Prevention and Control of Parasitic Zoonoses

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Learning Objectives

1. To understand the difference between prevention and control as applicable in epidemiology.
2. To describe salient preventive and control measures which are commonly used for parasitic infections.

Introduction

Prevention of parasitic diseases deals with their interception. Control measures are used to check the possibilities of dissemination of the infection. By controlling the infection, the aim is to minimize and sustain low level of parasitic infections prevalent in the general population. The control methods intend to eliminate the disease at the level of its reservoir and source.

The basic measures for prevention and control of parasitic zoonotic infections are similar to those of any infectious disease. These include reduction/elimination of source/reservoir for parasites, breaking/interfering the chain of transmission and reduction/elimination of the susceptibility of host(s) at risk of infection. The prevention and control of parasitic infections is a challenging task as the containment of these infections essentially requires a change in human behaviour, political/administrative support and implementation of proper control measures for parasitic diseases. The matter is complicated further by the fact that a number of *zoonoses* such as taeniasis, hydatid disease, toxocariasis, etc. affect rural populations residing closer to domestic animals. In addition, *Cryptosporidium*, *Toxoplasma* and other parasites cause opportunistic infections in immunocompromised hosts with HIV/AIDS or following immunosuppressive therapy. The current concept of the 'One Health' approach involving all lives on earth with inter-sectoral coordination and international cooperation is therefore essential for prevention and control of parasitic zoonoses.

Preventive and Control Measures

The prevention and control measures for parasitic diseases can be broadly categorized under the following headings (overlapping exists between measures).

Prevention and Control of Zoonotic Infections in Humans

Protection of the susceptible host, controlling the reservoir and interrupting the transmission of the

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parasitic infections are important components of the prevention and control of parasitic infections among humans.

Protection of the susceptible host: This can be achieved by immunoprophylaxis, chemoprophylaxis or personal prophylaxis.

1. **Immunoprophylaxis**: It is carried out by active or passive immunization. Active immunization by the vaccines being developed and evaluated in parasitic infections aims:
   (a) To interrupt the chain of transmission at any specific stage in the life cycle of the parasite.
   (b) To minimize the morbidity and mortality due to disease by producing a vaccine.
   There are multiple reasons for the non-availability of vaccines in parasitic infections. These include (1) the complex nature of parasitic antigens, which makes them difficult to characterize, (2) the difficulty in the identification of the protective antigen for use in vaccines with available techniques and (3) intricate mechanisms of most parasites to evade the host immune system.
   Despite these challenges, significant progress has been made in the field of development of vaccines for malaria and amoebiasis. RTS,S/AS01 (RTS,S) is the first and, to date, the only vaccine which has demonstrated significant reduction of falciparum malaria and life-threatening severe malaria in young African children. Moreover, three nations—Ghana, Kenya and Malawi—introduced the vaccine in selected areas of moderate and high malaria transmission in 2019.
2. **Chemoprophylaxis:** Chemoprophylaxis, carried out either at the individual level or at the community level, has been used successfully for many parasitic infections. For example, reduction of the reservoir of infection for paragonimiasis is achieved by means of mass treatment of the population with praziquantel or bithionol. Annual mass drug administration of diethylcarbamazine has achieved significant chemotherapeutic control of *Wuchereria bancrofti* infection in a community. Chemoprophylaxis has also been recommended in malaria. It is recommended for travellers from non-endemic areas and as a short-term measure for soldiers, police and labour forces serving in highly endemic areas (Table 1).
3. **Personal prophylaxis**: Human behaviour is crucial for prevention and control of parasitic zoonoses. Avoidance of raw or undercooked food and food preparations prevents transmission of parasitic diseases. For example, adequate cooking of fish kills the infective plerocercoid larva of *Diphyllobothrium latum*, thereby preventing transmission of diphyllobothriasis to humans. Thorough cooking of meat kills the cysticerci in the infected beef or pork, a useful strategy to prevent *Taenia saginata* and *Taenia solium* infections, respectively. Paragonimiasis is prevented by avoiding eating raw or partially cooked crab or crayfish. Avoiding eating raw or undercooked pork and regular inspection of meat prevent transmission of trichinellosis to humans.
   Health education to discourage ingestion of fresh and raw aquatic plants prevents the risk of transmission of *Fasciolopsis buski* infection to humans. Health education, especially on behaviour change, is necessary for implementation of the preventive and control strategies for low- and middle-income countries where resource crunch is a real issue. Health education with improved nutrition supplemented with dietary iron prevents anaemia due to hookworms. Treatment of persons suffering from ascariasis and deworming of school children for intestinal helminthic infections not only improves personal health but also prevents pollution of soil by eggs and larvae of soil-transmitted helminths. Avoidance of the practice of open-air defecation especially near water reservoirs and washing hands after playing with and feeding dogs are the best practices that prevent many parasitic infections, including intestinal protozoal and helminthic infections and other nematode infections.

Table 1 Chemoprophylaxis of malaria

Drug	Dosage
Chloroquine	300 mg (base) = 3 tablets of 100 mg or 2 tablets of 150 mg once a week, on the same day each week or 100 mg (base) = 1 tablet of 100 mg daily for 6 days per week
Proguanil	200 mg = 2 tablets once a day (in combination with chloroquine)
Mefloquine	250 mg = 1 tablet once a week, on the same day each week
Doxycycline	100 mg = l capsule once a day

Since many parasitic infections are area, country or continent specific, following 'travellers' guides' while visiting any such place would prevent such infections.

Controlling Infection in the Reservoir Hosts

1. **Early diagnosis:** Early diagnosis followed by early treatment reduces mortality and morbidity due to diseases to a great extent. Hence adequate laboratory support is crucial. Laboratories should be well equipped to perform not only simple microscopy, serological and other simple tests like card agglutination tests but also newer advanced diagnostic tests. However, the facilities to perform tests such as Western blot (WB), enzyme immunoassay (EIA), luciferase immunoprecipitation system, polymerase chain reaction etc., although important in select specific infections, they are not widely available in many laboratories of most low- and middle-income countries.
2. **Surveillance:** The primary measure for controlling parasitic zoonoses in humans is proper surveillance, both passive (usual) and active. *Passive surveillance* includes proper analysis of routinely available data regarding parasitic zoonoses from the health system. Persons having symptoms suggestive of zoonoses, high-risk professions (e.g. animal breeders, shepherds, butchers, restaurant workers, etc.), travellers coming from or having a history of travel in endemic regions and persons having immunosuppressive disease or taking immunosuppressive drugs need special attention and care. Inclusion of important zoonoses in national disease surveillance programmes (e.g. Integrated Disease Surveillance Project (IDSP) in India) based on the analysis of data-based indicators of the infection is useful. Any early warning signal (e.g. clustering of cases over time, place and person) would immediately alert the system to impending outbreak of such zoonoses.
   Active surveillance, e.g. arranging a special survey with or without using a field-level diagnostic kit or establishing sentinel surveillance for detection of such zoonoses, is also essential.
3. **Treatment:** Treatment of parasitic zoonoses in humans depends on the type of infection (s). Chemotherapy against many of the parasitic infections is effective. Treatment by combined therapy, with more than one drugs, is mostly effective. It is usually effective against the 'active' form of parasites, such as trophozoites and not cysts e.g. *Entamoeba histolytica* and other protozoal infections. Barring a few, most of drugs currently available are relatively economical, and occurrence of drug-resistant parasites is relatively lower unlike that of bacterial infections. Treatment or prophylaxis for zoonoses in immunocompromised persons (e.g. cryptosporidiosis, toxoplasmosis, etc. in patients with HIV/AIDS) by specific chemotherapy along with concomitant antiretroviral therapy is important. Surgical removal of large-sized hydatid cysts with or without pre- and post-intervention medicines is an example of surgical intervention in certain parasitic diseases.

Interruption of Transmission Cycle

Interruption of the transmission cycle to prevent transmission of parasitic infections includes the following measures.

Sanitation Measures Including Good Personal Hygiene

Sanitation measures include consumption of adequately cooked food, especially pork, beef and fish, and drinking of water that has been boiled, filtered or chlorinated. However, the concentration of chlorine used for water disinfection is not sufficient to kill certain parasites such as the cysts of *Entamoeba*, *Giardia*, etc. Iodination with tetracycline hydroperiodide or filtration using 0.22 μm filtration membrane is recommended for such cases. Regulation of slaughter houses with proper meat surveillance and hygienic cattle and pig rearing is also important. Thorough handwashing with soap and water is essential, especially for food handlers. It should also be practised in other situations like after using the toilet; after changing a child's diapers or cleaning a child who has used the toilet; before, during and after preparing food; before eating food; before and after caring for a sick person; before and after treating a cut or wound; after touching an animal or animal waste; after outdoor activities, etc. Sanitary disposal of faeces along with preventing open defecation, use of sanitary latrines, adequate sewage treatment, etc. are of paramount importance. Improved personal hygiene with the objective of keeping oneself clean (frequent bathing, wearing clean clothes, trimming nails, using clean bedding and checking for parasites, etc.) is equally important to prevent parasitic zoonoses.

Pet and Stray Animals Management

An effective registration system, drastic reduction (elimination), periodic surveillance with stool examination and deworming of infected dogs (by single dose of praziquantel at a dosage of 5 mg/kg of body weight) are some of the important steps to reduce the intensity of parasitic infection in pet animals such as dogs or rats. Avoiding contact with cat faeces containing oocyst, especially for high-risk individuals like immunodeficient patients and pregnant women, is an important measure for prevention of acquired and congenital toxoplasmosis. Contraceptive vaccination is an effective measure to control stray animals such as dog populations.

Reducing Vector Population and Vector Bites

Reducing vector populations and bites essentially depends on environmental measures, chemical measures and personal protective measures.

Environmental measures include general cleanliness, closing rodent burrows, locating cattle sheds and poultry away from homes, avoiding water collections and repairing cracks and crevices in walls, etc., preventing replication of insect vectors. Source reduction measures such as flooding and flushing of breeding places and biological measures by using *Gambusia* fish, etc. are various methods that are being used to control mosquito vectors of malaria, filariasis, etc. (Table 2).

Chemical measures include spraying the breeding site with oil and insecticides such as DDT, pyrethrum and temephos to kill mosquitoes and other vectors. Similarly, the use of suitable insecticides in homes and outhouses is useful to control sandfly vectors of leishmaniasis, mosquito vectors of malaria, filariasis, etc. Use of traps and bait impregnated with insecticides is useful in controlling tsetse fly populations transmitting sleeping sickness. Avoiding exposure to ticks by use of tick repellents helps in preventing transmission of babesiosis.

Personal protective measures to prevent being bitten by vectors are varied and many. These include the use of screens on doors and windows, insecticide-impregnated mosquito nets, insect repellents like DEET (diethyltoluamide), use of long pants and long-sleeved shirts which may be insecticide impregnated, and use of protective shoes while going to the forest. Avoidance of sleeping in open areas and on floors of mud houses prevents bites from insect vectors.

In effect, the interruption of the transmission cycle can be achieved in multiple ways. For example, Fig. 1 describes the integrated approach which is needed to control schistosomiasis, while

Table 2 Environmental management as per World Health Organization (WHO) guidelines

Environmental modification	Long-lasting or permanent transformation of land, water and vegetation to prevent, reduce or eliminate vector or intermediate host breeding habitats (water-related, vector-borne diseases) or environmental conditions which favour waterborne and water-washed disease transmission	Grading, filling, drainage, land levelling, housing, urban drainage
Environmental manipulation	Changes of environmental conditions to create temporary unfavourable breeding conditions for vector breeding or transmission	Water-level fluctuations, water velocity changes, flushings, weed clearing, salinity changes
Modification or manipulation of human habitation or behaviour	Any environmental manipulation of modification measures to reduce man–vector and/or man–pathogen contacts	Bed nets, personal protection, house screening, safe bathing and laundry places, latrines, wastewater treatment, water supply

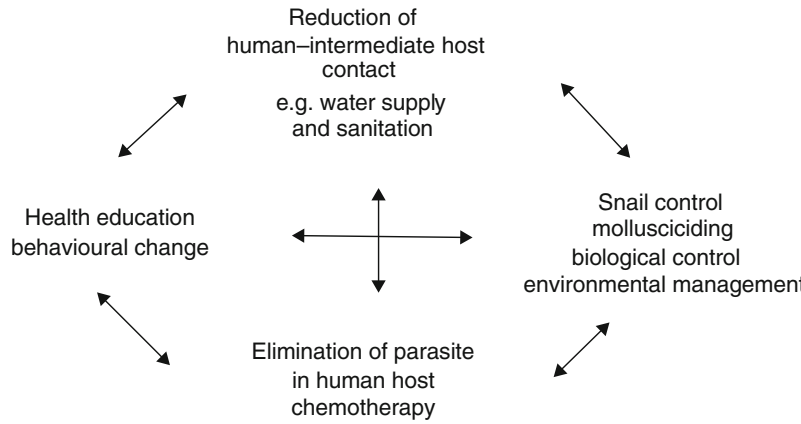

Fig. 1 Integrated approach to control schistosomiasis (Source: http://www.fao.org)

Fig. 2 shows the multiple ways by which malaria transmission can be reduced in the community.

Prevention and Control Among Animals

The basic principles for controlling parasitic infections in animals are essentially similar to those of human infections. Veterinary Public Health (VPH) action, defined as that part of public health action which is committed to the protection and improvement of human health through application of the capabilities, knowledge and professional resources of veterinary science, plays a key role.

The VPH actions are based on surveillance, animal control measures, control of livestock, supervision of the meat industry, slaughterhouses and the market, and control of vectors and vehicles.

Surveillance

Constant surveillance is an essential component of the control system and requires accurate, complete, timely and reliable information on specific diseases on a regular basis. Notification of important parasitic zoonoses is also a basic step in the overall surveillance system. Screening and testing of animals and humans is essential to assess the prevalence of zoonotic parasites in the community. Improved access to diagnostic tools and tests for detection of such parasites in humans, animals and the environment is an effective measure.

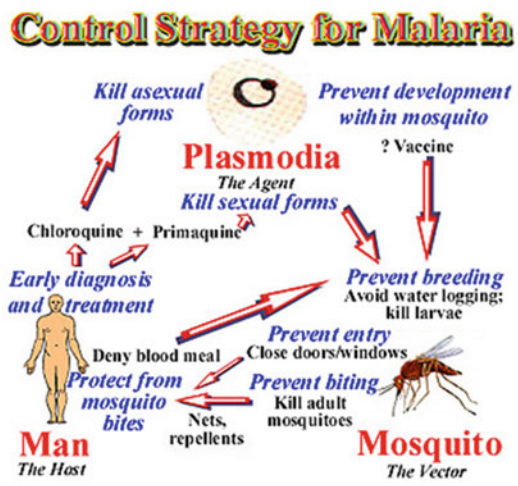

Fig. 2 Multiple control measures which are adopted for malaria (Source: https://www.malariasite.com/control-of-malaria/)

Slaughterhouse surveys are important in controlling echinococcosis, taeniasis, cysticercosis, trichinellosis and other zoonoses. Isolation and typing of the zoonotic agents are helpful in leishmaniasis, trypanosomiasis, etc. Epidemiological studies provide important knowledge of zoonoses and help to specify the suitable method (s) of control. They help to identify incidence of such zoonosis in humans and animals and determine the sources of infection associated with arthropods, animals, environment, crops, etc. Statistical data on dog and other animal populations helps in the control of parasitic zoonoses, particularly where dogs act as a main vector as in echinococcosis/hydatidosis.

Animal Control Measures

Animal control measures are an important goal of VPH action. The interventions include (1) ensuring proper feeding hygiene such as by discouraging raw meat and offal as feeds for both pet and stray animals; (2) quarantine of suspected animals, when transported for long distances for livestock import–export, pet trade, etc.; (3) testing and segregation/destruction of diseased and infected animals; and (4) immunization of exposed animals with effective vaccines.

Treatment of diseased and infected animals is an effective measure to control zoonotic parasitic infections such as preventing echinococcosis by deworming of animals and destruction of the excreta. Reducing parasitic load by deworming of pets, street animals and farm animals is an effective control measure. Control/elimination of 'stray' animals such as dogs to prevent echinococcosis and leishmaniasis; of cats to prevent toxoplasmosis; and of rodents to prevent leishmaniasis, toxoplasmosis, etc.

Control of Livestock, Meat Industry and Market

The control of livestock, the meat industry and the market is important to control parasitic zoonotic infections that are transmitted by the consumption of inadequate or undercooked meat and meat products. Preventive measures include (1) raising pathogen-free animals, (2) decontamination of feed, (3) regular inspection of slaughterhouses and markets with prohibition of slaughter of diseased animals, (4) ensuring adequate cooking of meat before serving and (5) health education of animal breeders, butchers, restaurant workers, cook, etc. regarding hygienic practices.

Overall, proper scientific reorganization of livestock, the meat industry and the market with suitable legislative and control measures to develop hygienic farming techniques is a key factor to reduce zoonoses in animals.

Vector Control Measures

Vector control measures prevent transmission of zoonotic pathogens from animals to humans. These measures include (1) proper feed hygiene to control toxoplasmosis, trichinellosis, etc.; (2) avoidance of feeding raw meat and offal to dogs to prevent echinococcosis and avoidance of feeding untreated refuge and meat products to cats to prevent toxoplasmosis; (3) arthropod control to reduce sandfly-transmitted leishmaniasis, tsetse fly-mediated trypanosomiasis, etc.; and

(4) biological control methods such as sterile male technique for mosquitoes to reduce mosquito populations.

Impact of Control Measures

Parasitic zoonoses are of diverse origin and also not uniformly distributed all over the world, and hence one single worldwide programme may not be applicable to prevent or control parasitic zoonoses. Specific targeted programmes for parasitic zoonoses in different parts of the world are few in number.

The control programme for cystic echinococcosis (hydatid cyst) in Uruguay in 2005 used dog surveillance by ELISA followed by anthelmintic treatment and dog control by castration and spraying. Human surveillance for cyst was done by ultrasonography. Over a 5-year follow-up, it showed significant reduction of dog positivity from nearly 10% to 2–3% and a corresponding reduction of human cyst from 6.5% to 2%. The trichinellosis prevention programme for Inuit communities in Nunavik, Canada (1992–1997), through meat screening, clinical and blood examination and use of anthelmintic (albendazole) with adequate community participation, was a success.

Programmes for control of congenital toxoplasmosis operate in many European countries with maternal screening for IgM and IgG antibodies. In a similar programme in Londrina, in the state of Parana, Brazil, there was significant reduction of affected pregnant women by 63% and affected children by 42%. Human African trypanosomiasis control programmes running in many African countries, including the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) with direct supervision and assistance from WHO, along with NGO and private sector support, showed a significant decline of 63% of the number of reported cases from 2000 to 2009. A Chagas disease control programme, based primarily on spraying indoor insecticides, in the Montalvania area of Brazil showed success by the total reduction in *Trypanosoma cruzi* infection from a high rate of 83.5%. Cross-sectional comparisons for the age groups 2–6 years and 7–14 years indicated a 100% reduction in *T. cruzi* incidence rates.

Conclusion

Prevention and control of parasitic infections remains a daunting and complex task and there is a need for convergence of multiple disciplines along with adequate administrative support. This has to be supplemented with adequate environmental and ecological changes to bring down the parasite population in the area and also to reduce the risk of transmission (Table 2). The provision of adequate financial resources at local and national level as well as through international funding would accelerate activities and efforts to control and prevent parasitic diseases.

Case Study

Insecticide-treated mosquito nets together with appropriate behaviour-change education is considered an effective preventive measure for visceral leishmaniasis (VL). Thus, during an epidemic of VL in eastern Sudan, 357,000 insecticide-treated mosquito nets were distributed to 155 affected villages. It was reported that an estimated 1060 VL cases were prevented between June 1999 and January 2001, giving a mean protective efficacy of 27%. Thus community distribution of insecticide-treated nets is a good measure for reducing the incidence of VL in a community. The village community should also be educated about the dangers of sleeping outdoors without using mosquito nets.

1. What are the hurdles in implementing prevention or control measures in resource-poor countries?
2. What are the international parasitic control programmes which are ongoing?
3. Name a few parasitic diseases which have been substantially controlled worldwide using public health measures.

Research Questions

1. How do we change the unfavourable human behaviour which is responsible for ongoing transmission of many of the parasitic zoonoses?
2. How do we develop and apply feasible, effective and efficient mechanisms to invoke political/administrative will among a large section of politicians/administrators in low- and middle-income countries?
3. How can we best improve and formulate proper control measures or national/international programmes for many endemic parasitic diseases?

Further Readings

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