has resulted in exposure to leishmaniasis in the Amazon and malaria in South-East Asia (Walsh et al., 1993).

5. Development projects particularly those involving water resource development themselves frequently exacerbate the health problems of the local or incoming population (Birley, 1995; Hunter and Rey, 1993; Erlanger et al., 2005; Keiser et al., 2005).
6. Conflict, civil unrest and associated population disruption have profound impacts on parasitic diseases. Epidemics are frequently associated with such events; those organisms which have a rapid capacity for adaptation and reproduction and are associated with vectors which have characteristics as generalists are more prone to create health problems in conflict environments (Molyneux, 1997, 2003). Table 5 lists recently documented conflict-related changes in parasitic disease epidemiology.

7. Agricultural development projects particularly associated with irrigated agriculture and development of monocultures are associated with changed patterns of insect-borne infections particularly malaria (Ijumba and Lindsay, 2001), leishmaniasis and schistosomiasis (Patz et al., 2004). A recent review (Keiser and Utzinger, 2005) on food-borne trematode infections (Clonorchis, Opisthorchis, Paragonimus, Fasciola and Fasciolopsis) has suggested that the growth of aquaculture is the major risk factor in the emergence of food-borne trematode diseases as public health problems in particular in South Asia; whilst Lun et al. (2005) has emphasized the importance of Clonorchiasis as one of the leading causes of cancers in this region.

Common themes that appear to operate in the above settings are expressed in Tables 6–8 (Molyneux, 2003).

Epidemics are provoked as stated above by ecological, climatic and environmental change, urbanization, human population movement resulting from civil unrest and conflict, reduced surveillance and drug or insecticide resistance. It is recommended by policy makers that health systems are restructured to include: a generalized ‘horizontal’ pattern of healthcare; insurance systems and user charges; and decentralization of management to district level (or equivalent). Such restructuring reduces the ability of the system to respond to factors that lead to epidemics. It must be borne in mind that the so-called “vertical” parasitic disease control activities, such as onchocerciasis control, lymphatic filariasis, Chagas disease and Guinea worm eradication programmes, have been remarkably successful (Molyneux, 2004) producing economic rates of return of between 15% and 30% which is regarded as being compatible with the best available
<table>
<thead>
<tr>
<th>Diseases</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleeping sickness (African trypanosomiasis)</td>
<td><em>Trypanosoma brucei gambiense</em> Epidemics in Democratic Republic of Congo (DRC) and Angola associated with destruction/disruption of health services (Ekwanzala et al., 1996). Epidemics spread in north-western Uganda following conflict-related migration from Sudan</td>
</tr>
<tr>
<td></td>
<td><em>Trypanosoma b. rhodesiense</em> Disruption of cotton and coffee production in Busoga during the Amin regime resulted in spread of <em>Lantana</em>, providing breeding sites for <em>Glossina fuscipes</em> and initiating transmission of acute sleeping sickness in peri-domestic environments, with cattle acting as reservoir hosts; restocking following cattle raiding induced epidemics following importations of infected cattle (Fèvre et al., 2001, 2005)</td>
</tr>
<tr>
<td>Visceral Leishmaniasis</td>
<td>Epipemics of <em>Leishmania donovani</em> in southern Sudan; a changed ecological situation, associated with an increase in <em>Phlebotomus orientalis</em> populations in maturing <em>Acacia/Balanites</em> woodland, initially provoked the epidemics, which were left largely uncontrolled because of the civil war, migration of infected populations, and scarcity of treatment centres and availability of drugs (Ashford and Thomson, 1991; Seaman et al., 1992)</td>
</tr>
<tr>
<td>Cutaneous Leishmaniasis</td>
<td><em>Leishmania tropica</em> Resurgence of <em>L. tropica</em> in Afghanistan (Kabul) following an increase in urban population density of non-immunes because of conflict (Ashford et al., 1992)</td>
</tr>
<tr>
<td></td>
<td><em>Leishmania major</em> Movement of populations to Khartoum, because of conflict and drought, and establishment of transmission amongst peri-urban reservoir of non-immunes living in shanties.</td>
</tr>
<tr>
<td>Malaria</td>
<td>Refugee camps in Afghanistan and Pakistan Refugee populations settled at lower altitude, in sites with relatively high rainfall; refugees with inadequate immunity or exposed to different strains of <em>Plasmodium falciparum</em>; absence of drugs and no control of <em>Anopheles</em>; malaria epidemics in camps (controlled by spraying tents to control <em>A. stephensi</em> and <em>A. culicifacies</em>), exacerbated by increase in prevalence of <em>Plasmodium falciparum</em></td>
</tr>
</tbody>
</table>
development investments (Benton and Skinner, 1990). Because of the complexity of the biological systems inherent in parasitic infections, such diseases are not amenable to control by a strictly “horizontal” health system approach.

However, there is an ever-increasing recognition that integration of disease control programmes, particularly those which involve regular chemotherapy, will be cost effective and produce significant synergies, collateral benefits and externality benefits e.g. in improved educational performance and school attendance (Miguel and Kremer, 2001; Molyneux and Nantulya, 2004; Molyneux et al., 2005). These approaches, largely preventative chemotherapy, are extremely low

Table 5 (continued)

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>Mass deportation of urban non-immunes to forced labour in rice fields and forests; conscription for construction of defences in border areas where multi-drug-resistant malaria commonly occurs</td>
</tr>
<tr>
<td><strong>Onchocerciasis</strong></td>
<td></td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>Weekly aerial larviciding against <em>Simulium</em> suspended because of security problems and local conflict. Levels of transmission consequently increased</td>
</tr>
<tr>
<td>Guinea Bissau</td>
<td>Civil unrest prevented the distribution of Mectizan with consequent resurgence in incidence (Borsboom et al., 2003). Suspension or reduction of ivermectin distribution because of conflict.</td>
</tr>
<tr>
<td>Sudan and Sierra Leone</td>
<td>Planning of programme for community-directed distribution of ivermectin retarded by the collapse of national structures; remaining (passive) distribution by non-governmental donors.</td>
</tr>
<tr>
<td>DRC, Central African Republic, Liberia and Angola</td>
<td>Planning of programme for community-directed distribution of ivermectin retarded by the collapse of national structures; remaining (passive) distribution by non-governmental donors.</td>
</tr>
<tr>
<td><strong>Dracunculiasis</strong></td>
<td></td>
</tr>
<tr>
<td>Ghana</td>
<td>Increase in reported cases 1 year after local conflict failed to contain cases from the previous year</td>
</tr>
<tr>
<td>Sudan</td>
<td>The civil war prevented adequate case-finding, case-containment, water-supply control and filter distribution (Hopkins et al., 2002)</td>
</tr>
</tbody>
</table>
cost compared with the costs of treating some of the higher-profile infections such as HIV/AIDS, TB and even malaria. Fenwick et al. (2005) calculate the costs of annual chemotherapy for polyparasitized populations of 500 million in sub-Saharan Africa as US$0.40; if this intervention was integrated effectively, a group of diseases could be tackled permanently reducing transmission, in some cases to the point of elimination and reducing morbidity in others. Molyneux et al. (2005) compare the costs of this intervention approach with costs of treatment of TB and HIV/AIDS and recommend a different approach by policy makers given the available interventions for these diseases which barely impact on the transmission hence

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**Table 6** Common themes associated with changing vector-borne parasitic diseases

<table>
<thead>
<tr>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidemics are often associated with generalist vectors (see Table 7)</td>
</tr>
<tr>
<td>Animal reservoirs or mixing vessels are associated as food sources for such vectors</td>
</tr>
<tr>
<td>Animal reservoirs may be domestic, wild animals or intensively reared species</td>
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<tr>
<td>Reduced biodiversity (often associated with 7 and 8 below) encourages expansion of adaptable generalist vectors and reservoirs</td>
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<tr>
<td>Ratios of <em>P. vivax</em>: <em>P. falciparum</em> change with increasing <em>P. falciparum</em></td>
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<tr>
<td>Extractive activities (uncontrolled) generate the development of anti-malaria resistance</td>
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<tr>
<td>Water resource development (dams, microdams, irrigation, aquaculture) generates change in vector-borne disease patterns over variable time frames</td>
</tr>
<tr>
<td>Malaria and Japanese encephalitis—Acute</td>
</tr>
<tr>
<td>Schistosomiasis/dracunculiasis—Medium</td>
</tr>
<tr>
<td>Filariasis—Chronic/long term</td>
</tr>
<tr>
<td>Deforestation/reefforestation impacts on vector-borne infections via behaviour of human, reservoirs and vectors through edge/interface effects/fragmentation patterns, degree and type of refoorestation, loss of biodiversity, loss of forest eliminating vector species common pattern of change occurring within different vector complexes</td>
</tr>
</tbody>
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**Table 7** Characteristics of generalist vectors

<table>
<thead>
<tr>
<th>Characteristic</th>
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<tbody>
<tr>
<td>Wide geographical distribution</td>
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<tr>
<td>Species complexes or species groups</td>
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<tr>
<td>Capacity to feed on a range of available hosts</td>
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<tr>
<td>Capacity for zoophily and anthropophily</td>
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<tr>
<td>Ability to exploit peri-domestic and peri-urban settings</td>
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<tr>
<td>Ability to exploit new pre-imaginal habitats</td>
</tr>
<tr>
<td>Efficient vectors with high vectorial capacity</td>
</tr>
<tr>
<td>No transovarial transmission</td>
</tr>
</tbody>
</table>

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regrettably there will be increasing incidence with no diminution of the pressure to apply and react to demands for treatment.

It is also important to distinguish between the control of an organism (parasite, vector or ectoparasite) at the level of the individual and at the level of the community. An example of the paradox (individual vs. community) is the conflict between the treatment of individual patients compared with the need to control or eliminate which requires large-scale community involvement.

The changing health policy environment has been emphasized, because it is important to recognize that approaches to control are dependent on an accurate knowledge of the totality of the problem. This requires biological, medical, epidemiological and social science inputs to define the aetiology (causative organisms), the vectors (if vector-borne), the parameters and the mode of transmission (e.g. vector-borne, water-borne, aerosol, orofaecal, venereal). Systems of surveillance, monitoring and evaluation are required to define prevalence and trends of infection and disease. Without such information a control programme cannot be appropriately designed and implemented. Biological information needs to be supplemented by consideration of issues such as logistics; cost effectiveness; potential for integration within existing programmes; past successes or failures; input from governmental sectors other than health (agriculture,
forestry, education, water, other natural resources, wildlife); acceptability of an intervention to the target communities; potential for ecological damage; priority rating afforded by the Ministry of Health (MOH); availability of human resources for implementation; and potential of research to provide improved products within a particular timescale.

4. CONCLUSIONS

This chapter provides the broader context and overview in which the specific disease control, elimination or eradication interventions are positioned within Ministries of Health and the underlying principles which govern such activities. Many interventions while strongly supported by government require extensive donor support if they are to succeed while other programmes operate and have been successful by the effective management and resourcing directly from allocated and identified budgets over many years. These have been vertical approaches in middle-income countries to solve particular disease problems and have not been incorporated in the general health programmes at district or sub-district level where the specialist skills are not available. There have been significant successes in driving some infections in local often isolated environments to elimination with only a limited need for future resources for evaluation and monitoring to ensure there is no recrudescence. The individual chapters in this volume provide detailed reviews of diseases and identify progress needs and prospects for control or even eradication. The reality remains that parasites remain a significant and unacceptable burden particularly in the poor and neglected populations of the least-developed countries. The increased global awareness of the problems of the poor and the clear link between poor health and poverty provides the opportunities for these diseases to be more widely recognized. The establishment of the GFATM but particularly the report of the Commission for Africa and the UN Millennium project identified parasitic diseases in Africa as an impediment to development. There is a need for either development research to develop more effective, affordable and accessible drugs or simply to
provide access to highly effective drugs, some of which are donated via generous pharmaceutical companies for as long as needed at the cost of simply annual or biannual delivery. These are the “quick wins” or rapid interventions. The challenge in the latter case does not depend on science but on the prioritization of resources towards implementation and the evaluation and assessment of the development impact of such interventions against the overwhelming burden of health needs in the poorest countries.

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**Useful Websites:**

www.cochrane.org.
www.commissionforafrica.org pp. 72, 198.
www.filariasis.org.
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www.who.int/wormcontrol.