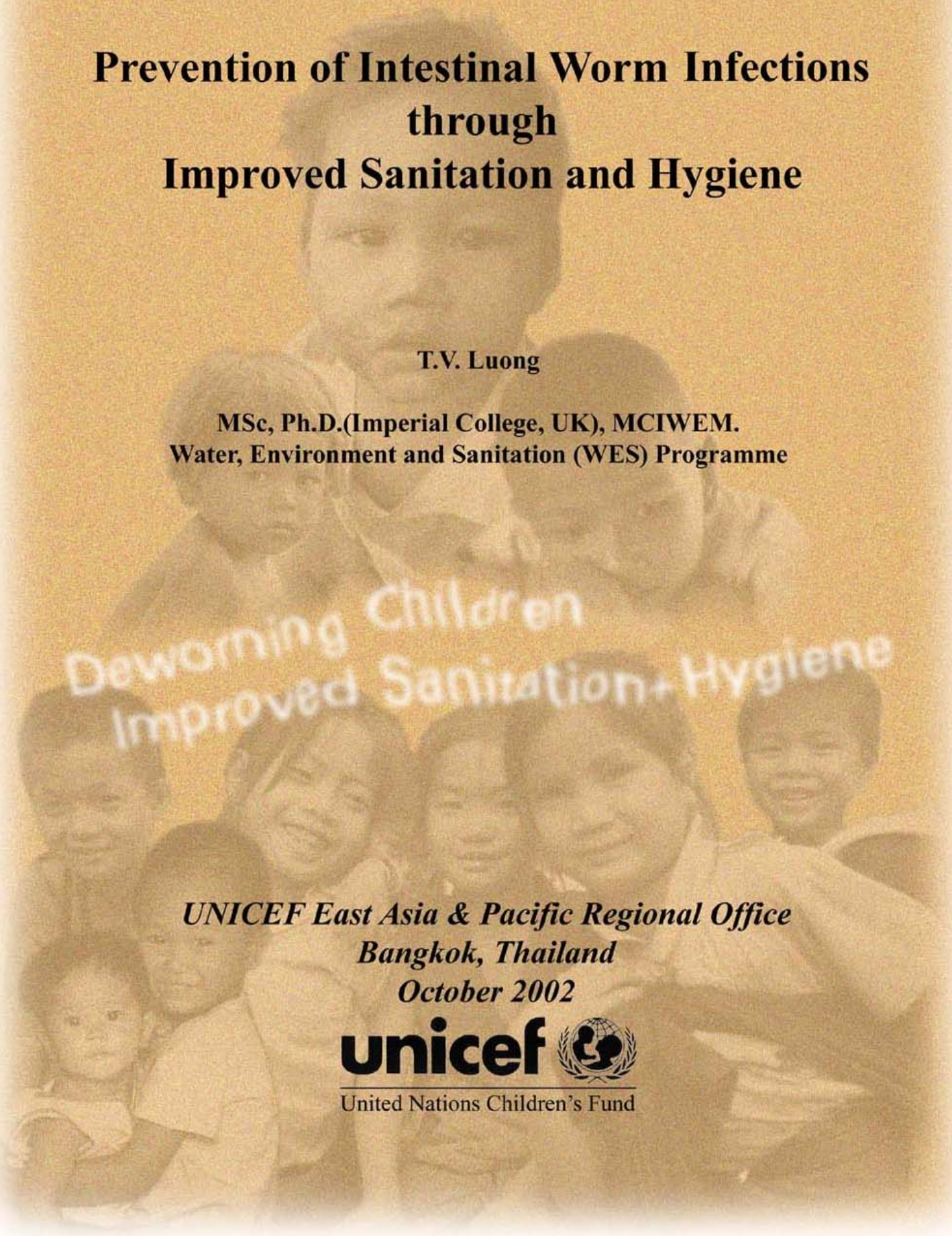
Prevention of Intestinal Worm Infections through Improved Sanitation and Hygiene

T.V. Luong

MSc, Ph.D.(Imperial College, UK), MCIWEM.
Water, Environment and Sanitation (WES) Programme



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Acknowledgements

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The author also extends her deep indebtedness to the Japanese Organization for International Cooperation in Family Planning (JOICFP) for the kind permission to use the two slide sets on roundworm and hookworm as education and promotion materials for field use.

Using This Document

This document has been prepared as a reference material for UNICEF staff and their project counterparts to use for the implementation of integrated school- and community-based de-worming activities and in the water, environment and sanitation (WES) programme.

Specifically, the document aims to reach:

- UNICEF programme and project officers responsible for water, environment and sanitation programmes and integrated de-worming activities;
- Planners and implementers of government agencies and NGOs responsible for integrated de-worming and WES programmes;
- Supervisors and officials in agencies and organizations employing the above categories of staff; and
- Others who have key responsibility for catalyzing behaviour change to improve environmental cleanliness and better hygiene.

Structure of the Document

Part I – The document reviews the magnitude of intestinal worm infections worldwide and its prevalence in some countries in Southeast Asia; related health problems; and the population groups most affected by intestinal worm infections. This document focuses on roundworm and hookworm infections. Objectives of the integrated de-worming and WES programme for children and high-risk population groups are presented.

Part II – Hookworm and roundworm life cycles inside and outside the human host and modes of transmission are described.

Part III – The key preventive interventions for intestinal worm infections are given.

Part IV – Two Power Point presentations on hookworm and roundworm are enclosed as information, education and communication (IEC) materials for use by project officers, health workers and teachers to create awareness among school children and community members.

Working with the Document

The document can be used as an advocacy and IEC tool as you work on the specific issues of integrated de-worming and WES programme. For effective implementation, it is important to understand the health and nutrition problems caused by intestinal worm infections: its prevalence worldwide and its life cycle inside and outside the human host, as well as its routes of transmission to enter the human host. Two sets of promotion materials in the form of Power Point presentations are included in the document. They can facilitate the ease of educating the target audiences. And at the same time, they can provide opportunity for discussion with community members and school children on taking appropriate actions to prevent intestinal worm infections and re-infection.

Part I INTRODUCTION

Overview

Helminth infections refer to worms that live as parasites in the human body. Worm infection occurs when infective eggs, or larvae, enter the body, mature, lay eggs and feed off the person. People get infected with worms when living in an unclean environment of poor sanitation and unhygienic habits. The three main types of common intestinal worms that infect humans are large intestinal roundworm (*Ascaris lumbricoides*), hookworm *(Ancylostoma duodenale and Necator americanus*) and whipworm (*Trichuris trichuira*). Globally, more than 3.5 billion people are infected with intestinal worms. Of them, 1.47 billion have roundworm; 1.3 billion are infected with hookworm and 1.05 billion with whipworm. (Table 1A, Appendix A) The highest rates of roundworm, hookworm and whipworm infections are often in children between age 5 and 15. It is estimated that about 400 million school-age children are infected with these three types of worms. Analysis of infection prevalence by age group (Figure 1, Appendix B) indicates that all age groups have infections. But the incidence of hookworm infection tends to grow with increasing age. (Figure 2, Appendix B). Therefore, adolescent girls and women of childbearing age are generally infected with hookworm.

This document focuses on hookworm and roundworm infections and their control through drug treatment as an entry point to promote improved sanitation and hygiene behaviour. These are the key preventive measures leading to a clean living environment, which is necessary for the proper development and well being of our children.

Health Problems Caused by Intestinal Worm Infections

Worm infections are one of the major health problems confronting millions of school-age children. These parasites consume nutrients from the children they infect, thus aggravating malnutrition and retarding physical development. They also destroy the tissues and organs in which they live. They cause abdominal pain, diarrhoea, intestinal obstruction, anaemia, ulcers and various other health problems. These ailments can impair learning and slow cognitive development, ultimately resulting in poor school performances of a child. It is not uncommon for heavy or long-term infection to result in death, if treatment is not given in time. It is especially important to note that the stunting of children's growth due to worm infections is not easily recognized because it occurs almost imperceptibly over time. Thus, the full impact of intestinal infections is often greatly under-reported or overlooked.

Intestinal worm infections destroy the well being and learning potential of millions of children in many developing countries.

Population Most Affected by Intestinal Worm Infections

Pre-school and school-age children and women of childbearing age, including adolescent girls, tend to have the higher proportion of worm infections. Although intestinal worms can infect all members of a population, these specific groups are at greater risk of heavy infections than others and are more vulnerable to the harmful effects of chronic infections. These vulnerable groups would benefit most from preventive interventions.

Comparing Helminths with Other Infectious Organisms

Intestinal worms, known by their species name as helminth, are different in several unique ways from other infectious organisms, such as bacteria and viruses. Understanding their differences enables planners and implementers to effectively formulate a sustainable integrated de-worming and WES programme for improvement of children's health and development.

- Helminths do not multiply in number within an infected person. Each adult worm is the result of the host being exposed to an infective egg, or larva, which enters the body either by penetrating through skin or by being ingested, depending on the species.
- Helminths accumulate gradually inside the host over time, so the onset of disease tends to be slow and may go unrecognized; when moderate to heavy worm infections have been acquired, onset of chronic disease occurs.
- Severity of disease caused by helminths will depend on the number of worms inside the infected person as well as the age, health and nutritional well being of that person and the duration of infection.
- There are a number of drugs that kill several species of helminths at the same time with a single dose. Re-infection, however, is quite frequent. Hence, drug treatment alone without the improvement of sanitation and hygiene practices will not break the routes of worm transmission.
- It is typical to find that helminths are not evenly or randomly distributed among people in a community; worms tend to clump or aggregate in their distribution. For example, 70 per cent of all worms may be found in as few as 30 per cent of all people in a community.

Prevalence of Intestinal Worm Infections in Some Countries of East and Southeast Asia

The situation of intestinal worm infections and de-worming activities in some countries are briefly summarized as follows.

Cambodia

A national survey conducted by CNM/MSF in 1997 of school children showed that intestinal worms, particularly soil-transmitted helminth (STH) infections, are highly prevalent in Cambodia. STH infection contributes to the overall morbidity rate in both rural and urban Cambodia and is a major concern.

A de-worming programme among school children has started in some provinces with 500 mg Mebendazole treatment, coupled with health education. The prevalence of intestinal worms has dropped to about one third of the initial level, but frequent re-infection is reported due largely to the lack of access to adequate sanitation, unhygienic habits and inadequate safe water supply.

China

The Ministry of Health is conducting a national survey on parasite infections. Such a national survey is done every 10 years. Based on the previous national survey in 1992, it was reported that:

- Roundworm infected 44.9 per cent of children and affected about 190 million children younger than 14. Hookworm infected 5.4 per cent of children and affected about 40 million children younger than 14.

- Hookworm infected 5.4 per cent children and affected about 40 million children younger than 14.
- Whipworm infected 12.6 per cent of children and affected about 70 million children younger than 14.

A nutrition survey in China reported that the rate of stunting in children younger than 5 in 1995 was 34.5 per cent, or 35 million children, in rural areas. The average body height of rural children younger than 5 in 1998 was 4 cm shorter than that of their urban neighbours.

Lao PDR

Helminth infection is quite high among the population, based on surveys and studies conducted by various institutions and government agencies. A survey of helminth infection among 12,558 school children in 6 provinces varied from rates of 27.5 to 62 per cent. Among them, roundworm infection was found in 1.6 to 28 per cent of the cases, hookworm in 3 to 33 per cent, whipworm 5.4 to 19.6 per cent, liver fluke (*Opistorchis viverrini*) 2.7 to 32 per cent and tapeworm (*Taenia*) 0.2 to 1.4 per cent. (Table 2A, Appendix A)

Thailand

A countrywide soil-transmitted helminth control programme started in 1980 with blanket treatment among primary school children. Since 1982, the helminth control plan has been included in the Government's successive Five-Year National Health Development Plan. Activities include stool examinations, worm treatment; improvement of household sanitation and promotion of health risk behaviour change through health education and the provision of safe water and sanitation. The programme is implemented by provincial health service facilities with technical and logistical support from the Department of Communicable Disease Control, Ministry of Public Health, at the central level.

Helminth control in the current 9th National Health Development Plan (2002-2006) has set the target to reduce the magnitude of problem to a level that does not contribute to the public health problem. The management system for surveillance, prevention and control is to be strengthened, with emphasis on improving intersectoral coordination.

Systematic countrywide surveys in the past three decades reveal a declining trend of intestinal parasite infection from 62.9 per cent in 1957 and 41.7 per cent in 1991 to 35 per cent in 1996. In 1996, the most common helminth infections were hookworm (21.6 per cent), whipworm (3.9 per cent) and roundworm (1.9 per cent).

Hookworm was, and still is, the most prevalent infection in southern Thailand compared with the other regions of the country. However, hookworm infection in the southern region was found to have decreased from 75.9 per cent in 1981 and 49.2 per cent in 1991 to 34.1 per cent in 1996.

Viet Nam

Viet Nam has comprehensive survey data on intestinal worm infection in 52 of its 53 provinces.

Intestinal worm infections have been the country's major public health problem and are endemic in the northern, central and southern regions. Within those regions, the infection patterns vary from river delta, plain, coast, highland and mountain areas. The countrywide infection of

roundworm ranges from 10 to 95 per cent; whipworm is 0.5 to 89 per cent and hookworm 30 to 69 per cent.

Distribution of Intestinal Worm Infection in Southeast Asia

GIS mapping of intestinal worm infection distribution

Geographical information system (GIS) methods were used to integrate the survey data with remotely sensed (RS) satellite sensor environmental data. The information was used to map the distribution of intestinal worm infections in five countries in the Greater Mekong Region: Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam. The number of surveys available for each of these countries varies considerably. Viet Nam and Thailand have comprehensive survey data at the provincial level. But survey data are particularly sparse for Cambodia, Lao PDR and Myanmar. Still, the GIS mapping lets people see from what is known and what are the patterns of infections in a particular country in relation to the type of landscape and cultural habits, or other factors

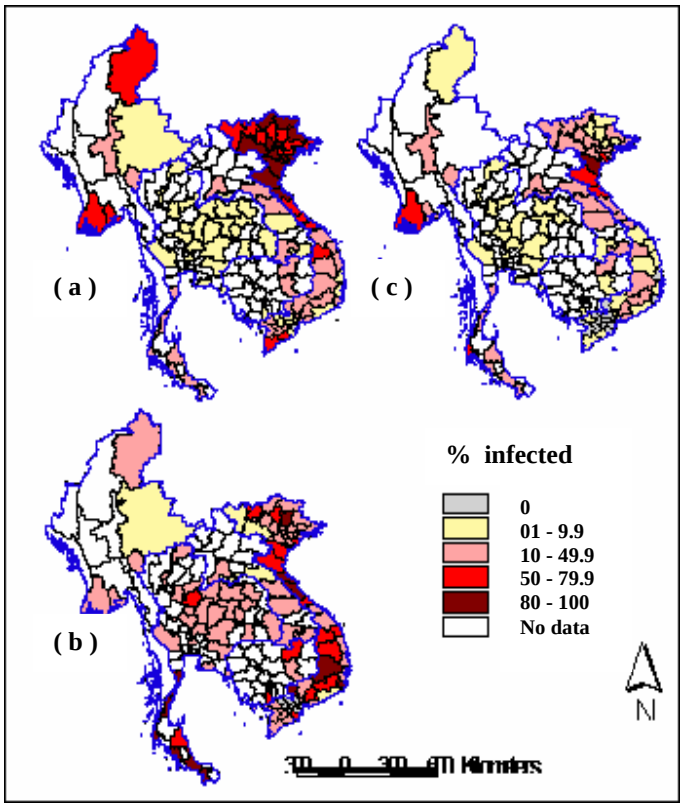


Figure 1. The distribution of (a) roundworm (*A. lumbricoides*), (b) whipworm (*T. trichiura*) and (c) hookworm in Southeast Asia, as indicated by province-level estimates based on available survey data. White indicates those provinces where there is no relevant data.

Figures 1a and 1b indicate that a high prevalence of roundworm and whipworm are found in the Red River Delta Region in northern Viet Nam, in the Mekong River Delta in southern Viet Nam and in the northern and southern regions of Myanmar. Prevalence is lowest in the central provinces of both Thailand and Viet Nam. Hookworm infection prevalence varies across the region in no clear pattern (Figure 1c): moderate prevalence (20 to 50 per cent) is found in central Thailand and some areas of Viet Nam; other provinces in Viet Nam and southern Thailand have a high prevalence (50 per cent and above).

Estimates of numbers of people infected and target population for control

The World Health Organization has set a criterion of 50 per cent or greater infection level within a province as guidance to target its programmes. Countries are advised to adopt the same threshold to determine which provinces would be priority areas for its worm infection control programme. On this basis, estimated 6.8 million school-age children in 35 of 175 provinces in Southeast Asia warrant mass treatment with de-worming drugs. However, some flexibility in the prevalence requirement may be needed. When adopting a 20 per cent prevalence threshold, for instance, estimated 15.8 million school-age children in 134 provinces would receive mass treatment. Table 1 summarizes the estimates of predicted prevalence, persons (total and school-age children) infected and the number of school-age children warranting mass treatment using the 50 per cent and 20 per cent thresholds. Each government should decide whether to adopt the 20 per cent or 50 per cent threshold for its de-worming programme. For example, Thailand has set the target to reduce the worm infections to a level that will cause it to stop being a public health problem in the country.

Table 1. Summary estimates of predicted prevalence, numbers (total and school-age children) infected and numbers of school-age children warranting mass treatment, using the 50 per cent threshold and 20 per cent threshold, which is the number in the brackets in the last column

	Population in 2002	Estimated prevalence		Total number infected (1,000s)		School-age children infected (1,000s)		School-age children receiving treatment (1,000s)
	(1,000s)	Roundworm	Whipworm	Roundworm	Whipworm	Roundworm	Whipworm	
Cambodia	13,403	22.0	8.0	2,948	1,072	884	321	0 (498)
Lao PDR	5,778	35.8	21.3	2,068	1,230	552	328	99 (551)
Myanmar	50,033	28.8	17.6	14,409	8,805	4,322	2,641	509 (3,490)
Thailand	63,430	23.2	8.8	14,715	5,581	2,472	937	0 (1,859)
Viet Nam	80,577	54.0	22.0	43,511	14,726	9,542	3,887	6,194 (9,419)
Total	213,221			74,689	34,417	17,774	8,117	6,802 (15,820)

Objectives of Preventing Intestinal Worm Infections

The overall objectives of preventing worm infections and re-infections are to improve children's health, nutrition and learning capabilities and improve women's lives and their caring capacity, work efficiency and economic productivity. These objectives require controlling the incidence of worm infections to such a degree that they are no longer a public health problem. The specific objectives in a programme to prevent worm infections and re-infection are to motivate people to improve their household and community sanitation and to change their hygiene behaviour. This

includes washing hands with soap and eating properly cooked food or thoroughly washed raw vegetables and fruit.

Controlling hookworm infection in women is critical because of the adverse affects on levels of iron in their bodies. Unlike the other types of worm infections, hookworms feed on the host's blood. Because iron reserves are vital to the well being of women, controlling this type of infection has tremendous health impacts. Females are in most need of protection from hookworm infection from the age of puberty and throughout their adult lives, primarily for reasons and benefits presented in Table 1.

Table 1 – Critical periods to intervene on prevention of hookworm infection in women

Periods	Specific Aims/Benefits
Adolescence	- Improve pre-pregnancy weight for height - Improve pre-pregnancy iron status
Pregnancy and Lactation	**Related to mother** - Increase maternal iron stores - Reduce the risk of maternal death in child birth - Reduce hospitalization rates for severe anaemia and haemorrhage - Reduce caloric stress in pregnancy and lactation **Related to infant** - Improve foetal growth; reduce low birth weight - Improve iron stores of infants - Prevent vertical transmission of hookworm - Decrease perinatal mortality - Improve early childhood development
Throughout Adult life	- Improve economic productivity of women - Improve well being and quality of life - Improve weight and height of all women - Improve iron status in all women

Part II HOOKWORM and ROUNDWORM

Hookworm

Ancylostoma duodenale (A. duodenale) and *Necator americanus (N. americanus)* are two species of human hookworms. They feed on blood and absorb digested food directly from the villi (shaggy hair of the membranes) of the intestine, which deprives the host of its needed nutrients. Hookworm attaches to the intestine by biting into the lining, thus causing ulcers and lesions. The maturing larvae and adult worms bite into the tissues and suck blood. When a hookworm feeds on blood, it releases the secretion of anticoagulant, causing the lesions it created to continue bleeding even when the worm has stopped sucking blood. It has been estimated that a single *N. americanus* is responsible for a mean blood loss of 0.031ml (plus or minus 0.015 ml) per day. Similarly, an *A. duodenale* will cause a mean blood loss of about 0.08-ml (plus or minus 0.02 ml) per day. In case of heavy infections, there may be 500 to 1,000 worms in the host. At that level, the infected person would lose about 50 ml of blood per day.

Symptoms or signs of hookworm infection are abdominal pain, nausea, headache, rash, itching, weakness, fever, vomiting, diarrhoea, dysentery and gastrointestinal bleeding. Hookworm infection causes iron deficiency anaemia. Anaemia is believed to be associated with high risk of maternal mortality and morbidity. Even minor infections may result in severe anaemia in children and in adolescent girls in most developing countries. Globally, about 1.3 billion people are currently estimated to suffer from hookworm infection. In areas of very intense transmission, heavy worm burdens can be built up in early childhood. In such cases, there may be retardation of mental and physical development.

Hookworm infection shows a slower rise with age than those of roundworm and whipworm (Figure 1B and Figure 2B, Appendix B). In general, more adults than children would be infected and the adults would have a larger worm presence in their bodies. Adolescent girls and women of childbearing age would generally be more heavily infected with hookworm than younger girls and boys.

Hookworms are usually acquired gradually during childhood with peak prevalence and intensity during a person's late teens and early adulthood. However, high hookworm prevalence has also been found in children of preschool age in some places.

Neonatal hookworm infection is caused almost exclusively by the *A. duodenale*. A study in China indicates that *A. duodenale* can pass from a pregnant woman and across her placenta to infect the foetus in utero. Many infants investigated with hookworm eggs in their stools were neonates (less than one month old). The shortest prepatent period (the interval between infection and appearance of eggs in the stools) in humans infected by the *A. duodenale* is about 56 days. Thus, it would appear that those infants must have been infected before birth while in their mothers' womb.

Hookworm infection is predominately endemic in areas where people lack access to safe drinking water and adequate sanitation, have unhygienic habits and are impoverished. Hookworms are usually more abundant in rural than urban communities.

Diagnosis of hookworm infection is by microscopic identification of eggs in faecal samples. Since the eggs of *N. americanus* and *A. duodenale* appear identical on microscopic examination, species recognition requires, in practice, either:

(i) The administration of a vermifuge, or worm-expelling drug, followed by collection of faeces and microscopic study of the released adult worms, which are morphologically distinct, or

(ii) The cultivation of hookworm eggs to the filariform infective larvae stage, when the two species can be differentiated.

Life Cycle and Transmission

Mode of transmission

The route through which both *A. duodenale* and *N. americanus* enter the human host occurs by the infective larvae penetrating the skin of bare feet or hands that have contacted with contaminated soil. In the case of *A. duodenale* only, the infected larvae can also infect humans when ingested with contaminated and unwashed raw vegetables or eating with dirty hands. Larvae migrate from the soil onto foods or even hands, which can transfer them onto foods if hands are not washed properly with soap. Occasionally the infective larvae of *A. duodenale* may pass the placenta and infect the foetus in the womb.

Life cycle inside human host

Hookworm begins its life in the human host when infective larvae penetrate the skin. They enter peripheral lymph vessels and veins of the legs and are carried with the blood stream to the heart. From the heart, they are pumped with the blood into the small blood vessels around the air sacs in the lungs. They pierce the walls of the blood vessels and get inside the air sacs. From the air sacs, they migrate, crawling through bronchioles into the bronchi, the trachea and into the pharynx where they are swallowed into the oesophagus. They descend into the stomach and proceed into the jejunum of the small intestine. The larvae molt during their migration and, about 15 days after infection, they complete their final molt and become adult. In 3 to 5 weeks after infection, the parasites become sexually mature. Both species begin laying eggs between 4 and 8 weeks after infection. The adult male is smaller than the female. The male measures 8 to 11 mm long by 0.4 to 0.5 mm wide; the female measures 10 to 13 mm long and 0.6 mm wide. Male and female worms tend to be present in a ratio of 1 to 3. *A duodenale* has a life span of 4 to 7 years, while *N. americanus* lives up to 15 years. However, 80 per cent of worms survive for less than 3 years.

Each female *A. duodenale* lays 25,000 to 35,000 eggs a day, while *N. americanus* produces 6,000 to 20,000 eggs a day, for as long as the female is fertilized and living in the intestine. The eggs move out of the host with the faeces. Millions of eggs are deposited into the environment when people do not use a latrine and defecate in the open. The eggs develop into infective larvae in the environment and then enter into the human host by penetrating the skin and/or ingestion.

Life cycle outside human host

The hookworm eggs have the best chance of survival if people defecate on moist soil rich in decomposing organic material and in an area that is protected from strong sunlight. Eggs survive in temperatures of 20 to 27 degree Celsius, but they dry out at higher temperatures.

Under suitable conditions, the eggs hatch into free-living, non-infective larvae in 24 to 48 hours. The hungry larvae dig into the faeces and feed avidly. The larvae molt on the third to fifth day and become infective. These infective larvae leave the faeces, burrow into the soil and wait for an opportunity to enter a human host. At this stage, the infective larva is covered by an external

sheath, which protects it from various degrees of dryness in the outside environment until it can find a host.

The infective larvae of *A. duodenale* develop in the same way as that of *N. americanus*. Infective larvae have a life span of 3 to 6 weeks, but they have been known to survive, under optimum conditions, for up to 15 weeks. They have a maximum vertical range of migration of about 1 metre in suitable soil. Their lateral movement is restricted to about 0.3 metres and usually less. The infective larvae are ready to penetrate the skin of a host. Bare feet and bare hands that come into contact with contaminated soil become convenient points of entry for the larvae. The juices produced by the penetration gland assist with the entry, which is hardly perceptible though it may invoke itching, known as "ground itch", and a rash. The infective larvae are then starting their life cycle and growth inside the human host.

Roundworm

Roundworm (*Ascaris lumbricoides*) is the largest of the human intestinal parasites. It lives and matures in the ileum and sometimes jejunum of the small intestine. Roundworm is often regarded as a parasite of children, but people of all ages may be infected. Some studies have shown that especially in endemic communities, up to about 90 per cent of children in the 5 to 9 age group may harbour the parasite, while 10 to15 per cent of adults may be infected. However, depending on human habits, adults and children may be equally infected.

The adult worm normally feeds on partly digested food from the intestine in humans. It has been reported that the host (having about 26 worms) may lose 10 per cent of his/her total daily intake of protein. There is also evidence that roundworm infection in children may contribute to vitamin A and C deficiencies. The early symptoms of roundworm infection are a pneumonitis with cough and sometimes blood stained sputum (which may contain larvae), dyspnea, substernal pain, fever and diarrhoea. These symptoms begin 5 to 6 days after infection, usually last 10 to 12 days and are caused by the roundworm larvae migrating and developing inside the human body. A heavy presence of adult worms in the small intestine may cause digestive disorders, nausea, abdominal pain, vomiting, restlessness and disturbed sleep. Adult worms may be passed out in the faeces or by mouth. Also, since the parasite discharges its wastes directly into the host, poisons from heavy infections may affect the host.

Roundworm infections can retard growth. They decrease the absorption of nutrients that the body needs to grow and cause obstructions in the small intestine in children. They are thought to be a cause of frequent or serious pulmonary disease among children. Death is not uncommon in children when adult worms migrate to other organs, such as the liver, gall bladder, appendix and brain, and, sometimes due to perforation of the intestine.

The harm that roundworm does to infected humans is due largely to the presence of both the larvae and adult worms. Migrating larvae cause serious damage to blood vessels. They break into the venules and lymph vessels of the intestine and migrate with the blood circulatory system. Because the larvae grow during this period, by the time they reach the capillaries of the air sacs in the lungs, they are too big to pass through them. They burst through the vessels and cause bleeding into the air sacs. When infection is heavy, blood is reported to collect in pools inside the lungs and bronchioles. The presence of the larvae in the lungs frequently leads to breathing difficulties and coughing as well as pain in the sternum. Bronchitis is not uncommon. Through the blood circulatory system, larvae may end up in several organs, including the eyes, brain and the spinal cord with serious consequences, and may cause death.

Diagnosis is by microscopic identification of the eggs in the faeces. The number of eggs counted gives an indication of the number of adult worms present.

Life Cycle and Transmission

Roundworm is long, cylindrical and tapers toward both ends. Female worms are longer than the males. Females measure from 200 to 400 mm long and the males are 150 to 300 mm. Since the sexes are separate, it requires infection with both male and female worms to produce fertile eggs in the host. It has been reported that, generally, infected persons harbour more females than male worms with an estimated ratio of 10 female worms to 3 male worms. There is always the possibility that a host may be infected only by female or by male worms. In such cases, the female worms produce the unfertilized eggs, which are incapable of developing further.

Each female worm lays about 200,000 eggs per day, for as long as she is fertilized and in the intestine. Adult worms in the human host live for less than 10 months, with maximum life spans of up to 1.5 years. The fertile eggs are ovoid and measure 45 to 70 micrometers by 35 to 50 micrometers in size. Each has a protective durable shell. The eggs are discharged into the lumen of the intestine and leave the host with the faeces into the environment. As long as the mature fertilized female worms are living in the intestine, eggs are produced and passed into the faeces.

Mode of transmission

Transmission of roundworm is mainly through faecal-oral route. Roundworm infection is transmitted by ingestion of infective eggs from human faeces that contaminate the drinking water, foods, hands and living environment. Faecal-contaminated soil may be carried long distances on feet or footwear and by animals into houses. Children playing in a compound pick up infective eggs from the ground or play things. Transmission of infection by contaminated dust is also possible.

Roundworm lives in humans only. Pigs and dogs may disperse the undeveloped eggs of roundworm by eating them in human faeces and excreting them later at other places (out doors and/or indoor environment), thus spreading the contamination.

There are three primary routes for roundworm transmission:

- Transmission in yard, compounds and in the open fields that have been contaminated by faeces, especially those of children;
- Transmission to persons working in fields where night soil (fresh human faeces) or raw sewage is used as fertilizer; and
- Transmission to persons consuming contaminated vegetables that have been grown in fields using night soil or raw sewage.

Life cycle inside human host

Roundworm infection starts with the ingestion of infective eggs in faecal-contaminated food, water and hands. The larvae move quickly and penetrate venules in the villi, which line the small intestine. They enter the blood circulatory system and start an 8 to 15 day larval migration phase within the host. They travel with the blood, which is loaded with nutrients from digested food from the intestine, through the large hepatic portal vein and are carried through the liver to the right auricle of the heart. They move with the blood into the right ventricle. From there they are pumped to the lungs and into the small blood vessels of the air sacs. The larvae break through the blood vessels, penetrate the thin walls of the air sacs, enter the bronchioles and eventually get into

the trachea. They migrate into the pharynx from where they may be coughed out with bloody sputum. Otherwise, they are re-swallowed into the oesophagus and returned to the stomach. From there, the larvae continue their journey to their final location, usually in the ileum but also sometimes in the jejunum of the small intestine. There they grow into adults. The entire process from infection to maturity takes less than three months.

Life cycle outside the human host

Roundworm eggs are discharged with faeces into the environment. The eggs do survive best in moist warm soils where they develop into an infective stage. The infective eggs are capable of surviving for up to a year in the soil, even where the oxygen level is low, and in low temperatures and dry environments. Infective eggs can survive for long periods; seven years' survival in soil has been recorded. Drinking water disinfected with chlorine does not affect them. In adverse conditions, they become dormant. Under ideal conditions of moist, shady soil at a temperature range of 22 to 33 degrees Celsius, a minimum of 10 to15 days is required for freshly excreted egg to become infective.

Part III PREVENTIVE INTERVENTIONS FOR INTESTINALWORM INFECTION

Anti-helminth drug treatment using Albendazole or Mebendazole that kill several species of intestinal worms at the same time would only result in a short-term reduction of infection in a target population. Re-infection is quite frequent within a relatively short period of time. The long-term key preventive interventions mentioned below are the basic requirements to break the intestinal worm transmission routes and life cycles:

- Provision and use of safe and adequate water supply;
- Improvement of environmental sanitation; and
- Practicing good sanitation and hygiene habits.

For both roundworm and hookworm infections, the important preventive interventions involving people's behaviour change are:

- Building and using sanitary latrine for safe disposal of human excreta;
- Washing hands with soap before eating or feeding children and after defecation; and
- Washing and cooking vegetables thoroughly.

While the implementation of a water supply and sanitation programme at the household and community level may take time, personal precaution against hookworm infection is to wear suitable footwear to protect the skin of feet, ankles and legs from coming into contact with infective larvae.

In areas where human excreta are used as organic fertilizer, people should be educated and motivated to use only the fully digested or properly composted human excreta and not to apply the raw or partially digested excreta to the field. Fully digested excreta are taken from a latrine pit where it has been sufficiently stored for one to two years. During this period, disease pathogens and worms' eggs have died out completely. It will not pollute the soil or the environment as well as the vegetables grown in the field. An integrated de-worming and WES programme should also educate people about the proper method of composting the human excreta for use as organic fertilizer.

Part IV IEC MATERIALS FOR INTESTINAL WORM INFECTIONS AND ITS PREVENTIVE INTERVENTIONS

Two Power Point presentations on prevention of hookworm and roundworm infections are included in this document for promotion and education purposes. In these two Power Point presentations, experiences from the School De-Worming Programme in Thailand have been incorporated. It is suggested to adopt the respective countries' experiences during these presentations if possible. Programme personnel and users are encouraged to develop more IEC materials at the country or local level.

In addition to the printed materials, real roundworms can be very effective educational material for children, parents and community members. For example, there can be presentations of roundworms preserved by alcohol in glass jars or bunches of live roundworms. Allowing people to see or touch the real worms could initiate very effective discussions on how the worms enter the human body, the harmful health effects and key actions needed for preventive measures at home, in schools and in the communities.

Hookworm Infection and Its Preventive Interventions
A Power Point Presentation

Slide

1. The hookworm.

2. Hookworm is one of the most harmful intestinal parasites to the human being. There are two species: on the left is *Necator americanus (N. americanus*); on the right is *Ancylostoma duodenale (A. duodenale*). In each case the male, on the left, is smaller than the female, on the right.

3. This slide shows the teeth of the two hookworm species.

4. A male hookworm measures 8 to 11 mm long by 0.4 to 0.5 mm wide, while the female is 10 to 13 mm long and 0.6 mm wide. Hookworms attach themselves to the human intestine by biting into the intestinal mucous to suck blood. *A duodenale* has a life span of 4 to 7 years and *N. americanus* lives up to 5 years.

5. In 10 days, some 50 hookworms can suck about 50 ml of blood from its human host. The body cannot make up the blood loss. Eventually, this can lead to anaemia.

6. Depending on the species, a hookworm lays 6,000 to 35,000 eggs a day in the small intestine. The eggs leave the host with faeces, which are deposited in the environment when people defecate in a field, or somewhere without a proper latrine.

7. When people defecate in the open, faeces are left exposed outdoors. The eggs in the faeces develop into free-living larvae in 24 to 48 hours. The larvae dig into the faeces and feed avidly. The larvae molt on the third to fifth day and become infective.

8. These infective larvae leave the faeces and burrow into the moist soil and vegetables, waiting for an opportunity to enter the human host.

9. The infective larvae enter the human body by penetrating the skin. When a person walks barefoot or touches the ground with his/her bare hands, infective hookworm larvae can penetrate the exposed skin. Obviously, you cannot see them.

10. The larvae can also enter the body through contaminated hands and through vegetables that are unwashed, unclean or eaten raw.

11. When hookworm larvae enter through the skin, the penetrated site becomes red, swells and itching, suffering what is known as “ground itch”.

12. Several hours after penetration, the larvae can clearly be seen under a microscope in this section of the leg skin of a human host.

13. Larvae enter the body via the skin and travel through the blood stream to the small intestine by way of the lungs, trachea, oesophagus and stomach. The adults lay eggs in the small intestine. The eggs are then passed with the faeces into the environment.

14. Once settled in the small intestine, the larvae become adults in about one month. They bite into the intestine mucosa and suck blood. Their steady diet: *human blood*.

15. This slide shows the adult worms clamping their teeth onto the intestinal mucosa and sucking blood.

16. An infected person tends to lose his/her appetite and becomes anaemic. Symptoms or signs of hookworm infection are abdominal pain, nausea, headache, rash, itching, weakness, fever, vomiting, diarrhoea, dysentery and gastrointestinal bleeding.

17. A person suffers from shortness of breath, heart palpitation, weakness and fatigue when infected with hookworms.

18. When a pregnant mother is infected with hookworm, the worms suck blood from both mother and foetus. This causes both mother and the unborn baby to develop anaemia. Some babies are born under-weight or premature. Heavy hookworm infection during pregnancy is known to be associated with high maternal mortality and morbidity.

19. One of the effective controls of hookworm infection is through school- and community-based de-worming programmes of children and adolescent girls. Parents and community members have to be motivated and educated to bring in stool samples for examination. If a child or a person is infected with hookworm, the eggs will be present in the faeces. This, and the following slides, shows the school-based de-worming activities in Thailand.

20. Mass stool examinations in the project schools and communities are required to be carried out to establish the baseline infection for effective distribution of drugs to the target population and subsequent follow-up actions. This slide shows the stool examination in one of the project schools in Thailand.

21. This is from a de-worming campaign in one of the schools in Thailand, where parents are involved and participate in activities.

22. Everyone cooperates; parents bring their children's stools for examination in the school campsite.

23. Prevention is better than cure. One of the most effective measures is to break the hookworm transmission cycle by ensuring faeces are disposed into sanitary latrines. It is vitally important and necessary to build a sanitary latrine for the family. Make sure all family members, including children, use the latrine and keep it clean always.

    Personal precaution against hookworm infection is to wear suitable footwear to protect the skin of feet, ankles and legs from coming into contact with infective larvae.

24. While preparing to build the sanitary latrine for the family, advise all family members to dig a hole in the ground for defecation and cover the hole with soil afterward to avoid exposed excreta on the ground. This is only a temporary measure and is not a long-term solution.

25. You should always wash both hands with soap (or ash if you do not have soap) thoroughly before eating or feeding children and after defecation. Fingernails should be neatly trimmed. Vegetables should be thoroughly washed and well cooked before eating.

26. Seeing is believing. When school children see the worm eggs in their own stools, they could be convinced to change their behaviour and influence their parents to change as well. People of all ages should be ready to protect their own health through taking preventive actions to improve sanitation and personal hygiene.

27. After hookworm and other intestinal worms are eliminated from our bodies and the living environment, we are all healthy and happy.

Roundworm Infection and Its Preventive Interventions
A Power Point Presentation

Slide

1. Roundworm (*Ascaris lumbricoides*) is the large intestinal parasite of human beings. It infects about 1.47 billion people worldwide. Prevalence and intensity of infection are particularly high among pre-school and young school children. In many developing countries, the infection rate can be as high as 60 to 90 per cent.

2. This slide shows the male roundworm (top) and female roundworm (bottom). Females are 200 to 400 mm long, whereas males are 150 to 300 mm.

3. A bunch of roundworms.

4. This is a roundworm's egg. An adult female worm lays about 200,000 eggs per day. The eggs are discharged with the faeces into the environment when people defecate in the open. The eggs thrive best in moist warm soils where they become infective.

5. This slide shows the development stages of a roundworm egg. Under ideal conditions of moist, shady soil, the roundworm embryo develops into a first-stage larva inside the egg. The larva then further develops and molts into a second-stage larva, and the egg becomes infective within 10 to 15 days. The infective eggs are capable of surviving for up to a year in the soil in low oxygen, low temperature and dry environment. Under adverse conditions, they become dormant. There is record of infected eggs in soil surviving for 7 years. Chlorine in treated water does not affect them.

6. Transmission of roundworm is mainly through faecal-oral route. The infective eggs enter into the human body when swallowed or ingested with faecal contaminated water or food, or pass onto food by infected hands, dirt under the nails, cups and plates. A child playing in a compound picks up infective eggs through dirty hands or play objects.

   Once the infective eggs enter into the human body, the larvae hatch in the duodenum and are carried in the lymphatics or blood vessels, through the liver and heart, to reach the lungs in 3 days. The larvae develop further in the lungs, penetrate the air sacs, ascend to the trachea and are re-swallowed down the oesophagus to reach the small intestine. They develop into adults in about 60 to 75 days and then live inside the intestine of the human host up to 1.5 years.

7. The danger of roundworm infection is that symptoms in about 85 per cent infection are not readily recognized. However, some early symptoms of roundworm infection are pneumonia with cough and sometimes blood stained sputum (which may contain larvae), abdominal pain and diarrhoea. These symptoms begin 5 to 6 days after infection, usually last 10 to 12 days and are caused by the roundworm larvae migrating and developing.

8. This picture shows intestinal obstruction by large numbers of entangled roundworm. (This is the small intestine of a child, 10 to 12 years old, who died from roundworm infection.)

9. Roundworms are pushing to come out when the intestine is cut open.

10. Roundworm obstructs the appendix.

11. Migration of adult worms into the human liver could result in death.

12. Travelling through the blood circulatory system, larvae land in the human brain, grow there and ultimately cause death.

13. When people defecate in the open, millions of roundworm eggs are deposited in the soil or environment. Eggs in the exposed faeces in the soil or environment develop into an infective stage. They cans be carried around freely by dust, wind and rain.

14. Roundworm eggs often spread through dirty hands. Dirty human feet and animals walking in and out of houses bring the roundworm eggs into the home, and thus contaminate the home environment. In addition, flies, cockroaches and rats are also common vehicles that carry the roundworm eggs into the home where they infect humans.

15. People ingest infective roundworm eggs through drinking contaminated water, eating unclean vegetables and foods that have been contaminated by dirty hands.

16. People need to adopt good hygiene habits by washing both hands properly with soap before eating or feeding children and after defecation; wash vegetables thoroughly, especially when eating them raw; cook food and vegetables properly to destroy the worm eggs.

17. Prevention is better than cure. One of the most effective measures is to break the roundworm transmission cycle by ensuring faeces are disposed into sanitary latrines. It is necessary to build a sanitary latrine for the family. Make sure all family members, including children, use the latrine and keep it clean always.

18. While preparing to build the sanitary latrine for the family, advise all family members to dig a hole in the ground for defecation and cover the hole with soil afterward to avoid exposing excreta on the ground. This is only a temporary measure and is not a long-term solution.

19. One of the effective controls of roundworm infection is through school- and community-based de-worming programmes of children. Parents and community members have to be motivated and educated to bring in stools for examination. If a child or a person is infected with roundworm, the eggs will be present in the faeces.

    Seeing is believing. When school children see worm eggs in their own stool, they are motivated to change their behaviours and influence their parents to change as well. People of all ages should be ready to protect their own health by taking preventive actions. The following slides show the school-base de-worming activities in Thailand.

20. Mass stool examinations in the project schools and communities are required to be carried out to establish the baseline infection for effective distribution of drugs to the target population and subsequent follow-up actions. This slide shows the stool examination in one of the project schools in Thailand.

21. Hygiene and health education of school children is the most important activity to motivate children to change their behaviours and to take home the good hygiene habits. Children can be effective agents to convince parents and community members to change their behaviours and to build and use sanitary latrines as well as to clean up the living environment.

22. During the de-worming day, school children are advised to take the de-worming tablets as soon as it is given to them.

23. A de-worming campaign in one of the schools in Thailand where parents are involved and participate in activities. This slide shows a meeting between health officers and parents. During the meeting, parents are informed that a microscopic examination reveals that their children's stools contain roundworm eggs. This indicates the children are infected with roundworm, hookworm and other worms. The health officers take the opportunity to educate the parents in taking preventive actions by building and using sanitary latrines and washing hands with soap.

24. After we work together to eliminate the roundworm and other worms from our bodies and living environment, we are all healthy and happy.

Appendix A

Table 1A The most common species of intestinal helminths that infect Human beings in the world today.

Common name	Species name	Term for infection	Geographical distribution	Site occupied in human host	Estimated no. of infections
Roundworm	*Ascaris lumbricoides*	*Ascariasis*	worldwide	Small intestine	1,470 million (a)
Hookworm	*Ancylostoma duodenale, Necator americanus*	*Ancylostomiasis Necatoriasis*	worldwide	Small intestine	1,300 million (a)
Whipworm	*Trichuris trichiura*	*Trichuriasis*	worldwide	Large intestine	1,050 million (a)

(a)= Data from Chan et al. (1994)
(b) = Data from Warren et al. (1993)

Table 2A – Prevalence of helminth infection among school children in 6 provinces in Lao PDR(1)

Province	No. of children examined	Total positive, %	Prevalence of helminth infection, %				
			Tapeworm (*taenia*)	Roundworm	Hookworm	Whipworm	Ov*
Vientiane city	2,837	1,182 (41.5%)	150 (5.3%)	215 (7.6%)	558 (19.6%)	433 (15.2%)	40 (1.4%)
Savannakhet	3,595	1,915 (53.3%)	58 (1.6%)	1190 (33%)	482 (13%)	932 (26%)	36 (1.0%)
Bolikhamxay	1,749	481 (27.5%)	311 (17%)	53 (3%)	152 (8.7%)	51 (2.9%)	3 (0.2%)
Vientiane Province	1,419	619 (48.6%)	405 (28%)	92 (6.5%)	359 (25%)	41 (2.7%)	7 (0.5%)
Saravance	1,599	669 (41.8%)	190 (12%)	174 (11%)	87 (5.4%)	344 (21.5%)	14 (0.9%)
Kharnmuane	1,359	843 (62%)	236 (17%)	233 (17.1%)	258 (19%)	437 (32%)	16 (1.2%)

(1) Source: Bounlay Phommasack, Deputy DG, Dept of Hygiene and Prevention, Ministry of Health, Lao PDR, March 2001
(*) Ov- Opistorchis viverrini- some intestinal trematodes may be included in Opistorchis infection

Appendix B

Figure 1. Representations of typical relationships between age and the prevalence of infection with the 3 most common species of intestinal helminths (data modified from Bundy *et al*., 1987; Bradley *et al*., 1991 and Hall *et al*., 1992)

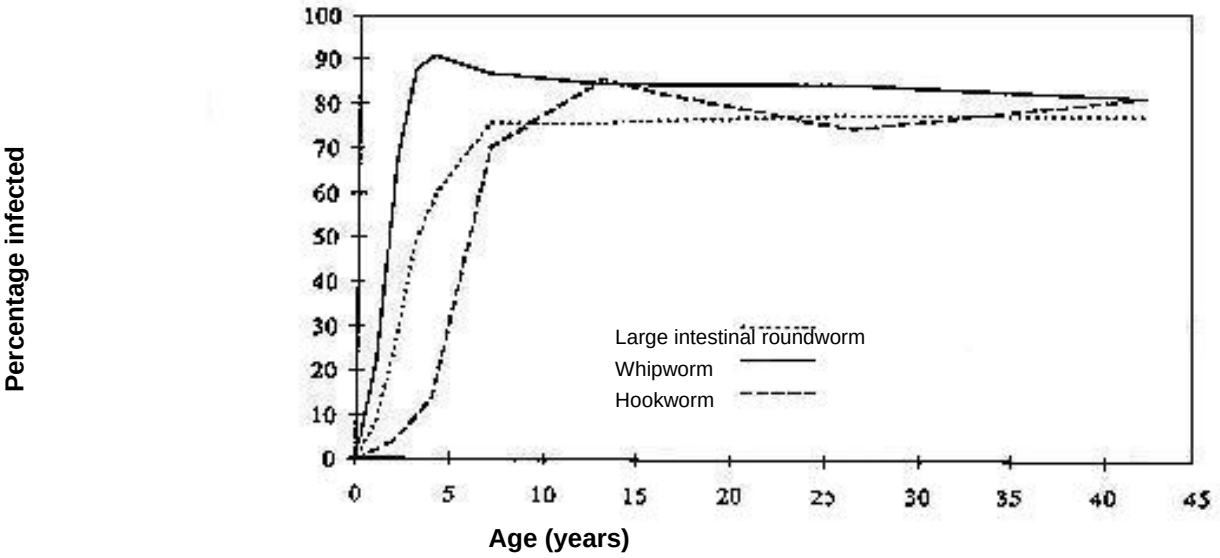
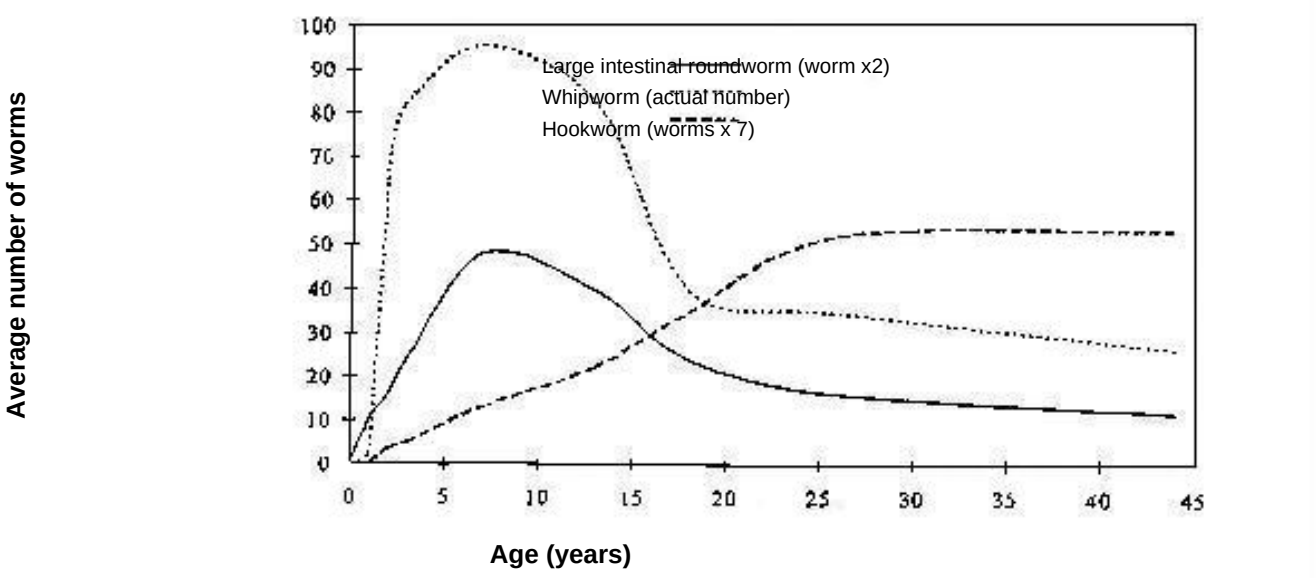


Figure 2. Representations of the typical relationships between age and the average number of worms in people with the 3 most common species of intestinal helminths (data modified from Bundy *et al*., 1987; Bradley *et al*., 1991 and Hall *et al*, 1992)



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