CHAPTER 6

Social Science Implications for Control of Helminth Infections in Southeast Asia

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Contents

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Advances in Parasitology, Volume 73
ISSN 0065-308X, DOI: 10.1016/S0065-308X(10)73006-2

Abstract

Social science perspectives can inform helminth disease control in Southeast Asia. The social science literature offers theoretical and conceptual models; research methods; recommendations for training and capacity building, health education and health care professional training; and practice guidelines, including implementation of evidence-based interventions. Priority themes include poverty, gender differences, health inequities and access to social resources. Implications for helminth control include broadening disease monitoring and surveillance to include social and economic variables and subjective measures of well-being; training for health professionals and researchers in the social determinants of health; and application of social science models, specifically the expanded 'Chronic Care Model', to the planning and evaluation of interventions. The chapter posits that helminth diseases meet the World Health Organization's expanded definition of chronic conditions, and that integrated delivery of multiple interventions is needed to address the full range of risks and outcomes due to helminth infection.

6.1. INTRODUCTION

Helminth parasites are among the most common causes of infection in developing countries. These infections strike approximately one-third of the nearly three billion people in Asia and sub-Saharan Africa who survive on less than US$ 2 per day (Hotez et al., 2008b). Although human helminthiases have been recognised for thousands of years, they are considered re-emerging diseases (Hotez, 2008; Murrell and Pozio, 2000; Senior, 2008) because new outbreaks occur in the context of environmental and socio-political change (Brindley et al., 2009). Helminthiases are diseases of poverty (Hotez and Ferris, 2006; Manderson et al., 2009), meaning that disease-risk is associated with social disadvantage. The commonly heavy burden of disease has a profound impact on child development, economic progress, educational attainment and workforce potential among affected groups (Goodhand, 2003; Rosenberg, 2007; Thanh et al., 2006). Despite scientific understanding of disease transmission, effective programmes for helminth control, these infections remain a challenge. This chapter focuses on applied social sciences as a resource for research, teaching and interventions in helminth disease control.

Awareness is growing concerning the role of human behaviour in the epidemiology of infectious disease, and its co-dominance with natural causal processes in defining parasitic disease ecology (Wilcox and Gubler, 2005). Humans play an important role in helminth disease transmission, both as individuals and as groups. At the macro-scale, globalisation widens income disparities that, in turn, create health disparities largely by influencing exposure to risks and access to protective resources

(Anderson et al., 2003; Armelagos et al., 2005; Labonte and Schrecker, 2007a,b,c). At the micro-scale, diet is a risk factor, for example, in Thailand where consumption of undercooked pork and fish increases the risk of contracting trichinosis and opisthorchiasis (Kaewpitoon et al., 2006, 2008a,b,c). Micro-scale factors are also important in helminth disease control. Behaviour patterns can vary over a small area with age, even at the village level, and with regard to sex and social status. Some environmental factors that influence the risk of infection, such as vector breeding sites, also operate on a small, local scale (Booth and Dunne, 2004). Detailed knowledge of the complex interactions of human, parasites, hosts and the environment is lacking (Macpherson, 2005). Effective behaviour change interventions that address cultural, social and behavioural dimensions of disease are poorly implemented in practice (Glasgow et al., 2003; Macpherson, 2005).

6.1.1. Social forces and human health

Globalisation is an important macro-scale, anthropogenic force that influences health and a wide range of health outcomes (Armelagos et al., 2005; Smith and Michele, 2002). Sociologist Anthony Giddens (1990, p. 64) defines globalisation as ''the intensification of worldwide social relations which link distant localities in such a way that local happenings are shaped by events occurring many miles away and vice versa.'' Although some economists maintain that globalisation promotes development that leads to improvements in population health, this process is neither automatic nor widespread or uniformly distributed across populations or regions (CSHD, 2008; Kawachi and Wamala, 2006; Labonte and Schrecker, 2007a,b,c; Marmot and Wilkinson, 2006). Globalisation influences health by altering the patterns of trade, especially with regard to food; and of human migration and travel; and introduces changes in agriculture and aquaculture. This brings people from non-endemic areas into contact with parasites of various kinds and can bring those in endemic areas into closer contact with disease sources and vectors (Armelagos et al., 2005; Keiser and Utzinger, 2005). Other social and political structures, which operate across a range of spatial scales from the very local to the national, also exert a strong and pervasive influence on health. These structures include health care systems, transportation, education, community characteristics and culture (Macpherson, 2005), factors often referred to as the social determinants of health (CSHD, 2008; Marmot and Wilkinson, 2006). Table 6.1 displays the social and behavioural factors discussed in this chapter.

All factors are not relevant in every situation. Ideally, participatory methods should be used to identify locally relevant factors in targeted areas. Community participatory methods are discussed in Section 6.3.1.

TABLE 6.1 Social factors that determine health and their major areas of impact

Factors	Area of impact
Societal level	
Culture and ethnicity	Status of women and other social relations; child-rearing practices, dietary practices; access to resources; exposure to risk; ideas about health and illness; occupational opportunities
Globalisation	Ecological disruption; development of antibiotic-resistant pathogens; and changes in agriculture, aquaculture and urbanisation
Poverty	Access to health promotion and disease prevention measures; daily living conditions; stress, including disease resistance and resilience
Health inequities	Daily living conditions; access to societal resources, including clean water, nutritious food, adequate housing, education and health care
Individual level	
Gender	Social and economic roles; access to resources, notably health care and education; exposure to risk; child and sick care responsibilities
Age	Intensity and prevalence of infection; causal organisms of disease; vulnerability to environmental versus behaviour-related exposures
Education	Health status and health-related behaviours, including diet and hygiene; exposure to risk; occupational opportunities
Occupation	Disease exposure; income; daily living conditions for self and family; social status of self and family
Health behaviours	Exposure to food-borne pathogens; contamination of water supplies from poor hygiene; success of treatment (compliance)

Participatory methods also serve to introduce the values and perspectives of affected individuals and groups so that interventions can be planned that gain community support and acceptance. Social determinants of health adversely and disproportionately affect resource-poor individuals, groups and countries. In this context, poverty and inequality can be considered major 'causes of the causes' of helminthiasis to paraphrase Michael Marmot (2006). Poverty is both a cause and a sequela of these diseases. Globalisation has widened inequalities within and between societies, and accelerated the emergence and re-emergence of diseases of poverty (Armelagos et al., 2005). Effecting change in health and social

policy that reduces health disparities will require long-term investment in communities, evidence-based findings, advocacy, institutional capacity building and political will (CSHD, 2008; Waikagul, 2006).

6.1.2. Relevant concepts and methodologies from social science

Conceptual and methodological issues are important when planning the integration of social sciences in helminth disease control (Kloos, 1995). Since 1945, a well-developed and much-debated body of social and critical theory, often called postmodernism, has evolved, and this theory provides conceptual support for analyses of health and health-determining social phenomena (Tomso, 2008). Jurgen Habermas's theory of communication (Gilder, 1987) and Giddens's (1984) structuration and globalisation theories (Giddens, 1990) are particularly relevant to health concerns that result, at least in part, from social inequities. In this chapter, we follow the World Health Organization (WHO) in the use of the term 'health inequities' to refer to the circumstances in which people live, work and age, including the systems that are put in place to address health and illness, including the political, social and economic forces that determine these conditions (CSHD, 2008). Concepts derived from social theories that are relevant to helminth control include the following:

- the influence of power differentials among individuals, families, groups, nations, etc. on health and health outcomes, often via access to resources (Tomso, 2008);
- the existence of limits on the 'agency' of individuals, and on individuals' responsibility vis-à-vis disease risk (Giddens, 1990), which includes critiques of blaming individuals for disease when other processes or agents, such as political and social factors, exert strong influence;
- the role that social structures play in creating and maintaining health disparities (Giddens, 1990); and
- the value of participatory planning and effective health communication (Gilder, 1987).

Relevant social science models that are discussed in this chapter include the 'PRECEDE-PROCEED model' (Green and Krueter, 1999), the 'Behaviour Change model' (Prochaska and DiClemente, 1982) and the 'Chronic Care model' (Wagner et al., 2001). The 'PRECEDE-PROCEED model' and the 'Chronic Care model' are discussed in Sections 6.2.2.5 and 6.4.1.2, respectively. The 'Behaviour Change model' was originally developed to address smoking, but has been adapted for a wide range of health interventions. More recently, the U.S. Society of Behavioral Medicine formed an interest group in multiple health behaviour change (Prochaska et al., 2008a), which may be useful in helminth

control given that behavioural risk factors span dietary practices, hygiene, and agricultural and animal raising practices (Suroso et al., 2006). Analysis of behaviour change in multiple health interventions can combine the use of traditional measures, which report change in each behaviour separately, with creation of combined change indexes, and inclusion of health-related quality of life indicators such as cost, worker productivity and subjective wellness (Prochaska et al., 2008b). Multiple risk factor interventions represent a new and growing field of endeavour that can benefit helminth disease control.

This chapter posits that helminth diseases meet the WHO-expanded criteria for chronic disease, which includes tuberculosis, HIV/AIDS and other health problems that persist across time and require coordination of health care management (WHO, 2002). We propose the application of the 'Chronic Care model', specifically in its recently expanded version (Jenkins et al., 2010), to helminthiasis control. In its expanded version, the 'Chronic Care Model' is based on a social ecological groundwork, and includes a community focus (Fig. 6.4).

6.1.3. Purpose and structure of this chapter

The purpose of this chapter is to provide an overview of the literature on social sciences and disease prevention, and a discussion of potential social science contributions to research, training and control of helminthiasis in Southeast Asia. Incorporation of social science perspectives in parasitic and infectious disease control is essentially a process of including and attending to the social determinants of health. Two broad categories of human factors are important in helminth control: (i) demographic and social characteristics at the community level, including culture and access to societal resources, and (ii) disease intervention and relevant social and health policy, including surveillance and research (Wilcox and Gubler, 2005).

In Section 6.2, concepts and methodology from the social sciences are introduced and applied to helminth disease control; and describe the major determinants of health at the individual and social levels, which were identified by review of the literature with an emphasis on infections caused by the helminthes in Southeast Asia. Social science approaches that can enrich helminth research are described in Section 6.3. These approaches include community-based participatory research (CBPR), implementation science, cross-disciplinary approaches, and qualitative and mixed-methods research. Although these are research methods, the principles upon which they are based can contribute to interventions and planning in helminth disease control. In Section 6.4, we provide a summary of the major themes in the literature on the social determinants of helminth diseases, as they pertain to research and control, including capacity building, application of the 'Chronic Care model' (Green and

Krueter, 1999), measures of poverty and health inequality, disease monitoring, and implementation planning and evaluation.

The literature cited in this chapter is from a broad range of social sciences, including demography, behavioural, economic and political sciences, as well as the multiple disciplines of fields more familiar to the tropical disease research community, such as epidemiology, public health, health services, health policy, and health communication and education. Diseases referenced in this chapter are helminth diseases endemic to Southeast Asia (Hotez et al., 2008b; Kaewpitoon et al., 2006; Keiser and Utzinger, 2005), including schistosomiasis and food-borne trematodiases (e.g. *Clonorchis sinensis* and *Opisthorchis viverinni*), cysticercosis as well as other tropical diseases, reference to which sheds light on control of the aforementioned diseases.

6.2. SOCIAL DETERMINANTS OF HELMINTH INFECTIONS

The Commission on the Social Determinants of Health (CSDH) was launched by the WHO in March 2005 (CSHD, 2008). Its mandate is to trace the pathways by which social determinants influence health status and outcomes. The report identified poverty as one of the key factors that determine health. Concern about inequities, 'unfair and remediable inequality', is central to WHO's mandate, harking back to the original definition of health in the WHO Constitution and the 'Health for All' initiative. In 2007, UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR) established an expert committee to examine the status of applied social science in tropical disease control and to integrate social sciences into the TDR (Manderson et al., 2009). Attention to the social determinants resulted in an altered view of helminthiases, and greater appreciation of the social and biological contexts in which these diseases emerge and persist (Aagaard-Hansen et al., 2009; Bruun and Aagaard-Hansen, 2008; Gazzinelli et al., 2006; Huang and Manderson, 2005).

We concur with the conceptual framework for schistosomiasis control shown in Fig. 6.1, which depicts the wide range of factors that must be considered to design research and plan effective interventions for helminth diseases. The inner group comprises the essential elements of prevention, diagnosis and treatment. The middle group contains cross-cutting intervention elements, and the outer group represents the more general social determinants of relevance (Aagaard-Hansen et al., 2009).

The Institute of Medicine (IOM) Committee on Capitalizing on Social Science and Behavioral Research to Improve Public Health in the United-States examined a wide range of social and behavioural research whose intent was to promote the health and well-being of individuals, families

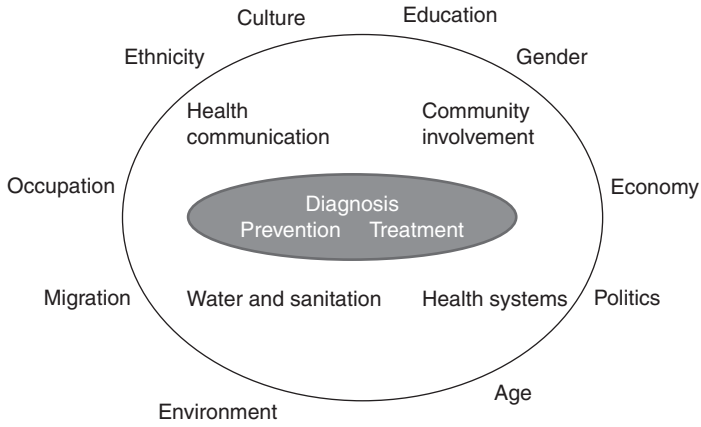

FIGURE 6.1 Conceptual framework outlining the main elements of schistosomiasis control (Aagaard-Hansen et al., 2009).

and communities. The committee identified an emerging consensus that research and intervention efforts should be based on a social ecological model (Smedley and Syme, 2000). This model assumes that differences in levels of health and health outcomes result from a dynamic interaction among genetics, behaviour and the environment, an interaction that unfolds over the life course of individuals, families and communities.

The social ecological model assumes that age, gender, race, ethnicity and socio-economic differences shape the context in which individuals function, and therefore directly and indirectly influence health risks and access to the resources that mitigate risk. In the literature, these are called risk and protective factors. Social-level factors that influence health, notably globalisation (Labonte and Schrecker, 2007a), are often referred to as 'upstream' phenomena versus individual-level factors, or 'downstream' phenomena such as gender, age and education (Smedley and Syme, 2000). Research and intervention efforts should attend to both upstream and downstream risk factors of disease (Manderson et al., 2009; Smedley and Syme, 2000). In the following sections, we discuss the social and individual, or upstream and downstream, phenomena that put people at risk for helminth diseases.

6.2.1. Social determinants at the societal level

Social and political factors, such as dominant cultural patterns and structures of inequity, make certain groups or individuals more vulnerable to helminth infection than others (Porter et al., 1999). These factors include, but are not limited to, culture, ethnicity, occupation and the impacts of globalisation and poverty.

6.2.1.1. Culture and ethnicity

Culture and ethnicity determine social relations and influence many health-related behaviours. For example, the status of women, child-rearing practices and dietary practices are often determined by culture, ethnic group and religious background. Culture influences habits and practices such as latrine construction and excreta disposal (Boia et al., 2006). Culture also influences people's ideas about health, disease and what constitutes healthy behaviours and good health care; and what occupations or types of employment are available to them. It can be difficult or dangerous for individuals or families to adopt behaviours or make lifestyle choices that diverge from existing social and cultural norms.

Similarly, when epidemiological studies point to ethnicity as a disease-risk factor, there is often an underlying pattern, such as division of labour among ethnic groups (e.g. Fenwick et al., 1982), that better explains the phenomenon. For example, the seclusion of women in some Muslim communities leads to women's lower rates of schistosomiasis due to less exposure to infected water (Michelson, 1993). Where infected water is used for daily ablutions by Muslim men, they have higher prevalence of water-borne diseases than women (Kuntz, 1952). In a Muslim community in northern Nigeria, activities involving contamination and exposure were almost exclusively carried out by men (Tayo et al., 1980). In schistosome-endemic areas in the People's Republic of China (P.R. China), minority groups are at greater risk of *Schistosoma japonicum* infection than the majority (Han) population. For example, in a single village in Yunnan province, the prevalence of schistosome infection was 70.0% (28/40) among Miao and 51.2% (88/172) among Yi ($P < 0.05$). In another village, the infection rate was 25.8% (126/488) among Yi and 18.9% (17/90) among Han. The association of ethnicity and infection does not point to biological or behavioural differences, but to differences in occupations and access to clean water (Zheng et al., 2000).

6.2.1.2. Impacts of globalisation

The impact of globalisation on health and disease spans ecological disruption, the spread of antibiotic-resistant pathogens and widening income disparity that produces other social and health disparities. Urbanization and changes in agricultural and industrial production are important large-scale processes that impact helminth disease, but it is beyond the scope of this chapter to address these dimensions. Instead, the focus is on health dimensions of globalisation that determine the risk of helminthiasis, re-infection rates and related health outcomes. Among these outcomes of globalisation, widening income disparities exert the strongest and most pervasive influence on health (Armelagos et al., 2005). According to the WHO, the linkages between globalisation and health include

direct influences on health systems, health policies and exposures as well as the indirect influences of the economy on the health sector, including effects of trade policies and financial flows on availability of resources, public expenditures on health and household income (Labonte and Schrecker, 2007a).

6.2.1.3. Poverty

The countries of Southeast Asia vary in terms of economic development, but throughout the region, helminth infections are more common and more severe in geographic areas and among populations living in poverty (Manderson et al., 2009). The relationship between poverty and disease is well-documented in the literature of development, and health is recognised as an important component of multi-dimensional conceptualisations of poverty (Hulme and Shepherd, 2003; McKay and Lawson, 2003; Wood, 2003). Health is both a benefit of development and necessary to development (Labonte and Schrecker, 2007a).

Lack of access to societal resources that promote and maintain health is the operative factor in the relationship between poverty and disease. Poverty-reduction initiatives launched worldwide during the past decade, such as the Millennium Development Goals (www.un.org/millenniumgoals/goals.html), tend to equate poverty with low income, and view the poor as a homogeneous group ineffectively integrated into the market economy (Hulme and Shepherd, 2003). The social sciences literature on chronic poverty reminds us that every community that suffers inter-generational poverty and every place of engrained poverty is unique (Hulme and Shepherd, 2003). This uniqueness speaks to the need for community-based and participatory approaches to plan effective interventions. Viewed broadly, the deleterious influence of poverty on health is one of diminished well-being, stunted development and reduced overall quality of life for individuals, families and communities.

Chronic or persistent poverty can be understood as the experience of significant deprivation for a period of 5 years or more (Hulme and Shepherd, 2003). The 5-year criterion reflects empirical data showing that long periods of poverty are more damaging than short ones (Harper et al., 2003) and the nature of economic panel data, which is often collected at 5-year intervals. Most measures assess poverty in absolute terms, but relative poverty (being in the bottom quintile of a country's income distribution) is as damaging and perhaps more difficult to escape (Hulme and Shepherd, 2003).

The impact of poverty is a function of gender, the age at which poverty is experienced, the social position in the family and contextual factors, including the quality of public education and health care as well as the social resources of the relevant community (Harper et al., 2003; Hulme and Shepherd, 2003). Persistent poverty is found most often in ethnic minority

communities living in remote, rural and politically contested areas (Baulch and Masset, 2003; Goodhand, 2003). The experience of poverty also depends on social contexts, for example, people's understanding of poverty differs in transitional versus developing economies (Hulme and Shepherd, 2003).

Subjective analyses of poverty obtained through qualitative research can help identify the locally relevant components of poverty, axes of differences in the experience of poverty and the appropriate units and scales for analyses of these factors (Camfield et al., 2009; Crivello et al., 2009; Hulme and Shepherd, 2003). Disadvantaged people often define the problem of disease in their lives as lost income from inability to work (Camfield et al., 2009; Labonte and Schrecker, 2007a), and explain their lack of access to health care as an issue of high cost, corruption and discrimination (Narayan et al., 2000).

6.2.1.4. Health inequities

Despite significant advances in scientific understanding of helminth disease, and development of programmes for prevention and treatment, marked disparities in access to care and resources perpetuate both the endemicity of these diseases in resource-poor areas of Africa, Asia and Latin America, and the re-emergence of these diseases in Europe and the United States. Worldwide, most funded health research is biomedical in focus and does not attend to inequities that determine health and illness (CSHD, 2008).

Improving the daily living conditions of women and children is the first major goal of the WHO's plan to eliminate health inequities, intergenerational poverty and associated cumulative disadvantage. Children share a disproportionately large burden of helminth disease (Bundy, 1988), with the exception of fish-borne parasites (Chai et al., 2005). In contrast, in Thailand, where raw and undercooked fish is fed to babies in certain areas, early onset of fish-borne parasitic infection from certain species is high (Sithithaworn and Haswell-Elkins, 2003). Helminth infections complicate pregnancy and stunt child growth and development. Maternal ill health and childhood disease have life-long impacts on human capability and potential (Hulme, 2003; Jukes, 2007). Some species, notably lymphatic filariasis, also disfigure and stigmatize the infected (Hotez and Ferris, 2006). After tobacco, infections are the most preventable cause of malignancies (Sripa et al., 2007).

6.2.2. Social determinants at the individual level

6.2.2.1. Gender

Most gender-oriented research on neglected tropical diseases (NTDs) has focused on women rather than on the more nuanced issue of gender and its relationship to other risk factors such as age and socio-economic status (Manderson et al., 2009). Although men and women react differently in

terms of biological and immunological response to infection (Booth and Dunne, 2004), considerable local variation in prevalence and intensity of infection can be best explained by differences in the social and occupational roles taken up by men and women (Special Programme for Research Training in Tropical Diseases, 2006).

In many cultures, there are different expectations for men and women's contributions to child care, preventive measures and care of the sick (Vlassoff and Manderson, 1998). These differences are determined by culture rather than nature. Cultural patterns alter in response to changes in social, economic and technological conditions, and institutional and legal environments. In spite of this capacity for change, gender analysis continues to reveal skewed power relations and structural inequities. This has a myriad of differentiated consequences for the health of women, children and men in many settings (Vlassoff and Bonilla, 1994). Gender issues need to be understood within a broader political and environmental context that accounts for inequality, political instability, violence, displacement and globalisation (Kawachi and Wamala, 2006).

Most reports indicate that the *S. japonicum* infection rate, and re-infection following treatment, is higher in men than that in women (Booth et al., 1996). In P.R. China, this is generally explained by men having more frequent contact with infected water than women (Huang and Manderson, 2005). In contrast, the higher prevalence of fish-borne parasitic disease and disease complications in adult males in parts of southern P.R. China and Southeast Asia may be related to the interaction of genetic (Laha et al., 2008; Sripa et al., 2003; Suttiprapa et al., 2008) and behavioural factors, including tobacco and alcohol use (Chai et al., 2005; Crompton and Savioli, 2007). Diet is an important factor in the transmission of food-borne trematodiases to humans when metacercariae are consumed in raw, undercooked or inadequately preserved food (Chai et al., 2005; De et al., 2003; Dung et al., 2007; Elkins et al., 1996). Surveillance statistics in Asian countries reveal that men are also at greater risk for trichinosis infection (Kaewpitoon et al., 2006, 2008a). Although women may be exposed to the parasites while preparing food, this is not considered an important risk factor for food-borne infection (Strandgaard et al., 2008).

Beyond exposure patterns, gender influences perceptions of illness and involvement in decision-making regarding access to treatment and use of treatment interventions. Women may ignore symptoms of disease longer than men in an attempt to meet other household members' expectations of them. Furthermore, they may not be allowed to seek treatment or to incur expenses related to health without permission from their husbands or fathers. While both men and women in endemic areas suffer from inequities and conditions of poverty, women are particularly disadvantaged due to the social and economic priority granted by the wider society to men (Danso-Appiah et al., 2004).

More attention should also be given to the role of women in prevention of helminthiasis. Women are often responsible for family health care and for guiding children's sanitation habits. Educating and empowering women may help change attitudes about behaviour and the value of technical innovations for improving household water supply and sanitation (Bruun and Aagaard-Hansen, 2008). Gender sensitivity is needed while working with local populations and health staff, especially for genital schistosomiasis (Talaat et al., 2004). Pregnant and lactating women need treatment for helminthiasis and interventions to prevent nutritional deficiencies that affect their own health and the health of their unborn children (Special Programme for Research Training in Tropical Diseases, 2006).

6.2.2.2. Age

Field studies of helminth infections demonstrate that intensity and prevalence of infection exhibit a marked dependency on host age. In endemically infected communities, peak levels of the major intestinal nematodes, *Trichuris trichiura* and *Ascaris lumbricoides*, and schistosome infections typically occur in schoolchildren aged between 10 and 14 years (Anderson and May, 1992; Crompton and Savioli, 2007; Gazzinelli et al., 2006; Li et al., 2009).

Figure 6.2 shows how helminth infections can vary by age. High prevalence of helminthiasis in children probably reflects the role of environmental risk factors. Treatment targeted at school-age children is a

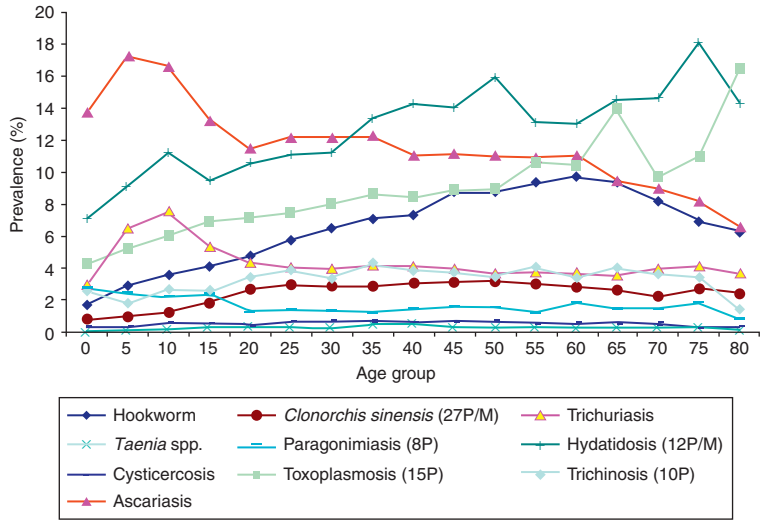

FIGURE 6.2 Age distribution of helminth infections in P.R. China.

good strategy for control of morbidity but does not reduce the vulnerability of the school-aged population (Brooker et al., 2006; Bundy and Guyatt, 1996). Even when mass treatment is performed at intervals, re-infection in endemic areas is inevitable. It has widely been assumed that the slow acquisition of resistance in adults is caused by repeated exposure to the same antigenic repertoire of a single parasite strain, which confers poor protection against re-infection (Galvani, 2005). Better access to safe water and effective sanitation, including sewage collection and treatment and waste disposal, is essential to sustain advancements in public health (Crompton and Savioli, 2007; Hughes et al., 2004; Montresor et al., 2002). Helminth infections that are prevalent in adults, such as hookworm and food-borne trematode, reflect the dominance of behavioural risk factors. Intervention among adults should include cultural sensitivity and a focus on health education and health promotion.

Apparent age-related trends in the acquisition of infection imply age-dependent heterogeneity in exposure risk and genetic susceptibility. These factors are included in mathematical models that aid in the design of vaccination programmes for the control of directly transmitted viral and bacterial infections such as schistosomiasis. Theoretical predictions are based on parameter estimates obtained from epidemiological studies and are compared with observed temporal trends in disease incidence and age-stratified serological profiles (Anderson and May, 1985). An age-structured epidemiological model of intestinal helminth dynamics was developed to evaluate the effectiveness of age-targeted community chemotherapy in reducing morbidity due to helminth infection. The magnitude of age-related heterogeneities is important in determining the results of age-targeted treatment. The model was verified using field data from control programmes for *A. lumbricoides* and *T. trichiura*, and provided accurate predictions of prevalence and mean intensities of infection during and following the control regimes (Chan et al., 1994). The model has been validated against data from a *Schistosoma mansoni* control programme in Kenya (Chan et al., 1995, 1997).

6.2.2.3. Education

The positive association between education and health is well established. Education improves health directly and indirectly through fulfilling work and economic conditions, access to social-psychological resources and access to healthy lifestyle choices (Ross and Mirowsky, 1999; Ross and Van Willigen, 1997; Ross and Wu, 1995, 1996). Educational attainment is negatively correlated with exposure to water infected with *S. japonicum* (Chen et al., 1990, 1996; Li et al., 1998; Yin et al., 2000) and with prevalence of *S. japonicum* infections (Huang and Manderson, 2005). The more educated the household head is, the less likely their family members are to have schistosomiasis. These findings underscore the importance

of the relationships among educational level, occupation and income. At the same time, education alone directly influences an individual's capacity to understand and act on public health education messages. For example, the educational level of the mother or caretaker is inversely associated with prevalence of soil-transmitted helminth infections in children pointing to the role of the mother in educating children about hygiene (de Silva et al., 1996; Gazzinelli et al., 2006; Naish et al., 2004; Quihui et al., 2006). These findings can inform decisions about the best approaches to use in health promotion and health education (Wang et al., 2009; Yuan et al., 2000), and how to design effective messages for families and communities.

Health education and health promotion efforts should focus on community-level education programmes about the role of diet and sanitation in disease, and attend to the social and cultural dimensions of food preference and preparation. In spite of methodological difficulties, there is a need for more knowledge about local variations in preferences and habits, in the areas of diet and sanitation, including personal hygiene issues, and aquaculture and farming practices concerning the disposal of excreta. Programmes aimed at dietary behaviour change must attend to economic realities, as well as the preferences that underlie the consumption of foods. These findings would also be applicable in the control of related health problems, including diarrhoea and dysentery.

6.2.2.4. Occupation

Occupation is a valid predictor of helminth diseases risk, taking the locus of transmission and age into account (Huang and Manderson, 2005). Types of activities and local patterns of production determine the exposure of individuals to schistosome-infested water (Attwood, 2001; de Silva et al., 1996; Jiang et al., 1997). Occupations such as fishing and farming place individuals in proximity to disease vectors, and increase risk of schistosome infection (Loroni-Lakwo et al., 1994; Watts and el Katsha, 1997). Frequency of contact with water by occupation places fishing first in terms of helminth disease risk, aquaculture second and farming third. The relative risk of *Schistosoma mekongi* and *S. japonicum* infection follows the same order (Attwood, 2001; Huang and Manderson, 2005).

Occupational status also exerts indirect influences on health. Occupational options are often determined by socio-economic status, including age, gender and social status. In Northeast Thailand, occupation influences individual and family health directly by determining the financial resources that are available for prevention and treatment of disease, and also indirectly by influencing the status of the individual and family, and the level of stress that they experience (Jongudomkarn and Camfield, 2006).

6.2.2.5. Health behaviours

Behavioural scientists describe human behaviour as a reciprocal interaction between individuals and their environments. The morbidity experienced by humans from helminthiases results from the integration of human activity with the helminth life cycles (Crompton and Savioli, 2007). Dietary choices and sanitation-related behaviours are particularly relevant in helminth disease control. Policies, health education and community-level interventions can promote changes in individual, family and group behaviours. Figure 6.3 depicts the 'PRECEDE-PROCEED model' (Green and Krueter, 1999) of health programme planning as applied to food-borne parasite infections. The model begins with epidemiological and social diagnoses and works backwards to determine the desired educational and behavioural outcomes, and the planning of programme delivery (Kloos, 1995).

The 'PRECEDE-PROCEED model' has been used successfully in helminth disease control (Jimba and Joshi, 2001; Kloos, 1995) to facilitate health education and behaviour change by differentiating the roles of individuals, communities and outside influences on infection as well as to separate deliberate and non-deliberate health-related behaviours.

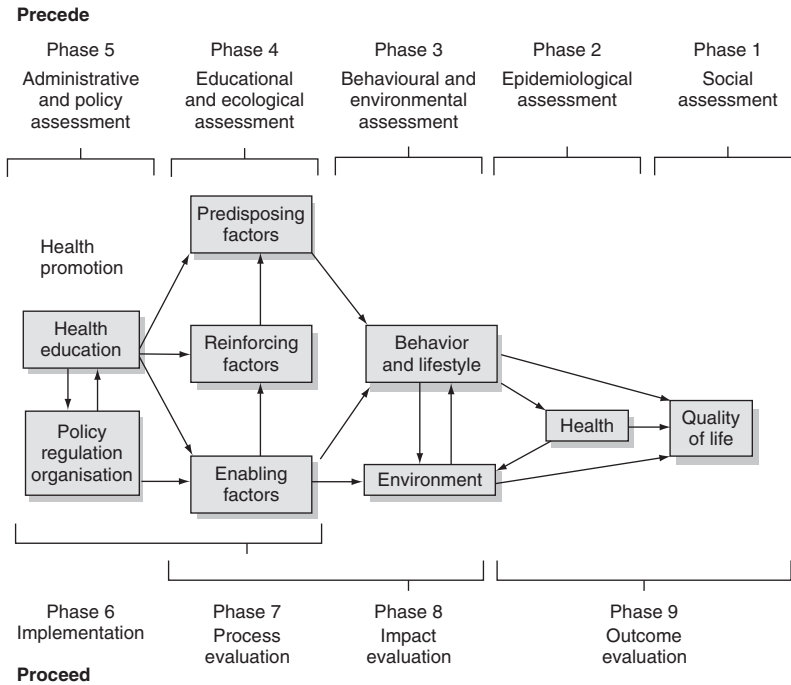

FIGURE 6.3 Green and Kreuter's PRECEDE-PROCEED model applied to food-borne trematodiases (Jimba and Joshi, 2001).

6.2.2.5.1. Dietary practices Ingestion of food-borne helminth larva is a major risk factor in the spread of helminthiases in Southeast Asia. Diet is culturally influenced, and also varies with gender, age and economic status. Where food-borne trematodiases are endemic, infections arise from the consumption of infective metacercariae in raw, pickled, smoked or undercooked fish, crabs, crayfish and vegetables that have been harvested from fresh or brackish water (Anantaphruti, 2001; Anantaphruti et al., 2007; Nithiuthai et al., 2004; Waikagul et al., 2006). Opisthorchiasis remains a major public health problem in many parts of Southeast Asia, including Thailand, Lao PDR, Vietnam and Cambodia. People become infected by eating raw or uncooked fish, which is traditional and popular in the northeastern and northern Thailand, particularly in the rural areas (Kaewpitoon et al., 2008a). Wild boar has emerged as a vector of infection in Japan in a form of 'meat sashimi' that is popular. Although fresh water crabs are more often the source of paragonimiasis in Japan, in a recent re-emergence of the disease, over 70% of cases were due to consumption of contaminated wild boar 'sashimi' (Nawa, 2000). Educational campaigns to encourage cooking methods that kill metacercariae must be introduced with care and sensitivity to cultural attitudes (Murrell and Crompton, 2006). Programmes aimed at dietary behaviour change must attend to these economic realities, as well as the preferences that underlie consumption of these foods. Fish is an important source of protein for millions of people living in areas where food-borne tremotodiasis is endemic, and aquaculture is a major industry in Asia where most of the world's finfish and shellfish are produced.

6.2.2.5.2. Sanitation-related behaviours A few highly infectious individuals can contaminate a whole locality, which poses a challenge for control, particularly in areas where prevalence of infection is low. In P.R. China, fishermen and boatmen excrete faeces into water when sanitation is unavailable. Even when latrines are available in rural areas, adults and children who are unfamiliar with these structures and processes may not use them. Bovine sources, especially buffalo in the lake areas in P.R. China, play a major role in the transmission of *S. japonicum* (Wang et al., 2009). In Vietnam, contamination of water with pig faeces is an important risk factor for infection with *Fasciolopsis buski* (De et al., 2003).

Introduction of fresh human and animal faeces as nutrients in household fish ponds is a major risk factor for food-borne tremitus infection. This practice is widespread in Asia. In rural Vietnam, latrines are often positioned directly above fish ponds populated by susceptible snails. To produce adequate food, fish ponds require nutrient enrichment, and alternative fertilizers must be made available if this practice is to decline. Capacity building in the management of water resources and sanitation, including construction of latrines, must include local training

courses that take place over time, rather than one-time training; follow-up interventions and support for the maintenance of sanitation supplies and equipment (Öman et al., 2009).

6.2.3. Access to societal resources

Access to societal resources is the single most important factor that influences health and health outcomes across a wide range of disease processes (Anderson et al., 2003; Labonte and Schrecker, 2007a,b,c). This includes access to basic resources, such as nutritious food, clean water and shelter; as well as education, employment and health care. Access to health care, including drugs and other services, and health education and information, is a critical issue in helminth control (Colley and Secor, 2007). Access to resources that prevent and control helminth infections is determined by the interaction of multiple factors, notably gender and poverty, and a complex interplay of social, cultural, economic and health system characteristics (Manderson et al., 2009).

Geographic distance from the resources, and related factors, such as transportation and personal mobility; travel time, cost and effort; and cultural, gender and language barriers also determine access. A geographic information system (GIS) is a useful tool for analysis of access patterns, including traditional (Euclidean) distance measures, as well as non-Euclidean measures that capture qualitative measures related to cultural and gender issues. Each community and cultural group exhibits unique access issues that can be explored using participatory and qualitative research methods. Along with differential exposures to a particular disease, disparities in access to resources for controlling disease or treating disease complications also influence health outcomes. Even when health care resources exist in a country or an area, health care is often degraded, delayed and more costly for economically impoverished people (WHO, 2002).

6.3. SOCIAL SCIENCES APPROACHES FOR HELMINTH INFECTIONS

6.3.1. Community participatory approaches

CBPR has roots in the action research proposed by Kurt Lewin in the 1940s (Adelman, 1993), and more recently in the participatory rural appraisal of development programmes of the 1960s (Wallerstein and Duran, 2003). An important characteristic of modern CBPR is that it balances research and action, and maintains a strong focus on iterative knowledge development in collaboration with the community (Minkler and Wallerstein, 2003). Participatory approaches can facilitate broader

access to and acceptance of evidence-based prevention and treatment for helminth disease including drug-vaccine combined therapy, improved sanitation and dietary changes (Keiser and Utzinger, 2005). In Northeast Thailand, where helminth diseases are most prevalent, a 10-year long programme of integrated liver fluke control that included monitoring and treatment, and a three-pronged community-based approach focused on education and participatory involvement resulted in significant reductions in disease prevalence (Jongsuksuntigul and Imsomboon, 2003). Assessment of treatment failure and the influence of adverse events can also be effectively addressed using a combination of qualitative research and community participatory methods (Colley and Secor, 2007).

6.3.2. Implementation science

The implementation of control strategies that address the social, cultural and behavioural dimensions of disease is hampered by a lack of culturally sensitive and evidence-based interventions, especially in resource-poor areas of the world (Madon et al., 2007). Strategies that involve health education and behaviour change are particularly poorly implemented in practice (Glasgow et al., 2003). Partnership arrangements can help to address behavioural risk factors, and to document community needs, including priority areas and sub-populations. Effective implementation requires long-term collaboration among researchers, practitioners and policy makers (Sussman et al., 2006).

The applied social sciences are a reservoir of methods for evaluation of programmes for the prevention and treatment of NTDs (Manderson et al., 2009). The 'RE-AIM evaluation framework' (Glasgow, 2009; Glasgow et al., 2003) is one such method that focuses on public health issues, and provides a structured format for evaluating programmes intended for wider implementation. 'RE-AIM' is an acronym for Reach, Efficacy or Effectiveness (depending on the stage of research), Adoption, Implementation and Maintenance. The model can be viewed at www.re-aim.org. This well-tested model has been widely used across a range of public health concerns that have behavioural health components, and could be applied to helminth control in Southeast Asia for planning and evaluating the impact and sustainability of interventions.

6.3.3. Cross-disciplinary and collaborative research

The complexity of social and environmental determinants of tropical disease, and the broad range of researchers and disciplines interested in helminthiases, have prompted scholars to call for cross-disciplinary sharing of knowledge (Bethony and Loukas, 2008; Fenwick et al., 2006). Potential models for this collaboration include the Schistosomiasis Research

Agenda (SRA) outlined by Colley and Secor (Colley and Secor, 2007), the open-access Public Library of Science journal, *PloS Neglected Tropical Diseases* (Hotez and Yamey, 2009) and TDR. Integrating social science approaches into helminth control activities has been a focus of these cross-disciplinary efforts. In 2005, the SRA conceptualised social control as comprised of health communication and education, community involvement, and health system and inter-sectoral involvement in control (Colley and Secor, 2007). Success in HIV–AIDS prevention includes significant behavioural approaches that have been associated with cyclical or iterative programme design with community involvement at every stage (Baldwin et al., 2009). Stages of CBPR include development of collaborative relationships, programme planning, programme implementation and evaluation, and dissemination of research findings (data analysis and data interpretation) from the perspectives of the academic researchers and the community members (Minkler and Wallerstein, 2003).

The Hazards Research Community represents an international, cross-disciplinary collaboration of physical and social scientists and community development experts whose work could be a model for helminth disease control. See, for example, the World Bank's 'Hot Spot' programme (Lerner-Lam, 2007), the international 'ProVention Consortium' (www.proventionconsortium.org) and the Hazards and Vulnerability Research Institute of the University of South Carolina (http://webra.cas.sc.edu/hvri/). The emphasis of the hazards research community has evolved from a focus on natural disasters to one that encompasses complex disasters, including war and environmental degradation. Hazards research is relevant to helminth disease control not only for its lessons in social sciences applications and cross-disciplinary approaches, but because human-made disasters, including conflict and forced migration, and complex emergencies, such as floods and landslides, are also risk factors for diseases of poverty (Armelagos et al., 2005; Goodhand, 2003; Jury et al., 2007; Wilcox and Gubler, 2005).

6.3.4. Qualitative and mixed-methods research

Mixed-methods research combines quantitative data, such as results of surveys or surveillance measures, with qualitative approaches to understanding attitudes and perceptions that are the precursors of human behaviour. Qualitative and mixed-methods research have potential for expanding the view of poverty to include well-being and health-related quality of life (Crivello et al., 2009; Labonte and Schrecker, 2007a). For example, qualitative research has shown that people's concept of well-being varies with religious and cultural characteristics (Camfield et al., 2009; Jongudomkarn and Camfield, 2006). In Thailand, Vietnam and Bangladesh, people tend to place good family and community relations

over other factors such as money and health as sources of happiness. In Thailand, ill health has been viewed as a problem largely because it reduces income and creates stress for the family (Jongudomkarn and Camfield, 2006). Qualitative research methods complement more familiar quantitative analyses of disease, and qualitative data about the lived experience are essential for understanding the social determinants of health (CSHD, 2008; Labonte and Schrecker, 2007a). Effective use of qualitative methods, such as focus groups and interviews, requires researcher training, sufficient time and well-developed relations with the community (Camfield et al., 2009).

6.4. IMPLICATIONS FOR RESEARCH AND CONTROL OF HELMINTH INFECTIONS

This section discusses social science implications for research and control of helminth infections. Here, we do not offer formal conclusions or recommendations, which is an active and evolving role of international, cross-disciplinary efforts. These efforts include TDR, the SRA (Colley and Secor, 2007) and the WHO Commission on the Social Determinants of Health (CSHD, 2008; Labonte and Schrecker, 2007a,b,c). Instead, we provide a summary of the major themes in the literature on the social determinants of health as they pertain to research and control of helminth infections.

6.4.1. Research

Research and interventions must develop from within partnership arrangements involving local organizations and affected communities. Planning should include inter-sectoral government coordination, and decades-long commitment of necessary resources. This will ensure community participation in planning in helminth disease control programmes, increase the relevance of research findings, build local capacity and facilitate programme evaluation to ensure long-term success.

6.4.1.1. Capacity building to address social determinants of health

The WHO recommends that teaching on social determinants of health be incorporated into the curricula for health professionals, including physicians, nurses, and auxiliary and community health workers (CSHD, 2008). Behavioural and social science themes of major importance in this context include the following (Cuff and Vanselow, 2004):

- mind–body interactions in health and disease, notably health and religious beliefs;
- patient behaviour, notably behaviour change methods;
- health practitioner role and patient–practitioner interactions;

- social and cultural issues, notably cultural competencies and social determinants of health, and health policy; and
- economics, including costs, effectiveness and the role of economic incentives in affecting patient health-related behaviour.

To achieve these goals, Ministries of Health can collaborate with training schools, colleges and universities (CSHD, 2008). Programmes for training of health care professionals can invite collaboration with schools of social science, and take steps to increase the status of faculty in these social science disciplines vis-à-vis the biomedical health sciences (Cuff and Vanselow, 2004). Opportunities exist for integrated, cross-disciplinary education and training in parasitology and tropical medicine in Southeast Asia (Waikagul, 1998, 2006). Current initiatives by organizations, such as TDR, the Bill and Melinda Gates Foundation and Wellcome Trust, aim to promote health research in low- and middle-income countries. These initiatives stress the importance of improving the research environment (including legal, policy and media approaches) and supporting individuals such as secondary school science teachers, early career researchers and senior scientists. Efforts are conducted in concert with institutional capacity building measures, including infrastructure development, partnership arrangements and creative use of competitive funding mechanisms (Greenwood et al., 2006; Nchinda, 2002; Whitworth et al., 2008).

Treatment that targets multiple NTDs also holds promise (Hotez et al., 2008a). Multi-behavioural interventions that address more than one disease are both cost-effective and relevant at the community level (Prochaska et al., 2008a). Multi-behavioural interventions include CBPR, iterative problem solving, attention to participant readiness for change and attention to design and measurement components (Prochaska et al., 2008a). Social science models, notably 'RE-AIM' and the 'Chronic Care model', can support programme monitoring and evaluation, and promote broader dissemination of effective and evidence-based helminth disease interventions.

6.4.1.2. Application of the expanded 'Chronic Care model'

The central concept that emerges from the literature on the social dimensions of infectious and parasitic disease is that helminthiases are diseases of poverty. Use of the term poverty in this context implies the influence of health inequities that create and maintain physical, environmental and social conditions that place humans at risk for disease and poor health outcomes (Manderson et al., 2009). With respect to helminth infections, measures of disease burden often combine prevalence with 'worm burden', because the impact of the disease varies with the number of worms infecting the host and the re-infection rate. The high re-infection rate in Southeast Asia contributes to poor health outcomes and adds a dimension of chronicity to these diseases.

WHO (2002) has suggested an expanded definition of chronic conditions to include tuberculosis, HIV/AIDS and other health problems that persist across time and require significant health care management. According to the expanded definition, chronic conditions are those that challenge the capacity of current health care systems to meet the needs of the affected populations and create social and economic consequences that deepen the problem in affected areas. Finally, chronic conditions are amenable to curtailment in response to innovations in science and policy.

Chronic disease management requires patient self-management or behavioural change support (Jenkins et al., 2010). This includes access to care, health education and health promotion opportunities for patients; the development of skills in the behavioural and social sciences for health professionals (Cuff and Vanselow, 2004); and management of the relevant political, social and health care environments (WHO, 2002). The 'Chronic Care model' (Wagner et al., 2001) is widely used across a range of health care sectors to improve chronic disease management. The model can be viewed at www.improvingchroniccare.org. The six key elements of the model are health care organization, clinical information systems, delivery design systems, decision support, self-management (or health-related behaviour) support and community resources.

In 2003, the 'Chronic Care model' was expanded to include creation of supportive environments, public policy, community action and greater porosity between communities and the formal health system with a focus on chronic disease prevention (Barr et al., 2003). Jenkins et al. (2010) have further expanded this model to include a community focus for reducing health disparities (Fig. 6.4). In the expanded 'Chronic Care model', the environment is viewed through an ecological framework that includes social, political and economic systems.

The key sectors are health and social services, politics and government, safety and transportation, education, communication, economics, recreation and the physical environment. The 'RE-AIM framework' (Glasgow, 2007; Glasgow et al., 2001) guides monitoring and evaluation activities in this model. Overall, the expanded 'Chronic Care model' is informed by the principles of CBPR (Minkler and Wallerstein, 2003).

6.4.1.3. Measures of poverty and health inequities

Although measures of poverty are debated, agreement can be found on key concepts. These include chronic versus transient poverty and absolute versus relative poverty; the timing of poverty in a person's life course; the focus for poverty analysis, that is, individuals, households, social groups or spatial areas; and the choice of components in cross-disciplinary analysis (Baulch and Masset, 2003; Harper et al., 2003; Hulme and Shepherd, 2003). The World Bank's global poverty measures are based primarily on an international poverty line of approximately US $1 or US $2 per day

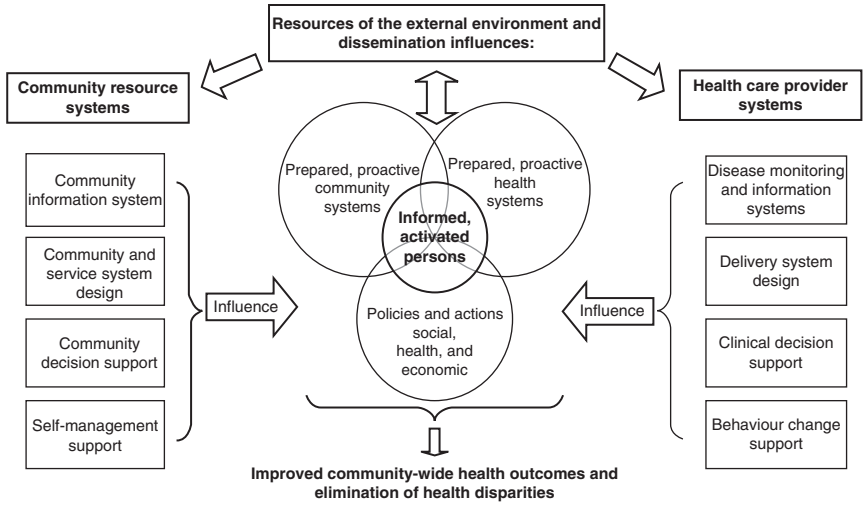

FIGURE 6.4 The expanded Chronic Care model (Barr et al., 2003), adapted from Jenkins et al. (2010).

(Chen and Ravallion, 2007). The World Bank also developed a tool to measure the relative economic position of households using data on durable consumer goods, housing quality, water and sanitary facilities and other amenities. These assets are combined into an index of economic status using 'Principal Component Analysis' (PCA) (Filmer and Pritchett, 2001). Using such an asset index (or wealth index), overviews of health indicators by population wealth quintile were made by the bank for countries included in the 'Demographic and Health Surveys programme' (DHS) (Houweling et al., 2003).

The availability of health information aggregated by geographical units in a region generally permits the analysis of inequities, which can serve as a basis for decision-making. There exists a wide variety of summary measures for magnitude of inequities in health (Wolfson and Rowe, 2001). In recent years, the 'Gini coefficient' along with a concentration index has become a standard measurement tool in studies of inequity in health and health care (Mackenbach et al., 1999; Murray et al., 1999). Benefit incidence analysis (BIA) is also used to measure and explain inequity in access to and utilization of health services (NCAER, 2002; O'Donnell, 2008).

6.4.2. Helminth disease control

6.4.2.1. Broadening the field for disease monitoring

Efforts towards helminth disease control will benefit from broadening the field for monitoring and surveillance to include socio-economic variables, notably poverty measures, access to social resources and subjective

measures of health and well-being. In South Korea, social science methods have contributed to the establishment of a national control system for repeated mass chemotherapy of soil-transmitted helminthiasis control in a community (Hong et al., 2006). Qualitative, mixed-methods and community participatory research are valuable tools in this arena. Better and more mobile diagnostic tools would help establish baseline data and permit analysis of the range of disease risk in Southeast Asia (Senior, 2008), including tools for expanded animal host modelling and monitoring parasite prevalence through faecal sampling in the field.

A paradigm shift is required to address the relationship between helminth disease and poverty, and the chronic nature of helminth disease complications including anaemia, cancers, loss of productivity, stunted physical and cognitive development and diminished quality of life (WHO, 2002). Disease risk mapping that integrates environmental, social and physical data to address these issues will inform helminth disease research and control programmes. Given the need to integrate social, epidemiological and environmental data for proper monitoring and surveillance of helminth diseases, GISs are useful tools for risk mapping (Malone et al., 2001; Rupasingha and Goetz, 2007; Senior, 2009).

6.4.2.2. Planning effective implementation

Effective helminth control interventions require a dynamic, multifaceted agenda that can be addressed through research including surveillance, training and capacity building, and development of long-term, collaborative partnerships among communities, researchers and policy makers (Kilama, 2009; Madon et al., 2007; Manderson et al., 2009; Sussman et al., 2006). The social sciences can provide insights into the social dynamics at the local, national and international levels that influence transmission and control. Social sciences methodologies and perspectives can be applied in research and implementation at the community level, and also at the level of health systems and policy (Bruun and Aagaard-Hansen, 2008).

If control efforts are to become more effective and sustainable, it will be necessary to work towards better use of available economic, technical and human resources. This implies the need for behavioural change for programme planners, and policy- and decision-makers at the national and international levels, as well as for the people who are risk for disease. For health policy-makers and managers, understanding the local social context of endemicity is important to avoid the 'top-down' policies that seldom meet with long-term success. Interventions must complement technical solutions with critical insights into the social and intervention management dynamics at all levels in order to meet with success.

6.4.2.3. Introducing integrated disease control strategies

In rural P.R. China, integrated control strategies have been applied to reduce or eliminate schistosome transmission, including removal of cattle from snail-infested grasslands, providing farmers with mechanized farm equipment, improving sanitation by supplying tap water and building lavatories and latrines, and health education (Wang et al., 2009). In addition to disease control, these strategies can increase agricultural productivity and biofuel generation, and improve quality of life. Inclusion of social sciences perspectives does not make control of helminthiases simpler. Instead, greater appreciation of the social determinants of helminth infections implies the need for integrated processes requiring a long-term investment. Beyond drug treatment, we must establish partnerships for planning, inter-sectoral government coordination and decades-long commitment of necessary resources (King, 2010).

Chemotherapy and vaccines in combination offer possibilities for infection control in resource-poor settings (Hotez et al., 2008a) where the demands of multifaceted approaches may exceed available resources. While chemotherapy remains the best option for morbidity control, there is recognition that drug delivery cannot interrupt disease transmission (King, 2009), especially in resource-poor areas with high re-infection rates. Chemotherapy alone introduces potential for the emergence of drug resistance, whereas integrated use of vaccines and chemotherapy offers considerable promise as long as programmes are evidence-based and sustained by careful planning and adequate funding (Bergquist et al., 2005, 2008; Fenwick et al., 2006; Hotez et al., 2008b).

More research is needed on the best modes of delivering combinations of interventions and on how local stakeholders can best be involved in the processes of priority-setting. For example, the role of reservoir hosts, notably cats, dogs and pigs, is understudied (Chai et al., 2005). Targeted mass treatment may be cost-effective (Olds et al., 1996), but ultimately unsuccessful if populations are re-infected by untreated domestic animals (Chai et al., 2005). Combined interventions that include mass chemotherapy and vaccinations, plus sanitation and health education components, are most likely to achieve positive results (Hesham Al-Mekhlafi et al., 2008; Senior, 2009).

ACKNOWLEDGEMENTS

The authors wish to thank Teri Lynn Herbert for expert advice and assistance with the literature search and LaTonya Logan for assistance with article review. Special thanks to Jens Aagaard-Hansen, Peter Steinmann and Stephen W. Attwood for their kind review and substantive comments on an earlier draft. T.W. Jia and X.N. Zhou are grateful to the Chinese Important Scientific Research Project on Infectious Diseases (grant no. 2008ZX10004-011). L.M. Vandemark thanks the U.S. Fulbright Program for its support.

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