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_I. Panel of Experts on Environmental Management for Vector Control (PEEM)_

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Credit individual slides:

Agricultural University Wageningen, Netherlands

World Health Organization

Dr Steven Lindsay, Durham University, UK A.8

About PEEM

The joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM) was established in 1981 to create a framework for inter-agency
and inter-institutional collaboration with a view to promoting the extensive use of environmental management for disease vector control as a health safeguard in the context of land and water resources development projects and for the promotion of health through agricultural, environmental, human settlement, urbanization and health programmes and projects. The collaboration originates from memoranda of understanding between three agencies (WHO, FAO and UNEP) covering the areas of prevention and control of water-home and water-associated diseases in agricultural development, rural water supply and waste water use in agriculture, forestry and aquaculture. In 1991 the three agencies were joined by UNCHS and PEEM’s mandate was expanded accordingly to include human settlements, urbanization and urban environmental management including urban water supply, sanitation, drainage and solid waste disposal.

The PEEM programme covers three areas of activities: promotion, research and development and capacity building. Under promotion, PEEM has organized several national seminars on water resources development and vector-borne diseases (Kenya, Benin and Zambia), and it has published several technical documents, including those in the PEEM guidelines series and in the PEEM river basin series (see bibliography). In the area of research PEEM is a partner in the Consortium Research Project on the Association between Rice Production Systems and Vector-borne Diseases in West Africa, and is starting a health status assessment initiative with IUCN (the World Conservation Union) as part of the latter organization’s Zambezi wetlands conservation and resource utilization programme. PEEM’s capacity building efforts include the development and testing of the training course Health Opportunities in Water Resources Development and the organization of and follow-up to a series of workshops on the promotion of environmental management for disease vector control through agricultural extension programmes.

Slide A.1

The diseases listed in this table have one common denominator: they are all transmitted by vectors, insects that play an active role in picking up the disease-causing organism from an infected (not necessarily sick) human being and infecting another human being. This transmission occurs through blood meals which the female insects have to take in order to reproduce. In many, though not all cases, the disease causing organism (parasite) undergoes the changes pertaining to part of its life cycle in the insect vector.

The exception in this list is schistosomiasis, which is not actively transported by a vector from one human being to the other. Rather, the intermediate host aquatic or amphibious snails only harbour the larva of the Schistosoma parasite and provide the micro-environment for it to change from a non-infective to an infective larval stage.

This dependence of the transmission on other organisms links the transmission potential directly to the ecological requirements of the vectors. Water is a crucial element for the mosquito- and snail-borne diseases; others like Old World leishmaniasis and Chagas disease depend on more arid conditions.

Because of their common denominator, this group of diseases offers a method of control that is different from all others, since it does not interfere with the patients, nor with me
disease causing organism: vector control aims to interrupt the transmission by attacking the vector, through environmental management, or by biological or chemical means.

On all the diseases listed, the World Health Organization regularly publishes up-dates through the Expert Committee reports (Technical Report Series) and through the annual World Health Report

**Slide A.2**

The estimates of the *prevalence* and *incidence* of the diseases listed cannot be more accurate than the surveillance systems at the country level allow. Prevalence refers to the number of cases at a given moment in time and incidence describes the number of new cases over a determined period.

In many countries in sub-Saharan Africa the annual health budget does not allow proper monitoring and surveillance, and the real number of, for example, malaria cases is, therefore, a rough estimate or an extrapolation from small surveys. For more chronic infections, such as schistosomiasis, the use of effective sampling techniques provides a more accurate picture. Critics have noted in the past that WHO’S figures for this infection have not fluctuated over the years, but it should be remembered that they should be considered in the context of a growing world population, so that the situation has, in fact, improved.

For many of the viral infections, and particularly dengue, whose epidemics occur in the urban setting, the number of severe cases and the mortality rates can be easily documented, but the number of infected people without symptoms or with only light illness will be much greater. What counts here is the acute burden on the health services.

Finally, governments may have political or economic reasons to not report or under-report vector-borne diseases. This may be particularly the case when incidence increases in association with a possibly already controversial development project. This has contributed to the lack of well-documented descriptions of the magnitude of vector-borne disease problems associated with water resources development.

**Slide A.3**

*Schistosoma mansoni* is widely distributed in sub-Saharan Africa. It also occurs among populations of the South American Atlantic coast and on a number of Caribbean islands, where it was introduced through the slave trade. Other foci can be found in the Nile delta in Egypt and in Saudi Arabia.

**Slide A.4**

The distribution of *Schistosoma haematobium* is also mainly sub-Saharan, but there are important foci in the Nile Valley, in other North African countries and in the Middle East. *Schistosoma japonicum* is the parasite species occurring in eastern Asia, in China and the Philippines.

The example of Ethiopia clearly shows how environmental conditions determine the distribution of the snail intermediate hosts and of the infection: in the Awash Valley,
Schistosoma mansoni is found at the higher altitudes (the upper valley) where the intermediate host, Biomphalaria pfeifferi, profusely breeds in tertiary and drainage canals of the sugar estates. Intestinal schistosomiasis has been reported in these irrigated areas since the mid 1960s. Schistosoma haematobium, causing urinary schistosomiasis, occurs in the middle and lower valley (where average temperatures are higher) where the intermediate snail host Bulinus abyssinicus breeds in the clear marshy waters of swamps in undeveloped flood plains.

Human migration patterns have been of prime importance in the spread of schistosomiasis in Ethiopia and elsewhere. Health records show that before the development of sugar estates, prevalence was limited to the provinces of Harar, Tigray and the Lake Tana Basins of Gojjan and Gondar. Agricultural development attracted people from these areas, including people infected with the parasite. The newly created snail habitats in the irrigation schemes provided fertile grounds for the local transmission of the disease to take off. The droughts of the early 1980s caused further demographic change, including a massive move of people from the endemic areas in Wello and Tigray to the irrigation schemes of the Middle Awash Valley.

References:


Among the clinical symptoms of intestinal schistosomiasis is severe enlargement of the liver and spleen. This and intestinal involvement are the main public health impacts due to chronic infection. In areas of low prevalence severe clinical features are seen in a relatively small proportion of patients. Symptoms such as abdominal pain, bloody diarrhoea and fatigue are reported by infected people in high-prevalence localities.

Fibrosis of the liver and portal hypertension may be life threatening and are irreversible in advanced disease. The enlargement of the liver in childhood has been correlated with the intensity of the infection.

Reference:

Slide A.7
With respect to the global distribution of malaria, several issues should be borne in mind:

- the distribution map indicates risk and does not indicate intensity of transmission. Malaria has a patchiness in time and location, except in the so-called holo-endemic and hyper-endemic areas (epidemiological terms relating transmission intensity to clinical patterns) of sub-Saharan Africa.

- the majority of malaria cases in the world (90%) occur in sub-Saharan Africa

- the map does not distinguish between the various parasite species, the most important of which are the virulent *Plasmodium falciparum* and the more benign *P. vivax*. The latter predominates in the Eastern Mediterranean and in South Asia, even though the proportion of *P. falciparum* cases in the latter area is increasing.

- the map does not indicate the problems of drug resistant *Plasmodium falciparum*, spreading in South East Asia and in Africa

- malaria was successfully eradicated from Europe, parts of the Eastern Mediterranean, parts of North, Central and South America, and parts of the Western Pacific, mainly through the spraying of residual insecticides. These were without exception areas of unstable vivax malaria.

- current important malaria foci are associated with areas of rapid economic development, with demographic and environmental change, and areas characterized by civil strife or refugee problems. Urban malaria is gaining importance.

Slide A.8
The clinical symptoms of malaria are reasonably clear, but the underlying pathology complex. The traditional fever and headache syndrome is related to the breakdown of parasitized red blood cells and the release of the parasites waste products in the blood stream are accompanied by liver and spleen enlargement and anemia. With a high concentration of parasites in the circulation, the *P. falciparum* feature of parasites clumping together in the small blood vessels of brain may cause severe cerebral malaria, which can be fatal in a matter of 24 hours.

The great majority of fatalities caused by malaria is among under five year olds in sub-Saharan Africa (rough estimates come to the figure of 1 million deaths a year); pregnant women are another vulnerable group; and migrants from non-malarious (usually high-altitude) areas moving into new development schemes (particularly irrigation schemes) make up a third important group.

Attribution of malaria transmission to a single environmental or behavioural factor is impossible. Moreover, malaria being a disease of poverty, it is usually part of a conglomerate of illnesses, including diarrhoeal diseases, malnutrition and other parasitic infections.
The incidence of yellow fever is highest in parts of western Africa, including Ghana, Nigeria and adjacent countries, and in northern South America, especially Peru, Bolivia and Brazil. Rural populations are at greatest risk, with most cases occurring among young adult males who enter the forests as part of their work.

Reference:


The group of filariases includes all those infections caused by parasitic filarial worms belonging to the species *Wuchereria bancrofti*, *Brugia malayi* and *Onchocerca volvulus*. Distribution of the disease caused by the infection with the latter, river blindness, is covered in slide A.13. The other two infections will both lead to the well-known clinical picture called elephantiasis.

In urban areas and in some of the rural areas of Asia the distribution of *W. bancrofti* is linked to the distribution of *Culex quinquefasciatus*, which breeds in organically polluted water. In Sri Lanka, in addition to the conventional breeding in open sewers and other stagnant water bodies with organic waste, the practice of obtaining coconut fiber by letting the coconut husks rot in water collections (so-called coconut husk pits) contributes importantly to the distribution of the disease along the coastal belt of the island south of Colombo. In rural Africa, anophelines are responsible for the transmission of this parasite. On the islands of the South Pacific a special form of *W. bancrofti* occurs which has a life cycle adapted to the biting pattern of its vector, *Aedes polynesiensis*. This vector takes its blood meal during the day-time (as opposed to dusk or night-time biting by the other vector mentioned). This *Aedes* species breeds profusely in standing water in open coconut shells.

*Brugia malayi* is transmitted by *Mansonina* mosquitoes, which have the peculiarity that their larval stage lives under water, taking oxygen from the roots of aquatic weeds. The distribution of the disease is therefore partly related to man-made reservoirs where such weeds have taken over.

Onchocerciasis or river blindness has a distribution both in Africa and Central and South America that is immediately linked to the preferred breeding conditions of the *Simulium* blackfly vector. The blackfly larvae develop attached to rocks in fast running parts of
rivers, including rapids, where water is highly oxygenated. Intense disease transmission therefore occurs among communities in the river valleys. The adult fly can, however, migrate over large distances (hundreds of kilometers) using favourable winds.

The Onchocerciasis Control Programme, at its onset in 1974 WHO’s single largest vector control operation, has eliminated the disease from a large part of West Africa (11 countries), as indicated in the map. Initially strictly a vector control operation, using insecticide release upstream from breeding places, in recent years these efforts have been backed up by the distribution of the drug Ivermectin. In January 1996 the African Programme for Onchocerciasis control became operational, aimed to expand the OCP operations to cover the entire distribution area of the disease in Africa. Elimination of the disease as a public health hazard is targeted by 2002. The World Bank and a consortium of bilateral donors continue to support these efforts.

Slide A.15

Long-term exposure to the infected bites of blackflies causes blindness. In the most endemic areas in Africa, where OCP started its work, it was a common phenomenon to have the majority of community members being guided by the younger members who could still see. Blindness is a result of the microfilaria load, affecting the skin and the eyes. Microfilaria are the larvae of *Onchocerca volvulus* living in the bloodstream of the victims.

Slide A.16

The socioeconomic impact of onchocerciasis has been devastating for the endemic countries. The transmission intensity was highest in the fertile river valleys where many villages were abandoned by their inhabitants. The prospect of blindness on the long-term contributed as much to this migration as the acute nuisance of clouds of blackflies in search for a blood meal. The potential for agricultural development in these valleys is enormous and FAO, in collaboration with the World Bank, is monitoring the re-migration of people and the expansion of agricultural production. Remote sensing is applied to carry out this monitoring over large areas.

Slide A.17

Slide A.18

Slide A.19

Slide A.20

Both vectors and animal reservoirs determine the distribution of the range of leishmaniases in the world. Even for specialists in this field the picture is complex. A first distinction that clarifies the epidemiology is that between the visceral and the cutaneous forms of the disease. In the visceral disease form (known as Kala-azar) the *Leishmania* parasite affects the internal organs and the disease is very likely to have a fatal ending if not treated. An arid, warm environment provides the ideal ecological conditions for the breeding of many species of sandflies. In the Old World these are sandflies of the genus *Plebotomus*, in the New World of the genus *Lutzomyia*. 
Kala-azar is commonly associated with dry, rocky hill country. In Kenya, sandflies live and breed near large termite hills, where they become infected biting rodents living in the holes of these hills. Dogs, wild carnivores and various species of rodents are commonly infected, and this zoonosis (a human disease with an animal reservoir) is therefore linked to certain types of vegetation or certain agricultural practices that affect especially the rodent populations.

Old world cutaneous leishmaniasis is also a zoonosis occurring in scattered foci throughout the tropical and sub-tropical belts. It is known by different local names: Oriental sore, Aleppo button, Baghdad boil or Delhi sore. Arid or even semi-desert terrain provides ideal habitats for the vector sandflies which spend the days in cool deep crevices in the ground, between rocks, in caves, cellars and house walls.

The association with the ecology of reservoir animals holds a key to the control of the disease. In Uzbekistan, large scale land-levelling works destroyed the burrow of the local reservoir rodents species (the great gerbil, *Rhombomys opimus*), thus interrupting the transmission. On the other hand, in one country in North Africa, a policy to settle nomadic tribes caused a chain reaction leading to an outbreak of the disease: the nomadic lifestyle ensured that a large camel population kept a desert type vegetation under control - when this stopped, the rodent population also living on this vegetation exploded and with it the sandfly population, creating a situation where conditions for disease transmission to humans were optimal. In Ethiopia, rock hyraxes are the main reservoir of the parasite.

In the New World, cutaneous and mucocutaneous forms of the disease exist, again known by various local names: espundia in the Amazon region, papalomoyo in Central America and pian bois in the Guyanas. The *Lutzomyia* vectors live in the forests, feeding on forest rodents such as *Proechimys guyanensis*, and also on monkeys and sloths, all of which serve as reservoirs. Those working in the forests such as gum-tappers (chicleros) are readily exposed to infection. The conditions in some plantations such as coffee, are conducive to vector breeding and people working in these agro-ecosystems are equally at risk. In 1995 the UNDP/World Bank/WHO Special Programme on Research and Training in Tropical Diseases funded research in Colombia to investigate the risk levels associated with different coffee varieties creating different ecological conditions.

The lesions caused by cutaneous leishmaniasis are frequently on the face, but sometimes also reveal other areas of the body exposed, for instance, in agricultural work. In terms of direct impact on production, the cost of visceral leishmaniasis is considerable. However, the social cost of the skin lesions caused by cutaneous leishmaniasis may also be considerable, certainly so in cultural settings where marriage has a strong economic component (dowries etc.). In the Americas, mucocutaneous infections are a risk for those who go into the forest for their livelihood.
The distribution of Japanese encephalitis provides an interesting example of “landscape epidemiology”. The virus causing the disease (referred to as brain fever in some of the endemic areas) normally circulates among certain domestic animals and birds such as egrets and herons, in the rice producing parts of South, South-East and East Asia. The culicine vectors are all species breeding in irrigated rice fields (especially at the early stages of flooding, before the rice plants have developed into a canopy).

Pigs are the key amplifying host of the virus, hence the disease is not found in muslim countries like Bangladesh, or in Malaysia, where pig rearing by the Chinese population and rice production by the Malays are geographically separated.

The migratory birds play a role in distributing the virus over larger distances. Recent changes in rice production (expansion of areas under irrigation, introduction of rice varieties allowing double or triple cropping) have been conducive to outbreaks of the disease.

Under favourable conditions, the rapid build-up of the vector population causes the virus to “spill over” into the human population - under stable conditions the mosquito species involved are zoophilic, i.e. they prefer taking their blood meals from animals.

The distribution of the disease has spread westwards in recent years, and it now borders with the distribution of West-Nile virus. The immunity to these two viruses show cross-reactivity so a further expansion westward of JE is not expected. In the industrialized countries of East Asia, the disease has been eliminated through extensive (and expensive!) vaccination campaigns of both humans and pigs.

Sleeping sickness occurs in the ecological setting where tsetse flies have their habitat. For the gambiense form of the disease, the *Glossina* species are riverine, requiring optimum shade and humidity. The contact between humans and flies is intimate when villagers congregate around pools or along rivers to collect water or to wash. In some areas, various *Glossina* species are sympatric, i.e. the distribution of different species largely overlaps. In such situations the control of one species often leads to the other species filling the ecological niches left by the eliminated population. Rhodesiense trypanosomiasis occurs in scrub savannah country because the *Glossina* vectors are less dependent on moisture. In this environment, wild and domestic animals provide good sources for blood meals.

Semi-arid areas with scrub vegetation, such as shown here, provide an excellent habitat for the vector of rhodesian sleeping sickness. In the past, control efforts in southern Africa aimed at destroying the tsetse fly habitat and killing game animals that serve as a
reservoir for the trypanosomes. This approach can, however, no longer be reconciled with conservation interests and is certainly not a sustainable solution.