



Reducing Deaths and Suffering
from Tropical Diseases



INTEGRATED VECTOR MANAGEMENT IN HUMANITARIAN EMERGENCIES

Toolkit

JULY 1, 2016
THE MENTOR INITIATIVE
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Acknowledgements

The **MENTOR Initiative** would like to thank the following individuals for their input in developing and finalizing this document:

Richard Allan, Owen Bicknell, Georgia Gore-Langton and Ruth Zwizwai developed the toolkit.

Nicola Stambach and Mariette Purcell (International Scribes) proofread, edited and translated the toolkit into French.

Technical reviews were conducted by **Alice Cowley and Sarah Hoiback and Richard Allan.**

Georges Torbey completed the graphical design and layout.

Catarina Lövgren and Lucy Allan translated the toolkit into Spanish.

We would like to thank colleagues from IFRC, ICRC, MSF, IMC, Oxfam, UNHCR, UNICEF, WHO and other NGOs, FBOs, the United Nations, Ministries of Health, and Universities, that have contributed to the development of this toolkit through the sharing of their work, reports, research and operational experience. Particular thanks goes to Professor Steve Lindsay and Anne Wilson from Durham University and Dr Raman Velayudhan from WHO Geneva.

This IVM Toolbox was made possible through support provided by the **Office of Foreign Disaster Assistance, U.S. Agency for International Development.**

The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

Abbreviations

CAR	Central African Republic
IDP	Internally Displaced People
IGR	Insect Growth Regulator
IEC	Information, Education and Communication
IRS	Indoor Residual Spraying
IVM	Integrated Vector Management
LLIN	Long lasting Insecticidal Net
LSM	Larval Source Management
MDA	Mass drug administration
MoH	Ministry of Health
NGO	Non-governmental Organisation
UNHCR	United Nations High Commissioner for Refugees
VBDs	Vector Borne Diseases
WASH	Water, Sanitation and Hygiene
WHO	World Health Organisation

Rationale Behind The Toolkit For Implementing IVM in Humanitarian Emergencies

¹ <http://www.who.int/mediacentre/factsheets/fs387/en/>

Mosquitoes are one of the deadliest creatures in the world, spreading diseases such as malaria, sleeping sickness, dengue fever, yellow fever, lymphatic filariasis, Zika, leishmaniasis, Japanese encephalitis, onchocerciasis and many others. Insects such as sandflies, black flies, tsetse flies and mosquitoes transmit 17% of the global infectious disease burden. Over one billion cases of Vector Borne Diseases (VBDs) occur annually, resulting in over one million deaths.

Malaria is currently endemic in 99 countries and causes 600,000 deaths, most of which are of children under the age of five¹. Dengue is currently the fastest spreading disease globally. The disease is endemic in more than 100 countries in the WHO regions of Africa, the Americas, the Eastern Mediterranean, South-East Asia and the Western Pacific, with two and a half billion people at risk. VBDs often co-exist in the same geographical area (some sharing the same vector) and vulnerable communities are therefore often at risk of infection from multiple diseases.

During natural or man-made crises, living conditions in towns and villages can quickly deteriorate. Whole communities may be displaced by flooding, earthquakes, or conflict, and be forced to live in over-crowded, cramped temporary camp shelters, or share housing with host families. Damaged or inadequate sanitation and water supplies, breakdown of basic services, poor access to food and effective health care, characterise many crises. These factors are likely present to various extents in all emergencies, increasing the population's exposure to insect bites and vulnerability to VBDs and other infections. When poorly nourished, the immune status is compromised and the impact of multiple infections amplifies, making case management more complex, at a time when access to health care services is often very limited. During humanitarian emergencies, malaria and other VBDs can cause very high morbidity and mortality rates amongst the most vulnerable communities.

² http://www.who.int/neglected_diseases/vector_ecology/ivm_concept/en/

The current WHO endorsed strategy for vector control is IVM (Integrated Vector Management)². This strategy proposes the logical use of integrated vector control in all countries, i.e. using a combination of vector control and individual protection tools and strategies designed to protect against the multiple VBDs transmitted in each geographical location. IVM, if well designed and delivered, can control one or more types of disease vector, and protect against single or multiple VBD risks far more effectively than the "one tool (i.e. the Long Lasting Insecticidal Net (LLIN) alone) fits all" approach, which has largely characterised the last decade of malaria control. IVM is also a vital strategy in controlling insect disease vectors in areas where insecticide resistance has compromised the efficacy of some vector control or personal protection tools.

This toolkit outlines the VBDs commonly encountered in humanitarian emergencies and recommends a range of IVM strategies for controlling them. The information provided is drawn from multiple sources, including an extensive literature review (published and grey data); consultation with NGOs, FBOs, World Health Organisation, UNICEF, UNHCR, and other United Nations agencies, Ministries of Health, and Universities; and a review of recent VBD control programmes in humanitarian crises. Some of these recent VBD control examples are outlined in case studies in the toolkit, to illustrate practical and effective IVM. The toolkit contains links to the tools that can be used for the different aspects of vector control in emergencies. There are links to useful templates and training information as well as tools to facilitate work in the field.

Key Reference Documents

- A toolkit for integrated vector management in sub-Saharan Africa (Steve Lindsey, 2016)
- Malaria control in humanitarian emergencies: an inter-agency field handbook – 2nd ed. (WHO, 2013)
<http://www.unhcr.org/456c11bd4.pdf>
- Refugee Health - An approach to emergency situations (Médecins Sans Frontières, 1997)
http://refbooks.msf.org/msf_docs/en/refugee_health/rh.pdf
- Handbook for integrated vector management (WHO, 2012)
http://apps.who.int/iris/bitstream/10665/44768/1/9789241502801_eng.pdf
- Conflict and Health (Conflict and Health (Understanding Public Health) (Egbert Sondorp and Natasha Howard, 2012)
- Disease Prevention Through Vector Control: Guidelines for relief organisations (Madeleine Thompson, 1995)
<http://policy-practice.oxfam.org.uk/publications/disease-prevention-through-vector-control-guidelines-for-relief-organisations-121159>
- Communicable disease control in emergencies: A field manual (WHO, 2005)
http://www.who.int/diseasecontrol_emergencies/publications/9241546166/en/
- World Malaria Report (WHO, 2015)
<http://www.who.int/malaria/publications/world-malaria-report-2015/report/en/>
- Global plan for insecticide resistance management in malaria vectors (GPIRM) (WHO, 2012)
http://www.who.int/iris/bitstream/10665/44846/1/9789241564472_eng.pdf
- Humanitarian Response (Office for Coordination of Humanitarian Affairs (OCHA), 2016)
<https://www.humanitarianresponse.info/en/home>
- WHO/WEDC Technical Notes on WASH in Emergencies (2013)
http://www.who.int/water_sanitation_health/publications/2011/technotes/en/

Case Studies

Case studies from **The MENTOR Initiative** operational experiences with collaborating NGOs, UN partners and local government partners demonstrate operational examples of IVM. These examples show the feasibility of implementing large-scale IVM activities in humanitarian response settings. The settings vary in geographical location, trigger event and scale. The background setting for each case study is important as it highlights the uniqueness of the environments in which the trigger event takes place. Case studies from the following crises are used:

Aceh, Indonesia - December 26, 2004, Indian Ocean earthquake and tsunami

Maban, South Sudan - December 2013, fighting between government and rebel forces

Yangon, Myanmar - May 2, 2008, Cyclone Nargis

Port au Prince, Haiti - January 12, 2010, Earthquake

1.

Introduction

Disasters can significantly alter the epidemiology of VBDs and the vulnerability of people to these diseases. This often results in an increase in transmission of diseases that are endemic to the area, and in some crises where populations are displaced, may potentially result in the introduction of a disease into an area where it was not previously endemic. Controlling the vectors of disease, or protecting humans from contact with the vectors, are priorities in emergencies, in order to reduce the risk of infection amongst vulnerable communities, high risk age groups or immunocompromised individuals, and protect them from disease. If done effectively, this can result in significant reduction of mortality and morbidity in emergencies³. However, making evidence-based decisions on the choice of vector control / protection tools and delivery strategies can be challenging in humanitarian crises.

³ http://apps.who.int/iris/bitstream/1/70485/10665/WHO_HSE_GAR_DCE_6_2010_eng.pdf

Integrated Vector Management (IVM)

Vector control in emergencies is often implemented in response to an outbreak or an emerging outbreak, with tools being selected to give an immediate impact, not necessarily resulting in long-term disease reduction. A classic example is reactive focal spraying (fogging) in response to dengue or Zika outbreaks.

The IVM approach is the World Health Organization (WHO) endorsed strategy for implementing VBD control. It is described as “the rational decision-making process for the optimal use of resources for vector control. The approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control.”⁴

⁴ http://www.who.int/neglected_diseases/vector_ecology/ivm_concept/en/

IVM aims to maximise resources to achieve the highest level of reduction of one or more vector-borne diseases. Humanitarian emergencies present unique environments in which to implement vector control using this approach and can allow best-fit strategies that are tailored for the specific setting, ensuring use of appropriate and effective tools.

In 2004, WHO published the Global Strategic Framework on IVM and in 2008 released a position statement on IVM to support the advance of the concept for vector-borne disease control, encouraging UN Member States to accelerate the preparation of their national policies and strategies. In 2012, a Handbook was published to assist countries in implementing IVM http://apps.who.int/iris/bitstream/10665/44768/1/9789241502801_eng.pdf.

In 2014, in partnership with WHO, a team from Durham University and The MENTOR Initiative committed to developing tools to assist partners working in developing countries and humanitarian crises, respectively, to plan and deliver effective IVM. Durham University’s current toolkit outlines experiences and challenges specific to the sub-Saharan African environment; further manuals on IVM in Asia and the Americas are planned. These manuals focus on country settings that are peaceful, stable, and have the operational and systems capacity needed to establish, sustain and monitor VBD at national programme level.

This Toolkit for IVM in Humanitarian Emergencies has been designed as a complimentary tool to the Durham University manual, but is designed to address IVM challenges and solutions for the unstable emergency contexts that result from natural disasters or man-made crises. These

settings present a constantly changing environment, where access to populations may be severely compromised, human resources, logistical, operational and health systems severely limited, and national co-ordination systems and programmes may be immobilised or severely weakened. In these settings, dependency upon international emergency partners and emergency donors to bolster disease control amongst the victims of the crisis is normal, and may persist for months or years.

Global Framework For IVM

The global framework for IVM requires the establishment of strategic principles. The key elements for successful implementation using IVM are:

Advocacy, social mobilisation, regulatory control for public health and empowerment of communities

Collaboration within the health sector and with other sectors through the optimal use of resources, planning, monitoring and decision-making

Integration of non-chemical and chemical vector control methods, and integration with other disease control measures

Evidence-based decision making guided by operational research and entomological and epidemiological surveillance and evaluation

Development of adequate human resources, training and career structures at national and local level to promote capacity building and manage IVM programmes

Further Reading

http://www.who.int/neglected_diseases/vector_ecology/ivm_concept/en/

Emergency Settings

Emergency settings require thorough situational analysis and evidence based disease control strategies to be developed to fit the epidemiological and operational context, and to target the priority disease risks identified. The principles of IVM can be upheld in an emergency response environment and are required for successful disease control, both in the immediate term, and in the longer term. Some emergencies become very protracted over a number of years, and cycle from acute phases to more stable phases, and intermittently may experience more acute events such as conflict, population displacement, breakdown of services, etc. It is therefore essential to implement a strategy that is tailored to the changing context over time, and which builds community ownership, and contributes to, and harmonises with, national strategies where ever possible.

Effective planning and coordination with international and national partners are especially important for humanitarian organisations as they often have limitations in the timeframe of funding availability, and competing priorities, which can hamper overall disease control coordination. Successful IVM implementation requires the leveraging of human resources and governmental ministries and departments, as well as working within the different clusters (sectors in a refugee crisis) of the humanitarian response system.

IVM strategies aim to incorporate several tools to control one or more vectors. In some cases, a single tool can control more than one disease. In humanitarian emergencies, budgetary restrictions, reduced human resources or increased priority on other diseases may affect the ability to prevent or control certain VBDs. However, if the principles of IVM are applied and followed, this will ensure that the most appropriate control strategies are put into place, and the greatest disease control impact is achieved.

1.1. Humanitarian Emergencies

⁵ <http://www.refworld.org/pdfid/46a9e29a2.pdf>

The United Nations High Commissioner for Refugees (UNHCR) describes humanitarian emergencies as “any situation in which the life or well-being of refugees will be threatened unless immediate and appropriate action is taken, and which demands an extraordinary response and exceptional measures”⁵.

There are different categories of humanitarian crises: natural disasters, man-made emergencies and complex emergencies. Natural disasters are classed as either biological, climate-related or geophysical; these include earthquakes, tsunamis, droughts and disease epidemics. Examples of man-made emergencies are armed conflict, plane crashes or bush fires. Complex emergencies usually have a combination of man-made and natural features, typically occurring in an already vulnerable population with poor health infrastructure both of which exacerbate the crisis, leading to a humanitarian crisis. Often, complex emergencies result in mass population displacement, creating large groupings of internally displaced people (IDPs) or refugees in temporary living conditions. Elevated mortality rates typically seen in the first phases of an emergency are due to increased exposure and vulnerability to diseases, poor access to effective healthcare⁶ and lack of access to effective means of disease prevention.

⁶ http://www3.med.unipmn.it/papers/2013/NEJM/-11-201307_nejm/nejmra1109877.pdf

Emergencies cause increased disease transmission because of multiple factors. Unmanaged surface water and poor sanitation conditions are perfect insect breeding sites and result in increased insect populations. Lack of shelter and inadequate shelter conditions, together with overcrowding result in increased transmission of disease and increased vulnerability to infection. Increased population movement can result in diseases spreading to new areas if a viable vector already exists. The vector can become infected by taking a blood meal from a person infected with disease. Humanitarian emergencies can be sudden, slow or chronic crises. The stability and relative resilience of the country prior to the triggering event for the crisis will determine how long recovery takes.

Health priorities in humanitarian emergencies

Controlling communicable diseases is one of the ten top priorities for organisations responding to emergency responses (Figure 1). Health priorities are determined through the rapid collection and analysis of health data. This is completed in the first few days of the trigger event, when the response begins (outlined in section 3). Background information can be gathered on potential diseases of risk. MoH data, reports of international and on the ground organisations (prior to the specific trigger event) can provide useful background on VBDs in the country. Necessary background information would include information on the population itself, the risk factors related to the main diseases of concern, and the requirements in terms of human and material resources for implementing disease control measures (including any identified existing capacity or stocks with national or international partners).

Figure 1: The ten top priorities (Refugee Health - An approach to emergency situations (Médecins Sans Frontières, 1997)) in emergencies are:

- 1. Initial Assessment**
- 2. Measles immunization**
- 3. Water and Sanitation**
- 4. Food and Nutrition**
- 5. Shelter and site planning**
- 6. Health care in the emergency phase**
- 7. Control of communicable diseases and epidemics**
- 8. Public Health Surveillance**

Further Reading

Malaria control in humanitarian emergencies: an inter-agency field handbook – 2nd ed. (WHO, 2013)
<http://www.unhcr.org/456c11bd4.pdf>

Refugee Health - An approach to emergency situations (Médecins Sans Frontières, 1997)
http://refbooks.msf.org/msf_docs/en/refugee_health/rh.pdf

Conflict and Health (Conflict and Health (Understanding Public Health) (Egbert Howard and Natasha Sondorp, 2012)

1.2. Diseases in Humanitarian Emergencies

During humanitarian emergencies, resulting stressors (i.e. lack of food and water, increased exposure to disease vectors, walking for days to reach safety) can weaken the body's natural defences. Infection and micronutrient deficiencies can induce immunodeficiency in otherwise healthy children, increasing susceptibility to diarrhoea, malaria and other infections. This leads to a cycle of repeated infections, reduced immunity, and deteriorating nutritional status in the affected population, especially in protracted emergencies.

Disease and death rates may be more acute amongst one type of community than they are amongst another, i.e. disproportionately affecting host communities, or refugees, or internally displaced populations. More than three-quarters of deaths in most humanitarian crises are attributed to communicable diseases. Emergencies exacerbate diseases in poorer communities as they have fewer resources to draw on to cope or recover from disasters, especially when emergencies take place in states that are fragile or in countries with chronic complex emergencies e.g. South Sudan, the Democratic Republic of Congo (DRC) and the Central African Republic (CAR).

In humanitarian emergencies, more people die from diseases and lack of health care provision than they do from armed conflict. In 2015, 11 countries had continuous severe humanitarian crises⁷, defined as level 3 by ACAPS (<http://www.acaps.org/>): Afghanistan, CAR, DRC, Iraq, Libya, Nigeria, Somalia, South Sudan, Sudan, Syria and Yemen. These countries are spread within a relatively small geographical area that also encompasses the regions with high burdens of infectious diseases, including VBDS⁸.

Following a trigger event such as an earthquake or conflict, humanitarian agencies should conduct a situation assessment prior to planning and launching an emergency response. This assessment will identify the likely diseases to which the population is vulnerable or likely to be exposed to, and when. Understanding the seasonality of endemic and epidemic-prone diseases is required to prepare for and control these diseases effectively⁹.

All communicable disease control responses should cover the stages outlined in the communicable disease control manual in emergencies by WHO:

Rapid assessments: these will identify disease threats facing the affected population as well as diseases with epidemic potential

Prevention activities: these will identify locations for vector control activities and implement them. Vector activities are across sectors, and implementation is across WASH, health, shelter and education.

⁷ http://www.acaps.org/sites/acaps/files/key-documents/files/geo_methodology_brief.pdf

⁸ <http://reliefweb.int/sites/reliefweb.int/files/resources/a-acaps-crisis-overview-2015-trends-and-risks2016-.pdf>

⁹ <http://www.ifrc.org/docs/idrl/I1036EN.pdf>

Surveillance: setting up or strengthening surveillance in order to determine prevalence of disease and monitor on-going changes in disease transmission. The system should be robust enough to detect outbreaks at an early stage of their evolution.

Outbreak control: in response to outbreak indicators, large scale prevention activities will be triggered in the relevant geographic area and supply chains and staff capacities reinforced in health facilities to cope with increased case loads .

Disease management: ensuring adequate technical capacity of staff and effective supply of essential commodities to provide diagnostic and case management services for vector-borne diseases.

Further Reading

Further information on each of the above sections is outlined in the WHO manual: Communicable disease control in emergencies: a field manual edited by M. A. Connolly (WHO, 2012). This also includes an annexe that has recommendations and examples of tools to use.

http://apps.who.int/iris/bitstream/10665/96340/1/9241546166_eng.pdf

1.2.1. Camp Planning for Displaced People – Preventing Vectors

Prevention of infectious diseases in emergencies begins with basic provisions. This includes good site planning for camps, shelter types, provision of clean water and proper sanitation, access to hygiene facilities, vaccination against specific diseases, sufficient and safe food supply, personal protection, community health education and social mobilisation.

Refugees and internally displaced people (IDP) fleeing conflict, and populations displaced through natural disasters, require temporary shelter. Needs assessment is an important aspect of determining what activities will be required and to what extent. Lead agencies should conduct water, sanitation, hygiene and health assessments in the early stages of a crisis response.

Site selection for sites can reduce risk factors for communicable disease transmission such as overcrowding, poor hygiene, vector breeding sites and lack of adequate shelter. Mass vaccination or mass drug administration early in the response may be appropriate to prevent some diseases (e.g. yellow fever, trachoma, measles, cholera and polio). Vector control needs can vary from a full-scale programme, targeting various vectors, to specific interventions such as fly control to reduce the spread of diarrhoeal diseases.

The different preventative measures and the diseases targeted are outlined here (Table 1).

Table 1: Disease prevention measures in refugee camp design and management. Taken from: Communicable disease control in emergencies: A field manual (WHO, 2005)

Preventative measure	Impact on spread of
Site planning	Diarrhoeal diseases, acute respiratory infections
Contained clean water	Diarrhoeal diseases, VBDs (malaria, dengue, yellow fever, chikungunya etc.), typhoid fever, guinea worm
Good sanitation and waste management	Diarrhoeal diseases, scabies, trachoma, leishmaniasis
Adequate nutrition	Tuberculosis, measles, acute respiratory infections
Vaccination	Measles, Meningitis, yellow fever, Japanese encephalitis, diphtheria

Vector control	Malaria, plague, dengue, leishmaniasis, Japanese encephalitis, yellow fever, others and viral haemorrhagic fevers
Personal Protection (insecticide-treated nets)	Malaria, leishmaniasis, lymphatic filariasis and others
Personal hygiene	louse-borne diseases: typhus, relapsing fever, trench fever, scabies, and other skin diseases
Health Education	sexually transmitted diseases, HIV/AIDS, diarrhoeal diseases, VBDs

Avoid vector-breeding sites when building settlements, when possible. Settlements should be on a gentle slope to allow good drainage in case of flooding. Local expertise and knowledge of the biology of the vectors should be reviewed. If this data is not available or not routinely documented by national and local health or related services, the initial assessment will determine epidemiological characteristics of the area.

Further Reading

For more on shelter and settlement planning see:

<http://www.spherehandbook.org/en/shelter-and-settlement-standard-1-strategic-planning/>

1.3. WASH and Waste Disposal Planning

Domestic waste and human and animal excreta may all act as breeding sites for domestic and filth flies which can transmit 26 enteric agents of diarrhoea. Domestic and animal housing waste also serve as breeding sites for sandflies in many crisis settings, increasing transmission of leishmaniasis, where endemic. If solid waste is not properly disposed of, it acts as a breeding site for cockroaches and rats as well as flies. Cockroaches, like flies, are mechanical vectors of bacteria, viruses and some nematode worms. Depending on the location, rats may transmit haemorrhagic viral disease to humans directly through contact with their urine and faeces. They also carry fleas that may, in turn, transmit diseases such as plague. Inadequate waste management will lead to an increase in the spread of VBDs within camps and other communities, as well as increasing the general irritation and nuisance such pests cause camp residents. Sullage, the water waste produced from everyday activities such as bathing, laundry and food preparation, must be drained away from refugee camps or households, as it is an attractant to flies and some mosquitoes and it can contaminate drinking water supplies. Sullage also provides a perfect breeding ground for culex mosquitoes, the vectors of lymphatic filariasis, Japanese encephalitis, and other vector-borne diseases.

A larger overview and tools for waste management in humanitarian emergencies are outlined in the technical notes by WHO (2011, updated 2013)

http://www.who.int/water_sanitation_health/publications/2011/technotes/en/

A field manual on Excreta Disposal in Emergencies An Inter-Agency Publication (Peter Harvey, 2007)

http://wedc.lboro.ac.uk/resources/books/Excreta_Disposal_in_Emergencies_-_Complete.pdf

Sphere Standards, WASH needs assessment

<http://www.spherehandbook.org/en/appendix-8/>

Sphere standards for WASH activities

<http://www.spherehandbook.org/en/how-to-use-this-chapter-1/>

1.4. Global Overview of Vector-Borne Diseases

Vectors are the living organisms that can transmit infectious diseases between humans or from animals to humans. Mosquitoes are the most common disease-transmitting biological vector. Biological vectors carry disease organisms internally, acting as host for part of the life cycle of the organism (bacteria, virus or parasite). However, other insect vectors, including ticks, sandflies and triatomine bugs, are biological vectors for specific diseases. Flies and cockroaches act as mechanical vectors, transmitting bacteria, viruses, parasites and nematode worms, by carrying infective human or animal excreta / waste on their legs or mouth parts, and depositing it onto food supplies. Insects are not the only disease vectors though, as rodents, bats and even some wild animals (bush meat) may carry viruses that can be transmitted to humans either through contact with their urine/faeces or body fluids (i.e. when bush meat is butchered). Perhaps the most unusual vectors are the snail species that carry the parasitic worm that causes schistosomiasis (liver fluke).

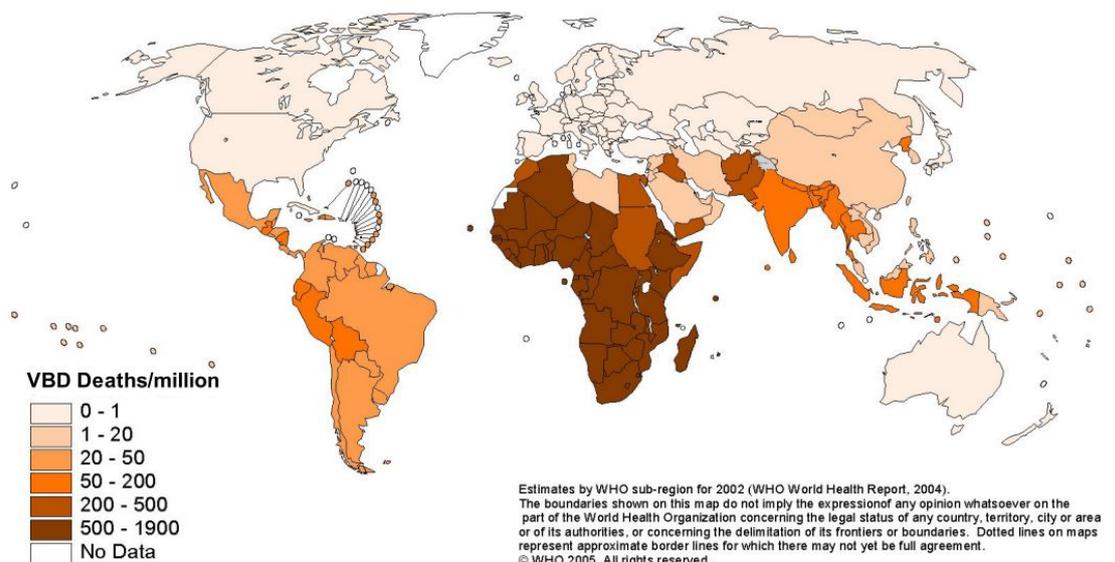
¹⁰ <http://www.who.int/mediacentre/factsheets/fs387/en/>

¹¹ <http://www.unhcr.org/456c11bd4.pdf>

Globally, there are over one billion cases and over one million deaths annually from VBDs¹⁰. Globally, VBDs account for over 17% of all infectious diseases¹¹. Populations displaced by conflict or other crises, and those trapped and isolated in villages cut off by long term conflicts, are normally the most vulnerable to VBDs, and have the poorest access to preventative and curative services. Malaria is endemic in more than 80% of areas affected by humanitarian emergencies, and dengue fever is rapidly spreading across the same areas. Distribution of other major VBDs varies, with some found in more contained geographical areas. All humanitarian emergencies are affected by VBDs to some extent, even those that occur on the European continent. Vector control and VBD prevention is essential in all humanitarian crises in order to help reduce morbidity and mortality, and maintain these at acceptable levels.

Deaths from vector-borne disease

Figure 2: Deaths from vector-borne diseases (WHO – World Health Report). Taken from - Health and Environment Linkages Initiative, Vector-borne diseases <http://www.who.int/heli/risks/vectors/vector/en/>



The distribution of VBDs is determined by a dynamic between environmental and social factors and can vary considerably depending on when and where the humanitarian emergency takes place. Figure 2 shows the distribution of VBD deaths with the highest burden being in Africa, the Middle East, Asia and Southern America.

The regions that experience the highest burden of VBDs are also the poorest and thus do not have the infrastructure or resources in place to prevent disease and deaths through strong vector control programmes and case management.

Depending on the geographical location and type of emergency, the population may be at risk of several VBDs. The emergency can alter the environment such that the population is more at risk of being exposed to disease vectors. For example, after a tsunami, destroyed housing and flooding may result in increased surface and open container water, leading to increased vector breeding sites, a rapid expansion of *anopheles* and *aedes* mosquitoes; outbreaks of malaria, dengue fever, chikungunya and yellow fever may follow within a few weeks. Identifying these risks at the outset of an emergency, is key to ensuring the most effective IVM strategy to mitigate against the VBD risks.

Integrated vector control activities should be evidence-based, and designed and implemented with relevant ministries to ensure overall integration into national policy and strategy. Capacity building of national partners at all levels should be a core component of international emergency responses to ensure both the maximum impact in the short term and longer-term sustainability where ever feasible.

This section outlines the main vectors that spread vector-borne diseases and looks at important aspects to consider for a vector control strategy in an emergency. More information on the epidemiology, clinical presentation and case management can be found on the World Health Organisation page <http://www.who.int/mediacentre/factsheets/fs387/en/>.

Vector control tools target different life stages of the vector. Using a combination of tools that target different stages of the vectors life cycle is likely to increase the impact of the programme on disease transmission. This is one of the main principles of IVM: targeting disease vectors from several angles to ensure sustained control of the vector, and to help combat challenges that factors such as human behaviour, insect behaviour changes, and reduced insecticide efficacy pose to control. These sorts of challenges can be impossible to overcome if attempting to control a VBD with single intervention programmes.

1.5. Disease Vectors, Associated Diseases And Major Strategies For Control

1.5.1. Mosquitoes

Vector Behaviour

Both sexes feed on plant juices and sugary solutions

Adult female mosquitoes require a blood meal in order to produce eggs

Females can live up to about a month and after their first 10-14 days, may take blood feeds every two or three nights.

Can feed on human, cattle and other domestic animals. Preference depends on species

Different mosquito species bite indoors or outdoors

Different mosquito species are day biting or night biting

Different mosquitoes may peak in different seasons

Some species lay their eggs in either clean surface water, others in clean containerised water, others in waste or polluted water.

Mosquito Vector Control Targets

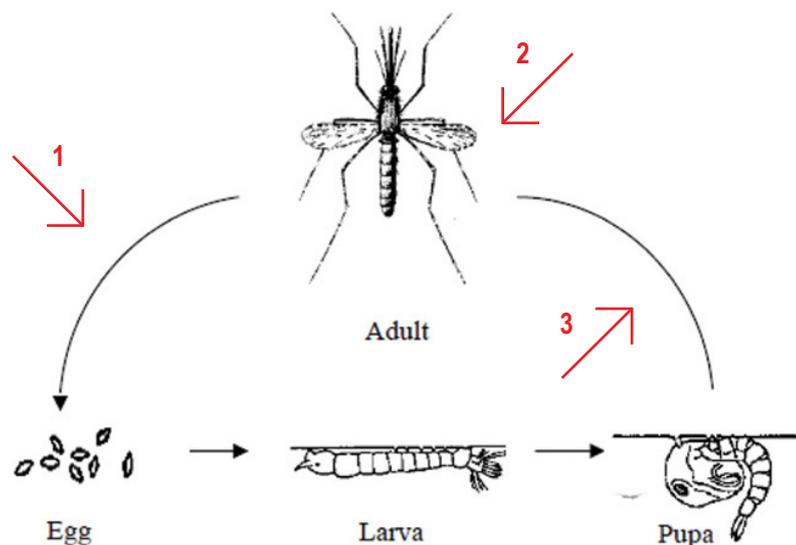


Figure 3: Malaria life cycle and vector control targets presented – modified from http://www.open.edu/openlearnworks/pluginfile.php/4555/mod_oucontent/oucontent/54/none/none/comms_dis_session5_fig6.jpg

Methods that prevent the female mosquitoes from laying eggs. Mechanical methods that prevent contact with the surface on which insects preferentially lay their eggs such as use of covers/lids on water containers, or polystyrene beads on top of latrine waste fluid, will prevent various mosquitoes and flies from laying eggs. Other methods involve rubbish clearance and larval source management: discarding containers that collect water and can thus provide breeding sites, and regularly emptying drinking water storage containers that are required for day-to-day use.

Methods that kill or prevent the adult vector from biting. Indoor Residual Spraying (IRS), insecticide-treated plastic sheeting, and insecticide treated wall linings kill adult insects (e.g. malaria mosquitoes and sandflies) that rest on the inside walls of houses, during the day or night. Fogging kills daytime biting adult insects while they are flying or resting outdoors (e.g. dengue mosquitoes, or sandflies). Personal protective measures, such as LLIN kill adult insects that attempt to bite people sleeping under them at night, or the insecticide which LLIN are treated with, acts as a repellent and helps to deter insects from biting. Household modifications such as window, eave and door screens or curtains help to reduce entry of mosquitoes, sandflies and domestic flies, and are more effective if treated with insecticides.

Methods that stop larval development. Chemical or biological methods can be used to prevent or stop larval growth in breeding sites. Larviciding water used as breeding sites, or adding larvivorous fish into water storage containers and ponds, effectively prevent vectors from completing their development cycle and help to reduce the viable vector populations. When combined with methods to kill adult vectors or to prevent vector human biting contact, disease transmission can be even more effectively reduced (2)

Anopheles:

Malaria (*Plasmodium falciparum*, *P. ovale*, *P. vivax*, *P. malariae*)

Lymphatic filariasis (*W. bancrofti* parasitic roundworm)



Figure 4:
https://commons.wikimedia.org/wiki/File:Anopheles_albimanus_mosquito.jpg

¹² <https://www.cdc.gov/malaria/about/biology/mosquitoes/>

Anopheles Vector Behaviour¹²

There are approximately 3,500 species of mosquitoes grouped into 41 genera. Human malaria is transmitted only by females of the genus *Anopheles*. Of the approximately 430 *Anopheles* species, only 30-40 transmit malaria.

Anopheles female mosquitoes lay eggs in diverse open surface water sources. From clean, slow-moving water including fresh water and brackish water, to ground pools, small streams, irrigated lands, freshwater marshes and forest pools.

Adult females lay up to 200 eggs at a time, singly and directly onto the water's surface. Eggs hatch within 2-3 days, develop through immature larval and pupal stages over several days, and then emerge from the water as viable adult mosquitoes.

The primary malaria vectors in Africa are *An. Gambiae*, *An. Arabiensis* and *An. Funestus*. The vectors are very anthropophilic and thus are highly efficient vectors.

Anopheles can fly up to 2km to find a host. For this reason, vector control activities designed to control breeding sites must target all breeding sites within a 2km radius.

The *Anopheles* vector may be present during the dry season when other mosquito populations are low.

Anopheles mosquitoes locate humans at night, through detection of their natural body odour, mixed with CO₂ breathed out. Pregnant women release more pheromones, and may be more attractive to mosquitoes and are at even greater risk of being bitten and infected, than when non pregnant.

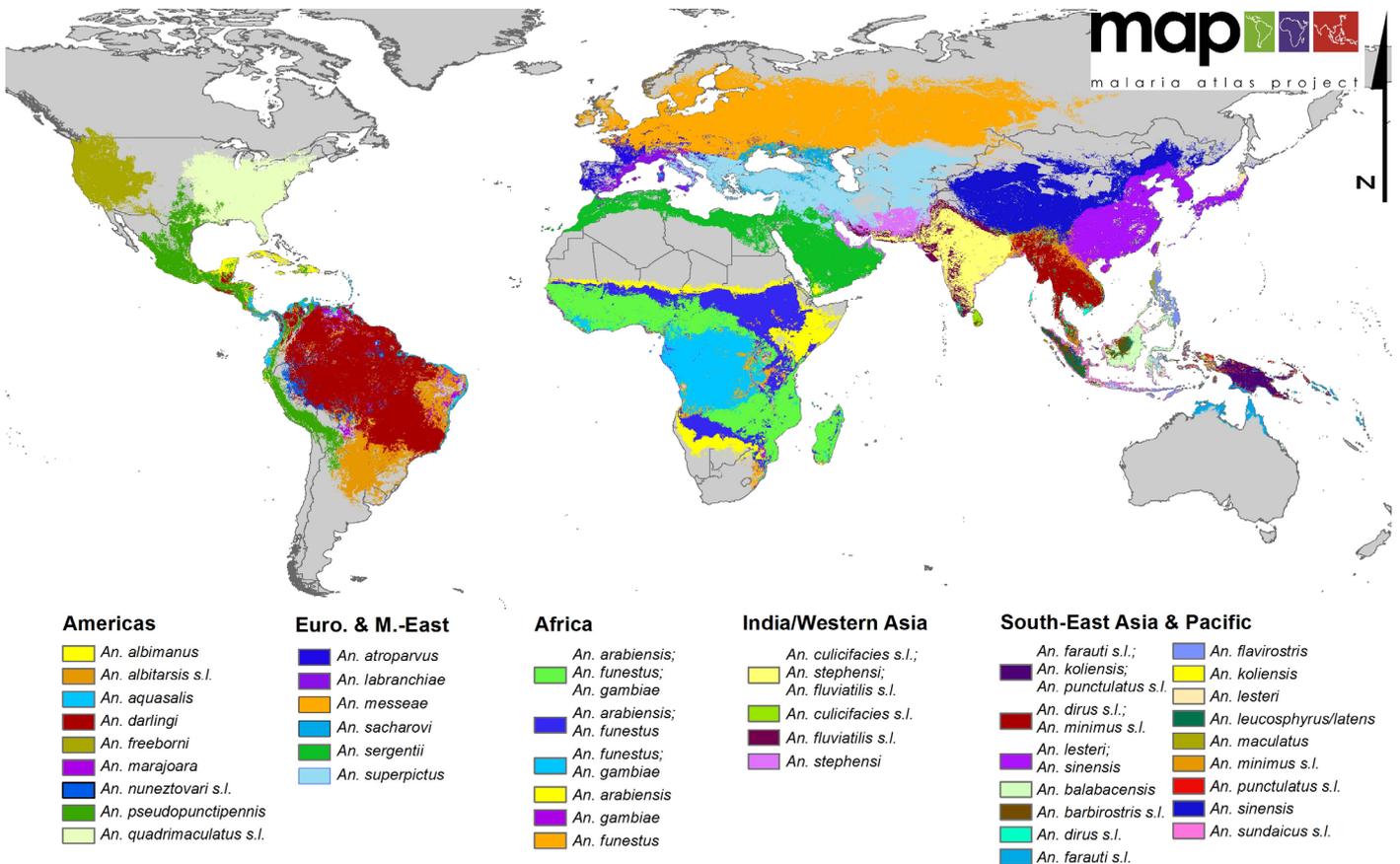


Figure 4: Geographical distribution of anopheles vectors Sinka et al 2012 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3349467/>

Geographical Variation in Dominant *Anopheles* Species

Each species will have a different preference for breeding sites. Correct identification of any vector implicated in disease transmission is key to successful control.

Disease agents

Malaria

Malaria is a parasitic disease caused by protozoan parasites of the genus *Plasmodium*. Only four plasmodium species develop in humans: *P.falciparum* (causing the life-threatening form of malaria), *P.vivax*, *P. ovale* and *P. malariae*. Of these, only *P.vivax* and *P. ovale* have persistent liver forms that may lead to relapses after the initial blood infection has been cured.

P.falciparum and *P.vivax* are the main species of public health importance. *P.falciparum* is found most in the tropics and subtropics. 80–90% of malaria cases in sub-Saharan African countries are due to *P.falciparum*. In 2015, the sub-Saharan region was home to 88% of malaria cases and 90% of the global annual malaria deaths.

Lymphatic filariasis

1.10 billion people in 55 countries are living in areas that require preventive chemotherapy to stop the spread of infection.

Lymphatic filariasis is caused by nematodes parasites, also known as roundworms, of the family Filariodidea. There are 3 types of these filarial worms: *Wuchereria bancrofti*, responsible for 90% of the cases, *Brugia malayi*, causing most of the remainder, and *Brugia timori*.

Adult worms lodge in the lymphatic system and disrupt the immune system. When lymphatic filariasis develops into chronic conditions, it leads to lymphoedema (tissue swelling) or elephantiasis (skin/tissue thickening) of limbs and hydrocele (scrotal swelling)¹³.

Vector Control And Prevention

Anopheles biting habits illustrate why LLINs (see LLIN implementation 5.4) have been such an important tool for reducing malaria transmission. *Anopheles* mosquitoes bite between dusk and dawn while people are sleeping and mainly indoors (endophagic). After feeding, they will rest indoors or outdoors depending on the species. IRS is also a very effective tool as it kills the adult vectors while they are resting on walls before and after feeding; IRS does not require a behaviour change and cannot be repurposed or sold, with the ease that LLIN often are. Both these strategies target the adult vector as outlined (2) on figure 3.

IRS protects the whole community if >80% of households in any targeted community are sprayed, by decreasing the overall vector population. Spraying an individual home without spraying most of the community will not protect that individual household from malaria (IRS implementation chapter 5.2) as each household requires its surrounding households to be sprayed, in order to reduce the number of viable adult vectors from reaching it. Mosquitoes will sometimes be killed even within the incubation period of the malaria parasite. Insecticide treated plastic shelters (ITPS) and insecticide treated wall linings and curtains, act in the same way as IRS to protect communities.

Larviciding open surface water breeding sites, or their physical adjustment, where they are few, well defined, accessible and small enough to effectively treat, can sometimes also add to control of anopheline mosquitoes. However, this tends to only be a consideration in semi-arid areas where breeding sites may be few, fixed and findable (see 5.5.). Larviciding is generally less feasible in areas with high vegetation and heavy rainfall, where breeding sites are too numerous.

Using a combination of these prevention tools to target different life cycle stages and behaviours of the *anopheles* mosquito should further decrease the populations and therefore disease transmission. This is the main principle of IVM: targeting one disease or multiple diseases from several angles to ensure effective and sustained reduction of the vector and disease. However, there should be a clear rationale for the combination of tools chosen, in each case.

Aedes:

Zika (Zika Virus)

Chikungunya (Chikungunya Virus)

Dengue Fever (Dengue Virus SER-1, SER-2, SER-3, SER-4)

Rift Valley Fever (Rift Valley Fever Virus)

Yellow Fever (Yellow Fever Virus)

Lymphatic Filariasis (*W. bancrofti* parasitic roundworm)

Figure 6: *Aedes Aegypti*. Source <http://www.bbc.co.uk/news/health35427491->



***Aedes* Vector Behavior**

Aedes mosquitoes are very adaptable to changing environments and like to live in close contact with humans.

They thrive in poor, crowded living environments where there is no piped water, where household's reliance is on the use of water storage containers, and where waste removal systems are inadequate. This makes them a very important transmitter of disease in poor urban settings both when stable or affected by natural disasters.

Aedes aegypti are the primary vectors of Zika, dengue, chikungunya, and yellow fever, though *Aedes albopictus* is also known to transmit dengue fever, and may potentially be able to transmit other diseases.

Aedes aegypti bite primarily during the day. This species is most active for approximately two hours after sunrise and several hours before sunset, but can also bite at night in well-lit areas. This mosquito can bite people without being noticed as they approach from behind and bite on the ankles and elbows. They tend to be nervous biters, taking several short blood meals from several different sources.

In areas where *aedes*-borne diseases are endemic, populations caught up in humanitarian emergencies are particularly vulnerable.

Aedes mosquitoes lay eggs in water containers such as waste tyres, flowerpots and rubbish cans. They also breed in any natural objects that can hold water such as tree holes.

Aedes can also lay eggs in flood plains and flooded irrigation systems, when these conditions occur, which can be the case after natural disasters.

Aedes female mosquitoes lay around 150 eggs per batch. Unlike most species, these are laid separately. These eggs are resistant to drying and can survive very long periods, often more than a year, making control of the mosquito very difficult.

Disease Agents

Viral Haemorrhagic Fevers

Various acute viral haemorrhagic diseases are transmitted by infected mosquitoes. These are Rift Valley fever (Africa, Arabic peninsula), dengue (Asia, Africa, Pacific, Americas), yellow fever (Africa, tropical Americas) and Zika virus (Americas, Africa, Asia).

More than 2.5 billion people in over 100 countries are at risk of contracting dengue.

Yellow Fever is vaccine preventable. Dengue vaccine is registered in endemic countries¹⁴.

Differential diagnosis of Zika, dengue and chikungunya fever remains challenging as it is based on clinical symptoms and co-infection can occur¹⁵. Mild cases of yellow fever are clinically indistinguishable from other febrile illnesses but severe cases are characterized by jaundice.

Lymphatic filariasis

1.10 billion people in 55 countries are living in areas that require preventive chemotherapy to stop the spread of infection.

Lymphatic filariasis is caused by nematodes parasites also known as roundworms, of the family Filariodidea. There are 3 types of these filarial worms: *Wuchereria bancrofti*, responsible for 90% of the cases, *Brugia malayi*, causing most of the remainder and *Brugia timori*.

Adult worms lodge in the lymphatic system and disrupt the immune system. When lymphatic filariasis develops into chronic conditions, it leads to lymphedema (tissue swelling) or elephantiasis (skin/tissue thickening) of limbs and hydrocele (scrotal swelling)¹⁶.

Vector control and prevention

Vector populations can be reduced at community level if all households participate regularly in: manual emptying and cleaning of water storage containers, keeping lids on water containers that cannot be emptied, or larviciding water. This method of source reduction or environmental modification/rubbish clearance targets stage (1) by preventing the female mosquito from laying eggs and stage (2) by preventing eggs or larvae already present in the water source to develop into adult mosquitoes. Waste management is an important aspect of *aedes*-borne disease control, to remove all waste containers that otherwise hold water and act as breeding sites.

Wearing long-sleeved shirts, long trousers and socks, and applying insect repellent (DEET (N,N-diethylmetatoluamide) to exposed skin and under the ends of sleeves and trouser legs will help to prevent sandflies biting.

Further Reading

<http://publichealth.valentbiosciences.com/public-health/insects/mosquitoes/aedes>
<http://www.cdc.gov/zika/pdfs/VectorControlAedesMosquitoes.pdf>

¹⁴ http://www.who.int/immunization/research/development/dengue_vaccines/en/

¹⁵ http://ecdc.europa.eu/en/healthtopics/zika_virus_infection/factsheet-health-professionals/Pages/factsheet_health_professionals.aspx

¹⁶ <http://www.who.int/mediacentre/factsheets/fs102/en/>

Culex:

Japanese Encephalitis

West Nile Fever

Lymphatic Filariasis (B. malayi and B. timori parasitic roundworms)

Figure 7: Culex mosquito image-
<http://vectorie.eu/menuitem/vector-biology/>



Culex mosquitoes breed in various types of stagnant, polluted ground water that is rich in organic material: surface water habitats such as sewage systems, container sources and drainage systems. This can also include swamps and man-made water sources such as waste tyres, drink containers, jars and buckets.

Culex mosquitoes are painful and persistent biters that prefer to bite between dusk and dawn, and readily enter houses for blood meals, although they feed both indoors and outdoors.

Culex mosquitoes usually lay their eggs at night. They lay them one at a time on water surface, sticking them together to form a raft of around 150 eggs, 0.7mm long

Further Reading

<http://publichealth.valentbiosciences.com/public-health/insects/mosquitoes/aedes>

<http://www.cdc.gov/zika/pdfs/VectorControlAedesMosquitoes.pdf>

Disease Agents

Lymphatic filariasis

1.10 billion people in 55 countries are living in areas that require preventive chemotherapy to stop the spread of infection.

Lymphatic filariasis is caused by nematodes parasites, also known as roundworms, of the family Filariodidea. There are 3 types of these filarial worms: Wuchereria bancrofti, responsible for 90% of the cases, Brugia malayi, causing most of the remainder and Brugia timori.

¹⁷ <http://www.who.int/mediacentre/factsheets/fs102/en/>

<http://www.who.int/mediacentre/factsheets/fs386/en/>

Adult worms lodge in the lymphatic system and disrupt the immune system. When lymphatic filariasis develops into chronic conditions, it leads to lymphedema (tissue swelling) or elephantiasis (skin/tissue thickening) of limbs and hydrocele (scrotal swelling)¹⁷.

Japanese Encephalitis

Japanese encephalitis (JE) is an acute inflammatory disease caused by a flavivirus. The infection affects the brain, spinal cord and meninges. Less than 1% of human infections present clinically, but case fatality rate among those who present with clinical disease is 25–50%.

24 countries in the WHO South-East Asia and Western Pacific regions have endemic JE transmission, exposing more than 3 billion people to risks of infection.

JE is vaccine preventable.

West Nile Fever

West Nile fever is caused by the West Nile Virus (WNV) and can cause a fatal neurological disease in humans.

80% of people who are infected do not show any symptoms.

WNV is commonly found in Africa, Europe, the Middle East, North America and West Asia

The virus can cause severe disease and death in horses; a vaccine is available for horses but not yet for people.

West Nile Virus (WNV) is a member of the flavivirus genus, the same genus as Japanese Encephalitis.

Only 20% of those infected with WNV develop fever; an estimated 1 in 150 of those who are infected with WNV develop severe disease.

Vector control and prevention

Environmental modification to reduce vector burden by removing breeding sites for culex mosquitoes around the home (1), (2).

As the culex mosquitoes bite between dusk and dawn, LLIN can be used effectively to reduce vector burden.

Indoor residual spraying is a common tool for vector control of mosquito borne diseases targeting the adult flies. IRS is a successful method to reducing vector burden as it kills mosquitoes resting on inside walls normally following feeding.

Improved sanitation can also reduce vector burden by targeting stage (2) on the malaria life cycle in figure 4. Personal protective measures including wearing long sleeves and trousers, and using mosquito repellent on exposed skin will also target stage (2).

1.5.1 Sandflies

Sandflies:

Leishmaniasis

Sandfly Fever (Phelebotomus Fever)

Figure 8: A *Phlebotomus papatasi* sand fly image. Public domain photo by James Gathany, via CDC



Vector Behaviour

Sandflies breed and rest in cool, moist environments. Sandfly larvae can be found in rubbish sites, animal shelters and human housing, particularly in cracks in walls.

Sandflies eggs require a humid environment for development and larvae need a cool, moist habitat with decaying rubbish or matter. Adult sandflies often rest during the day in the same places in which they breed.

Sandflies survive in dry environments by withdrawing to cool, humid resting sites during the day, only becoming active at night when temperatures drop and humidity increases.

The female sandfly can cover a radius of several 100 meters, however, the feeding activity will be influenced by the temperature, humidity and air movement of the environment. Sandflies are weak fliers. Light wind can inhibit flight and reduce biting.

Disease Agents

The Leishmaniasis are currently prevalent on all continents except Australia and Antarctica, and are considered to be endemic in 88 countries, 72 of which are developing countries.

- 90% of visceral leishmaniasis cases occur in Bangladesh, Brazil, Ethiopia, India, South Sudan and Sudan.
 - 90% of mucocutaneous Leishmaniasis cases occur in Bolivia, Brazil and Peru.
 - 90% of cutaneous leishmaniasis cases occur in Afghanistan, Syria, Iran, Saudi Arabia, Brazil, and Peru.
-

Humanitarian emergencies occurring in these areas would be at great risk of epidemics or outbreaks and surveillance should aim to capture this when being set up.

WHO Leishmaniasis Fact Sheet (WHO, 2016)

Controlling communicable diseases in humanitarian emergencies (WHO, 2005)

Epidemics are linked to human migrations from rural to poor suburban areas and to environmental changes that can take place after trigger events such as natural disasters and conflict. Mass destruction of urban environments during conflicts created epidemics of cutaneous leishmaniasis in Kabul, Afghanistan in the 1990s, and has resulted in an epidemic across northern Syria since 2013. The associated movement of non-immune people to transmission areas can result in epidemics. There have been severe epidemics of visceral leishmaniasis among refugees and IDP in recent years, notably in Sudan.

Vector control and prevention

Control of sandflies is essential during leishmaniasis epidemics. The main tools for prevention should be IRS for urban settings, LLIN and Long lasting insecticidal curtains (LLIC) for non-urban households, and in both cases, these should ideally be combined with environmental / waste management. Health promotion and appropriate targeted Information Education Communication (IEC) should be delivered as part of the IVM package to enhance uptake and correct usage of the IVM tools and strategies amongst the target communities.

Encouraging people to wear long-sleeved shirts, long trousers (or the equivalent) and socks, and to apply insect repellent (DEET (N, N-diethylmetatoluamide) to exposed skin and under the ends of sleeves and trouser legs will also reduce sandfly bites, and can be included in IEC messages to the population, but is not an alternative to the main IVM tools.

IRS is an effective method for reducing the sandfly burden and disease transmission in urban communities, targeting adult vectors that rest on walls or in humid corners of houses and animal shelters.

Insecticide treated curtains prevent sandflies entering households and kill those that do enter.

Sandflies are much smaller than mosquitoes and small mesh LLINs are therefore recommended when used for leishmaniasis prevention, and in areas where people are at risk from both leishmaniasis and malaria. LLINs provide individual protection for those sleeping under them every night.

Waste management is another important part of sandfly vector control: regular removal of domestic waste from urban areas to well managed waste management areas, sited no closer than 400 meters from the nearest housing areas, will also reduce the vector burden.

Animal reservoir control is appropriate in some settings: leishmaniasis infects dogs and other small animals which then act as reservoirs of infection. Culling or treating animals with insecticidal collars may reduce transmission.

Chemical larviciding of natural breeding habitats in some countries may be challenging, and finding all breeding sites can be difficult. In many African settings, adult sandflies often live in rock crevices, caves, rodent burrows, cracks in tree bark etc. that are cool, dark and humid. Both rodent burrows and peri-domestic areas provide access to blood meals as well as shelter.

The waste management section in section 1.6. outlines the criteria for waste management and the activities that can be carried out.

Further Reading

<http://ecdc.europa.eu/en/healthtopics/vectors/sanflies/Pages/sandflies.aspx#sthash.mThlFe5i.dpuf>
http://apps.who.int/iris/bitstream/10665/44412/1/WHO_TRS_949_eng.pdf?ua=1

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4191944/>

1.5.3. Ticks

Ticks:

Crimean-Congo-Fever

Lyme Disease

Relapsing Fever (Borreliosis)

Tick-borne Encephalitis

Tularaemia

Figure 9: Tick image - Source
CDC <https://www.cdc.gov/vhf/crimean-congo/images/tick2.jpg>



Vector behaviour

Ticks live on livestock which can be treated with insecticides to deter or kill ticks. There are families of ticks: the Ixodidae (hard ticks), and Argasidae (soft ticks). Both are important vectors of disease-causing agents to humans and animals throughout the world, including bacteria, rickettsiae, protozoa, and viruses¹⁸.

Most people are infected through the bites of immature ticks called nymphs; these are less than 2 mm in length and difficult to see. Nymph stages feed during the spring and summer months whereas the adult ticks are most active in the cooler months of the year. Ticks cannot fly or jump; instead, they wait for a host, resting on the tips of grasses and shrubs in a position known as «questing». While questing, ticks hold onto leaves and grass by their lower legs then hold their upper pair of legs outstretched, waiting to climb onto a passing host. They quickly attach to the host and find a suitable place to bite. Ticks can attach to any part of the human body but often migrate to hard-to-see areas such as the groin, armpits, and scalp¹⁹.

¹⁸ http://entomology.ucdavis.edu/Faculty/Robert_B_Kimsey/Kimsey_Research/Tick_Biology/

¹⁹ <https://www.cdc.gov/lyme/transmission/index.html>

Disease Agents

Crimean-Congo Fever

The Crimean-Congo haemorrhagic fever (CCHF) virus causes viral haemorrhagic fever, with a case fatality rate of between 10- 40%. CCHF is endemic in Africa, the Balkans, the Middle East and Asia, countries south of the 50th parallel north which is the geographical limit of the tick vector. The virus is primarily transmitted to people from ticks and livestock animals. Human-to-human transmission can occur resulting from close contact with the blood, secretions, organs or other bodily fluids of infected persons²⁰.

²⁰ <http://www.who.int/mediacentre/factsheets/fs208/en/>

Lyme Disease

Lyme disease is caused by the bacterium *Borrelia burgdorferi* and is transmitted to humans through the bite of infected blacklegged ticks. Lyme disease is a common disease spread by ticks in the northern hemisphere and is estimated to affect 300,000 people a year in the United States and 65,000 people a year in Europe. Infections are most common in the spring and early summer.

Relapsing Fever (Borreliosis)

Vector-borne disease caused by infection with bacteria in the genus *Borrelia* and transmitted through the bite of a tick or louse. Tick-borne relapsing fever is found primarily in Africa, Spain, Saudi Arabia, Asia, and certain areas of Canada and western United States. Rodents can also be infected by ticks and serve as reservoirs for some *Borrelia* species. People who are infected develop sickness between 5-15 days after they have been bitten. With treatment, the mortality rate for humans with Tick-borne relapsing fever is about 1%. However, without treatment mortality rates range from 30 to 70%.

Tick-borne Encephalitis (TBE)

Viral infection spread to humans by the bite of a tick. Approximately one in 100 cases of TBE are fatal. Infected ticks are mainly found in the rural areas of central, northern and eastern Europe. There are also two sub-types of TBE which can be found in eastern Russia as well as some countries in East Asia, in particular forested regions of China and Japan. The World Health Organization (WHO) estimates that between 10,000 and 12,000 cases of TBE are reported worldwide each year.

²¹ <http://www.nhs.uk/conditions/Tick-borne-encephalitis/Pages/Introduction.aspx>

Tularaemia

Tularaemia is caused by the bacterium *Francisella tularensis*. The bacterium is capable of surviving for weeks at low temperatures in water, moist soil, hay, straw or animal carcasses. Rabbits, hares, squirrels, foxes and ticks can carry the bacterium and act as reservoirs of infection. Human infection can occur through different mechanisms, however, most importantly through the bite of infected ticks (as well as mosquitoes and flies)²².

²² <http://ecdc.europa.eu/en/healthtopics/Tularaemia/Pages/index.aspx>

Further Reading

<http://www.who.int/mediacentre/factsheets/fs208/en/>

1.5.4 Triatomine bugs

Triatomine bugs:

Chagas Disease (American Trypanosomiasis)

Vector Behaviour

Figure 10: Triatomine or kissing bug image - source Wikimedia Commons



Vector Behaviour

Triatomine bugs, also known as the kissing bug, typically live in the wall or roof cracks of poorly-constructed homes in rural or suburban areas. They tend to hide during the day and become active at night when they feed on human blood.

The parasite is transmitted into humans by contact with the faeces or urine of the bug, left on the skin whilst the blood sucking bug is taking a blood meal. The parasites then enter the body when the bitten person instinctively smears the bug faeces or urine into the bite, the eyes, the mouth, or into any skin break.

Disease Agent

About six to seven million people worldwide, but mostly in Latin America, are estimated to be infected with *Trypanosoma cruzi*, the parasite that causes Chagas disease annually.

Chagas disease is mainly in endemic areas of 21 Latin American countries.

30% of chronically infected people develop cardiac changes whilst 10% may develop digestive, neurological or mixed alterations which may require specific treatment.

Vector Control

Spraying of houses and surrounding areas with residual insecticides (IRS).

House improvements to prevent vector infestation.

Personal preventive measures such as LLIN.

Good hygiene practices in food preparation, transportation, storage and consumption

Further Reading

<http://www.who.int/mediacentre/factsheets/fs340/en/>

1.5.5. Tsetse flies

Tsetse flies:

Human African Trypanosomiasis/Sleeping Sickness/ HAT
(*Trypanosoma brucei gambiense* and *Trypanosoma brucei rhodesiense*)

Figure 11: Tsetse fly image.
- <http://www.bitinfos.com/wp-content/uploads/06/2014/Tsetse-fly.jpg>



Vector Behaviour

The tsetse fly (*Glossina* species) inhabits rural areas and bites during daytime hours. Unlike some vectors, such as mosquitoes, both male and female flies are capable of carrying and transmitting the disease when they can detect their host.

Disease Agent

Tsetse flies are infected with the trypanosomiasis *T.b. gambiense* and *T.b. rhodesiense* which cause sleeping sickness (human trypanosomiasis) when tsetse flies bite and pass on the trypanosomes. *T. b. brucei* species only infects cattle and other large animals. The gambiense form normally infects humans and is rarely isolated in animals, whilst the rhodienese affects human and animals.

Cases of HAT have been seen to occur significantly more often in countries where there is conflict or population displacement. Figure 5 shows the distribution of trypanosomiasis risk on the African continent and demonstrates the correlation risk and the causal factors.

Population displacement increases transmission and the migration causes trypanosomes to circulate from high-incidence to low-incidence areas. As well as this, conflicts cause breakdown of control measures and surveillance, increasing the spread of disease.

Figure 12: Sleeping sickness risk in Africa. Map 8.1 at http://www.who.int/csr/resources/publications/CSR_ISR_1_2000tryps/en/

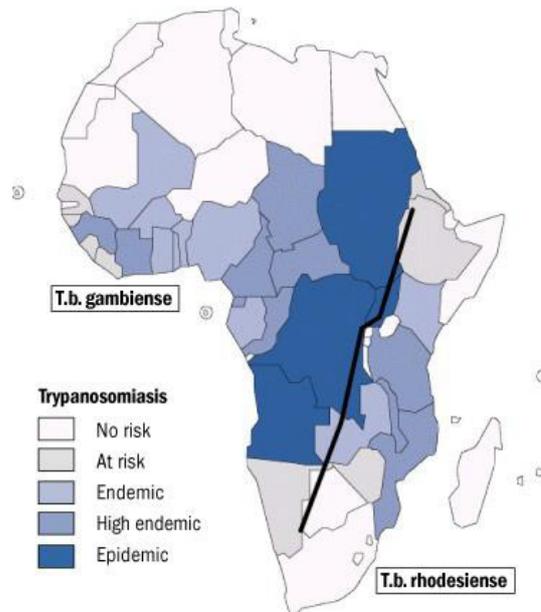


Figure 13: Example of tsetse fly traps - Roberts J. Source - <http://ibol.org/tracking-the-tsetse-with-barcodes/>



Vector Control

Fly traps

Tsetse flies are attracted to cattle and bush pigs, their preferred hosts, by odour and colour (blue and black). The main vector control methods are diamond shaped fly traps, made of blue and black material, and sometimes treated with cow odours to increase attraction. There are different traps available and their differences are outlined in the WHO guide: http://www.who.int/tdr/publications/documents/tsetse_traps.pdf. Traps are an effective control of tsetse flies in sleeping sickness areas when they are hung on the banks of rivers, lakes and ponds that are used by people for collecting water or washing. The flies, first attracted by odour, and blue, and finally attracted to land on the black material, enter the trap, cannot exit and die of heat.

Further Reading

More on tsetse fly vector control

http://www.who.int/trypanosomiasis_african/vector_control/en/

Decisions making tools for control methods

<http://www.tsetse.org/index.html>

More on sleeping sickness control and global strategy for elimination by 2020

http://www.who.int/trypanosomiasis_african/en/,

http://apps.who.int/iris/bitstream/10665/182735/1/WHO_FWC_WSH_15.12_eng.pdf

Disease distribution when responding to an emergency can be found below

http://www.who.int/trypanosomiasis_african/country/foci_AFRO/en/

1.5.6. Fleas

Fleas:

Plague (transmitted by fleas from rats to humans)

Rickettsiosis

Figure 14: Image of The Oriental rat flea, *Xenopsylla cheopis*.
source - http://www.cdc.gov/dpdx/images/fleas/X_cheopis_BAM2.jpg



Vector Behaviour

They are found worldwide in poor living conditions, thus commonly in humanitarian emergencies. They are wingless, with mouthparts adapted for piercing skin and sucking blood.

Fleas are insects of the order Siphonaptera. Fleas are external parasites, living off the blood of mammals including rats, domestic animals and humans.

Fleas breed in damp, smelly environments and in houses, preferentially in piles of old clothing, old shoes and soft furnishings.

Fleas are a nuisance and cause an itching sensation. Some people suffer allergic reactions to flea saliva, resulting in rashes. Flea bites generally result in the formation of a slightly raised, swollen itching spot with a single puncture point at the centre (similar to a mosquito bite).

Fleas transmit a variety of viral, bacterial, rickettsial, protozoan and helminth diseases to humans, the most important of which are plague and rickettsiosis.

Disease Agents

Plague

- The plague bacterium (*Yersinia pestis*) is transmitted by fleas, and cycles naturally among wild rodents. Plague can also infect humans when flea infested rodents enter homes.
- Bubonic plague is the most common form of plague. It usually occurs after the bite of an infected flea. The key feature of bubonic plague is a swollen, painful lymph node, usually in the groin, armpit or neck. If not treated early, the bacteria can spread to other parts of the body and cause septicemic or pneumonic plague. Septicemic plague occurs when plague bacteria multiply in the bloodstream. Pneumonic plague occurs when plague bacteria infect the lungs. Pneumonic plague is almost always fatal if not treated rapidly.

Rickettsiosis

-
- Tick-borne rickettsioses are caused by obligate intracellular bacteria belonging to the spotted fever group (SFG) of the genus *Rickettsia* within the family Rickettsiaceae. Other Spotted Fever can be caused by the Typhus group of bacteria.
 - Rickettsiosis is transmitted to humans via external parasites like fleas, as well as lice and ticks. The typhus group is mainly transmitted by lice or fleas.
 - Symptomatic rickettsial diseases normally present as moderate illness, but some diseases such as scrub typhus and epidemic typhus, may be fatal in 20%–60% of untreated cases and prompt treatment is essential²³.

²³ <http://wwwnc.cdc.gov/travel/yellowbook/2016/infectious-diseases-related-to-travel/rickettsial-spotted-typhus-fevers-related-infections-anaplasmosis-ehrlichiosis>

Vector Control

Control measures include using flea collars, washing animal bedding and using methods to eliminate the reservoir. Insecticidal powder can be applied in houses using either mechanical or hand pumps with a fogger to kill adult fleas. Insecticidal sprays containing an insect growth regulator such as pyriproxyfen or methoprene can be used to kill eggs and pupae (See 5.6). Borax is sold as a «Natural Laundry Booster» and can also be used at a household level as a treatment for flea infestations. Borax contains sodium borate which kills fleas by dehydrating them.

The main messages for flea control to the community are:

Maintain good personal hygiene and clean living conditions

Look out for signs and symptoms (rash, allergic reaction to bites) as well as for flea-borne diseases

Treat living spaces with insecticides to eliminate flea infestations

Treat livestock occasionally as well

Further Reading

https://www.cdc.gov/plague/resources/235098_plaguefactsheet_508.pdf

1.5.7. Black flies

Black flies:

Onchocerciasis (River blindness)

Figure 15: Black Fly - <http://www.cdc.gov/parasites/onchocerciasis/disease.html>



Vector Behaviour

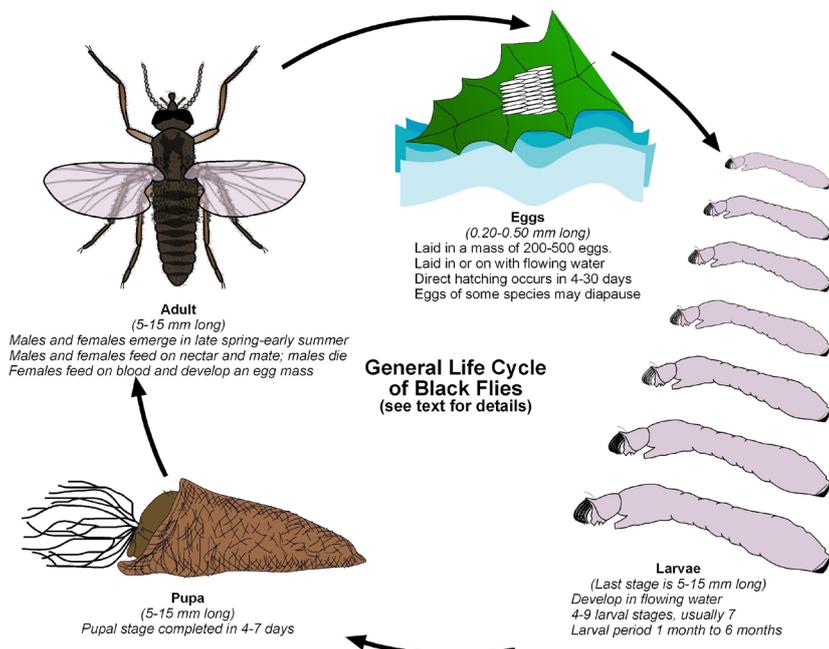
Blackflies (*Simulium* species) breed in fast-running rivers or streams and can devastate riverside communities.

Blackflies are highly anthropophilic making them very efficient at transmitting parasites to humans, thus transmitting disease (see Figure 16)

Blackflies bite during the day. Female blackflies need to ingest blood for ovulation.

Communities that live near these environments or use flowing rivers and streams for activities such as bathing and laundry are most at risk of being bitten by black flies.

Fig 16: Life Cycle of the Black Fly



Disease Agents

Blackfly bites transmit the parasitic filarial worm *Onchocerca volvulus*.

The larvae develop inside the blackfly and become infective for humans in about 10 to 12 days.

If a blackfly bites an infected person, onchocerciasis larvae can be ingested by the blackfly, after which they migrate to the flight muscles.

Vector Control and Personal Protection

Chemical control: blackfly larvae can be eliminated from rivers and streams using aerial insecticide spraying and other means, but this is not feasible in conflict based crises, and is rarely used today.

Personal prevention methods such as using DEET-based insect repellents, may repel greater numbers of black flies. Permethrin products designed for ticks are effective but can only be applied to clothing, limiting their usefulness.

Mass Drug Administration (MDA) of Ivermectin will prevent embryogenesis, thus interrupting transmission. However, this method requires sustainable infrastructure for community-based distribution. In an emergency, MDA may be feasible but it has to be conducted with sustainability in mind, as control of the disease requires annual repeat MDA.

1.5.8. Aquatic Snails

Aquatic Snails:

Schistosomiasis (bilharziasis)



Figure 17: *Biomphalaria*
Schistosomiasis carrying snail.
[http://www.nematodes.org/
NeglectedGenomes/MOLLUSCA/](http://www.nematodes.org/NeglectedGenomes/MOLLUSCA/)

Vector Behaviour

Freshwater gastropod snails are infected by the trematode flatworms of the genus *Schistosoma*. Larval forms of the parasites which are released by freshwater snails penetrate the skin of people in the water.

These snails inhabit shallow waters close to the shores of lakes, seas or rivers, i.e. places where communities come for day-to-day activities; they do not thrive in permanently flooded or riverine environments.

Disease Agents

Schistosomiasis is an acute and chronic disease caused by parasitic worms.

Estimates show that at least 258 million people required preventive treatment for schistosomiasis in 2014. Schistosomiasis transmission has been reported from 78 countries.

Transmission occurs when people suffering from schistosomiasis contaminate freshwater sources with their excreta containing parasite eggs which hatch in water. Schistosomiasis is found in tropical and subtropical areas, especially in poor communities without access to safe drinking water and adequate sanitation. It is estimated that at least 90% of those requiring treatment for schistosomiasis live in Africa.

In the body, the larvae develop into adult schistosomes which live in blood vessels.

The females release eggs, some of which are passed out of the body in the urine or faeces. Others are trapped in body tissues, causing an immune reaction at those sites.

Vector Control And Personal Protection

Mass drug administration

Control of schistosomiasis is based on drug treatment (MDA, using Praziquantel which is donated free of charge to high burden countries), snail/vector control, improved sanitation and health education. Snail control can be achieved by maintaining a “close cut” vegetation on water banks to remove snail habitats.

Chemical molluscicides

It can be used selectively in snail-infested water. However, their use requires the full implementation of integrated vector management principles using evidence base to determine whether they are useful. “Side effects” include the death of many fish species, as well as the targeted snail populations, making them impractical and unacceptable for use in most emergency settings. Plant-derived molluscicides have proven too variable in their effectiveness and are difficult to manufacture.

Sanitation measures

Improvement of sanitation as well as vigorous drying after water exposure may also stop *Schistosoma cercaria* penetration.

Education

Community awareness activities to discourage swimming and washing in infected water sources can reduce transmission, though are unlikely to change behaviour amongst children. Introduction of piped water supplies to facilitate washing and access to safe drinking water within communities, combined with behaviour change, is needed to achieve long term reductions in disease.

Further Reading

Schistosomiasis control strategy, including the main recommended strategy of mass drug administration <http://www.who.int/schistosomiasis/strategy/en/>.

1.5.9. Flies

Flies:

Trachoma

Diarrhoeal Diseases (Rotavirus, *Vibrio cholerae*, *Shigella* spp.,
Salmonella spp.)

Figure 18: *M. Domestica* housefly image. Source - <http://www.wikiwand.com/en/Fly>

Figure 19



Vector Behaviour

Flies are implicated in both direct and mechanical transmission of pathogens that cause disease in humans. Flies usually breed extensively when there is a breakdown in, or lack of, adequate sanitation: lack of latrines, unsanitary overcrowding, inadequate water supplies and uncontrolled rubbish.

These flies will breed in animal manure, human excrement, rubbish, animal bedding and decaying organic matter.

Alongside causing disease, flies are also a nuisance to populations.

Disease-causing agents are spread on its body, in its mouth parts or through its vomit and faeces.

Disease Agents

Diarrhoeal Diseases

- Diarrhoeal disease is the second leading cause of death in children under five years old. It is both preventable and treatable. Children who are malnourished or have impaired immunity are most at risk of life-threatening diarrhoea²⁴.

- Flies spread over 26 enteric diseases including bacterial diseases shigellosis and cholera. These diseases are caused by viruses, bacteria or parasites.

- Flies spread infection from rotting and contaminated waste, by landing in these and then on food and water sources ingested by the community.

²⁴ <http://www.who.int/mediacentre/factsheets/fs330/en/>

Trachoma

- Flies that land on faces and feed off secretions are mechanical vectors for trachoma
- Trachoma is an infectious eye disease caused by the bacterium *Chlamydia trachomatis*, spread by contact with an infected person's hands or clothing. It is the world's leading infectious cause of preventable blindness, and is one of the oldest diseases known to man.

Vector Control

To combat trachoma, the World Health Organization has endorsed an integrated strategy known as SAFE: Surgery, Antibiotics, Facial cleanliness and Environmental improvements.

Clean water, proper sanitation and hygiene promotion are important aspects of fly control. Good maintenance of latrines is necessary and where suitable, chemical fly control can be implemented to reduce vector burden if WASH and shelter are not managing to keep these vector populations under control.

Further Reading

Implementing SAFE strategy for trachoma control

<http://trachoma.org/sites/default/files/guidesandmanuals/Implementing20%the20%SAFE20%Strategy20%for20%Trachoma20%Control20%English.pdf>

Trachoma epidemic surveillance protocol:

<http://trachoma.org/sites/default/files/guidesandmanuals/WHO20%Prevalence20%Protocol20%Trachoma20%English.pdf>

2.

Considerations unique to Humanitarian Emergencies

The WHO handbooks on IVM and the Durham university toolkit for sub-Saharan Africa focus on IVM in non-emergency settings, but provide very useful additional information to this toolkit. Emergency settings are very unique, variable and challenging environments and pose unique disease control demands.

This IVM toolkit draws on the WHO and Durham work and applies and adapts it to humanitarian emergency settings in a clear and practical way, to ensure effective IVM planning from the earliest stages in host populations and camp settings.

2.1. Organisational Structures

Creating long-term structures and systems is integral to IVM. Even in an emergency it is important to understand the local vector control environment, main players and tools currently being implemented. Several countries have adopted the IVM approach after WHO endorsement. Each country is at a different stage of implementing IVM: some countries have policy documents; others have an IVM programme integrated within the MoH (Ministry of Health) or the environmental agency. It is important to understand the landscape of players in vector-borne diseases to ensure that they are incorporated into future developments and plans.

Effective VBD control is multi-sectoral, both globally and at country level. Vector-borne disease control will include key sectors such as public health, water and sanitation, shelter/camp management, education and social protection/community services. Operational partnerships are essential among a range of organizations. It is critical to work with national and local government agencies when planning and implementing an emergency malaria control response.

2.2. Humanitarian response activation and leadership

The humanitarian response system structure is well established and coordinated using the cluster system. Since 2005, the cluster approach has been adopted by the inter Agency Standing Committee (IASC). The primary mechanism for inter-agency coordination of humanitarian assistance, this agency leads both non-UN and UN agencies. The cluster system is a mechanism for a coordinated health crisis response strategy, as well as for better monitoring and evaluation of the implementation and impact of those strategies through clear leadership roles and responsibilities. Refugee settings however are an exception: the cluster approach is not activated, instead the UNHCR is the lead agency and the different lead groups are called sectors instead of clusters. The procedure for activating one or more clusters includes consultation between the Resident/ Humanitarian Coordinator and the Humanitarian Country Team, and then correspondence with the Emergency Relief Coordinator on the rationale for each cluster and the selection of cluster lead agencies based on coordination and response capacity of each of the agencies.

Clusters are activated in response to two scenarios:

- 1) Response and coordination gaps exist due to a sharp deterioration or significant change in the humanitarian situation
- 2) Existing national response or coordination capacity is unable to meet needs in a manner that respects humanitarian principles²⁵.

²⁵ <https://www.humanitarianresponse.info/en/coordination/clusters/activation-and-deactivation-clusters>

For new humanitarian emergencies, the cluster/sector activation procedure entails the following:

The UN Humanitarian Coordinator (HC) or Resident Coordinator (RC) consults relevant partners.

S/he proposes leads for each major area and sends a proposal to the Emergency Response Coordinator (ERC).

ERC shares the proposal with Global Cluster Leads.

ERC ensures agreement at global level and communicates agreement to HC/RC and partners within 24 hours.

HC/RC informs the host government and all partners.

The Cluster/Sector Approach

The Cluster Approach consists of groups of relief humanitarian organizations (UN and non-UN) working in the main sectors of humanitarian action, e.g. shelter and health. Clusters/sectors provide a clear point of contact and organisational structure for the humanitarian response, allowing accountability for adequate and appropriate humanitarian assistance. Clusters/sectors create partnerships between international humanitarian actors, national and local authorities and civil society.

There are currently eleven clusters. Whilst infectious diseases fall under the health cluster, vector control does not fall neatly into one sector but crosscuts WASH (Water, sanitation and hygiene), shelter and camp management, NFI (Non-food Items) as well as the Health Cluster/Sector. Co-ordination across clusters is an important aspect of planning and implementing IVM. The various roles of each cluster/sector are outlined in the link above.

After a humanitarian emergency is declared following a trigger event, relief agencies respond under the leadership and coordination of the Humanitarian and Relief Coordinator. The wellbeing of displaced people and communities isolated by conflict or natural disasters depends on provision of water and sanitation, food, shelter and health care. The first steps in responding to a humanitarian response is to perform an initial assessment to understand the needs of the population. Surveillance is essential after the initial assessment to ensure that any changes in the population are closely observed and that the response is prepared to react swiftly to any problems.

The clusters/sectors coordinate emergency responses as well as early recovery: vector control implementation should involve several clusters from the outset.

3.

Determining which VBD to respond to

Knowledge of VBD epidemiology in areas affected by humanitarian emergencies is essential for appropriate prevention and case-management and is part of an initial assessment. Instead of relying on a single vector control method, IVM implementation first requires the understanding of the local vector ecology and local patterns of disease transmission, and then necessitates choosing the appropriate vector control tools from the range of options available as a result of the analysis.

A needs assessment provides the evidence base for strategic planning of resources. It also provides the baseline data to monitor the response. Assessing the needs of the affected population is a continuous process throughout the response to monitor and evaluate impact of activities, and tailor response on a continuous basis. Assessments are coordinated in partnership with all humanitarian actors to identify needs of the population. Local and national authorities, civil society and affected communities should participate in this process. The result of this process will be a humanitarian needs overview (HNO), within which the needs may be attached to a severity ranking to prioritize resources.

3.1. Vector-borne disease situation analysis

The following guiding principles can be used for the assessment, planning and selection of VBD control activities:

Maximise the use of existing information at international, national, district and community levels to determine the diseases at risk and the policies and implementation activities which have been taking place to control them.

Install or improve a disease reporting data collection system, if an emergency is already underway.

Conduct rapid epidemiological surveys, if no data is available or data is inadequate.

Link control interventions to current effective national IVM or disease control policies.

Use available local expertise to assist with the selection of VBD control options.

These activities allow an effective vector control programme to be planned. The rapid survey or local data will ascertain the diseases present in the emergency country or region and give an idea of how likely they are to occur, and when they are most likely to occur during the year.

A surveillance system will need to be put in place, if there is not one already functional. This passive data collection will be on-going monitoring of various diseases. This will allow detection of outbreaks or increases in incidence of the vector-borne and non-vector-borne diseases. This information can then be used to monitor the impact of any IVM programme implemented. Understanding disease burden and needs at the beginning of any programme will determine the speed required for interventions or preparations that may need to be made to prevent high rates of mortality or morbidity from VBDs.

3.2. Rapid surveys

Rapid health surveys are conducted to evaluate the emergency in order to determine the major health and nutrition needs of the population.

There are tools for collecting data on various indicators such as mortality as well as rapid prevalence data collection tools that can capture information on various diseases. See the following links:

MSF Rapid health assessment of refugee or displaced persons 3rd ed. (MSF, 2006)
http://refbooks.msf.org/msf_docs/en/rapid_health/rapid_health_en.pdf.

Annexes I-IV in the Malaria control in humanitarian emergencies. An inter-agency field handbook – 2nd Ed
<http://www.unhcr.org/456c11bd4.pdf>.

The WHO Communicable disease control in emergencies: A field manual (WHO, 2005) also contains sample survey forms for health assessments from page 199 onwards
http://apps.who.int/iris/bitstream/9241546166/1/96340/10665_eng.pdf.

Malaria Indicator Surveys from Roll back malaria:
<http://malariasurveys.org/toolkit.cfm>

Rapid surveys may be used when the local VBD overview is not clearly defined or there is no data available. They are used to assess whether these diseases are present or are likely to become a problem. Rapid surveys can:

Identify population groups most at risk of specific VBDs (as this will not always be pregnant women and children under the age of five)

Estimate the proportion of the population, both symptomatic and asymptomatic, infected with the named diseases

Assess basic clinical signs and symptoms in a patient and parasite presence (if applicable) using microscopy or Rapid Diagnostic Tests (RDTs). The two types of rapid malaria surveys are clinical-based, using data from patients attending health facilities or mobile clinics, or involve conducting a cross-sectional prevalence survey across the affected population.

These surveys will also determine priorities for action, including the most appropriate case management and vector control measures.

3.3. Vector-Borne Disease risk assessment

A substantial amount of vector analysis can be done prior to arrival. Reports from NGOs working in the countries prior to the triggering event and national surveillance reports provide useful information on the vector-borne diseases present in the affected area.

Key to IVM is evidence-based decision making guided by operational research, entomological and epidemiological surveillance and evaluation. This begins with understanding the vectors present or known to be present in the area, their habits and the local ecosystem. This requires an entomologist prior to operations beginning to ensure as much information as possible is gathered on the vectors, including insecticide resistance and species differentiation, all of which may impact the choice of methods.

For an overview of diseases, see WHO's countries page: <http://www.who.int/countries/en/>. This page has links to each country's profile and website, providing information on the diseases of importance which are being responded to, on-going initiatives for different diseases outbreaks and control and, depending on the country, information on mortality. PubMed is a good source for published articles: <http://www.ncbi.nlm.nih.gov/pubmed/>. Even if the information available is old, it will still be useful to give an idea of the vector species and diseases of importance present. Other NGOs or International NGOs will have information on different diseases, especially if it is a chronic emergency, in which case monitoring and surveillance systems will be in place to identify outbreaks early on. This may be the reason why vector control or VBD specialists are requested to assist in the response.

Global Atlas of Helminth Infections and Trachoma Atlas are examples of initiatives that have up to date information on helminth infections, schistosomiasis, lymphatic filariasis and trachoma: <http://www.thiswormyworld.org/>, <http://www.trachomaatlas.org/>.

Up-to-date Information on malaria can be found at: <http://www.worldmalariaareport.org/>
Zika virus epidemiological updates from regional WHO office PAHO can be found at: http://www.paho.org/hq/index.php?option=com_content&view=article&id=11599&Itemid=41691&lang=en

These maps have region-specific surveys that cover areas in which the emergency response is taking place. Having up to date data allows for regional differences and comparisons to be made and for the seriousness of the disease to be determined. Trends over time are important to give an idea of whether interventions to be implemented will make an impact.

Insecticide resistance is an increasing problem in vector control. Using tools which are inefficient will render control initiatives obsolete. IR Mapper (<http://www.irmapper.com/>) is a useful tool that can be used to view results from insecticide studies: WHO susceptibility tests and CDC bottle assays are performed on malaria mosquitoes collected from sites throughout the world. This information is vital for determining which chemical compounds can be selected for implementation activities, alongside the WHO Pesticide Evaluation Scheme-recommended insecticides and larvicides and those approved for use in a specific country: <http://www.who.int/whopes/en/>.

Using available MoH data will also help determine if a response area is susceptible to a particular VBD or if the refugee population that may be moving into a new area have particular VBDs. Some Ministries of Health have websites, updated regularly or infrequently. These are great information sources about activities already taking place in a country.

Some VBDs will have vertical programs already existing with established national strategies, protocols and policies in place such as malaria, leishmaniasis or dengue control programs. Implementing IVM will require identifying the programmes in place, the stage they are at and leveraging the information and human resources to implement vector control in an emergency. In some emergencies, all MoH and government structures are destroyed and there is no leadership body to get these resources from or to partner with. In such situations, vector control activities will take place with all disease control and response parties using the cluster/sector response system.

Following identification of disease vectors present in a crisis, a plan for the prevention and control of these diseases can be put in place and resources accordingly allocated. The evidence for effective vector control in humanitarian emergencies has expanded in recent years, as well as field experience from different organisations and disasters, confirming the feasibility of timely vector control interventions.

The level of response to these diseases will depend on whether the diseases present are causing high mortality or morbidity compared to other health problems that the population may be experiencing. Many vector control programmes in refugee and IDP camps are introduced in response to a crisis. Preparing for such eventualities will make the response much more effective.

In sudden acute epidemics of a VBD, a spraying programme can be initiated prior to any other control activity. This is likely to be effective in the short term but not in the longer term unless other control measures are also used. In line with the principles of IVM, different vector control tools will have to be used as well as spraying in order to maximise impact by targeting different stages of vector development, i.e. larviciding halts growth of mosquito larvae whereas IRS kills adult mosquitoes resting on the walls.

3.4. Local determinants of disease

Once on the ground, it is important to identify the diseases of importance, the locally known areas of vector proliferation, and the ecosystems conducive to vector breeding. This will help with the mapping and planning of interventions. Interventions will be better accepted and sustained if the affected host community is involved from an early stage. This will be local, regional and national authorities as well other technical expertise such as entomologists.

4.

Implementing IVM in emergencies

Rather than relying on one vector control method, IVM stresses the importance of understanding the local vector ecology and patterns of disease transmission first before choosing an appropriate vector control method from the options available or feasible. Most countries in which emergencies take place are likely to have more than one vector-borne disease or require more than one tool to implement long lasting reduction in disease transmission. The vector assessment will determine the diseases present or of importance. Decisions will then be made on the tools that would be effective. This may then be followed by adjustments due to budgetary or feasibility concern.

There is limited documented operational experience of implementing vector control in emergencies other than that for malaria and dengue control. This toolkit draws upon operational experiences in various emergency settings. Some vector control tools have been specifically designed for acute-phase emergencies. For instance, ITPS in new settlements, where shelter is limited, may be more acceptable and feasible than LLINs or IRS, particularly during acute phases. Other methods, including permethrin-treated blankets and topical and spatial repellents, may sometimes be useful as adjunct control measures while planning for more long term vector control methods.

4.1. Tools required to implement vector control

After a situation assessment has identified any local disease vectors, and the potential diseases risks for the population, the most effective and feasible IVM tools for that situation can be chosen. Any chemical based products such as LLIN, LLIC, IRS insecticides, larvicides etc. will need to be chosen in consultation with the ministry of Health or Environment, to ensure the acceptability of the product, and to ensure that it is registered and can be imported into the country. Some vectors may be resistant to some of the insecticides or larvicides, ruling out their use. An entomologist will likely be required to determine the efficacy of insecticides or larvicides in order to provide an evidence base which can be used to inform decision making.

Implementation

Timing of the vector control implementation is important. It is based on the understanding of the transmission dynamics such as the high transmission season and the habits of the vector. This helps ensure implementation activities are performed when the highest reduction in vectors can be made. A good example of this is seasonal malaria: the effect on transmission is much greater if IRS is performed immediately prior to the onset of the rains. Likewise, many dengue programmes are reactive to epidemics but if sustained control interventions had been established and sustained earlier, the epidemics might have been avoided. Even following a tsunami when a population is given temporary shelter, activities can be implemented to reduce larval sources near the population such as proper rubbish disposal and covering or larviciding water tanks. Such action taken from early stages of a crisis will mitigate the risk of epidemics in subsequent months.

Vector control implementation will require a team of trained personnel to deliver the tools. These will include community health advocates, community leaders, community teams for IRS, larvi-

cide or LLIN delivery (who, depending on the emergency, may need to be speak several local languages), supervisors, and Ministry of Health or Ministry of Environment delegates supporting implementation and monitoring, depending on their level.

All activities should be accompanied with IEC activities for the targeted diseases and the chosen vector control measures, in order to increase acceptability of the tools and community participation and uptake. In refugee and IDP camps, respected community leaders will be able to work with the implementation teams to communicate to their community. Leaflets, theatre and music may be required to ensure good knowledge dissemination amongst the target population.

Different organisations may already have IEC materials that can be modified for the target population. The MoH, WHO, UNICEF as well as the National Red Cross/Red Crescent (who should already be consulted during initial assessment and planning stages) may produce useful IEC materials, so collaboration and co-ordination between partners can save costs and increase efficiency.

During the assessment stages it is essential to outline the key players and their role in the emergency response. All activities should be coordinated and any key meetings should be attended and updates given to ensure no overlap or conflicting activities. IEC partners, community health workers and drama troupes will need to be identified and coordinated.

Clear distribution sites need to be identified such as health posts or schools, to ensure good monitoring of tools and ensuring that those eligible are covered.

4.2. Training

Those delivering vector control campaign activities will have to undergo specific training in order to achieve good quality, and safe, implementation. The participation of the community is essential for a successful vector control implementation. The support of community leaders and other influential community members or groups is important to ensure high acceptability of tools and delivery strategies. Community health workers have an important role to play for vector control activities. They can give clear information on upcoming campaigns and, where appropriate, demonstrate tools (e.g. LLIN hanging). They may already be trained in delivering some IEC material through the national programmes, thus it is important to find this out as part of the initial assessment.

For IRS, rigorous training takes several days to ensure high quality work. Since the spray equipment is expensive and is easily damaged if not maintained, it is vital that training is implemented for sprayers as well as supervisors.

One of the main components to IVM, as stated in the WHO guide (2012), is the “Development of adequate human resources, training and career structures at national and local level to promote capacity building and manage IVM programmes”.

4.3. Procurement

Programmes should procure IVM products recommended by WHO and Roll Back Malaria (RBM). The use of trade names in the planning stages and throughout should be avoided since a product may be registered under different trade names in different countries. The most important criterion to be considered for chemical based IVM tools is the active ingredient and ensuring that it meets WHO specifications. The WHO pesticide evaluation scheme (WHOPES) has a list of WHO-approved insecticides and information can be found here: <http://www.who.int/whopes/en/>. National regulatory authorities, ministries of public health and environmental authorities may require additional procedures to be approved for use in the specific country. Before procuring or using insecticides for malaria control, many countries and programmes require an environmental assessment. Such activities can delay procurement and delivery of vector control activities; gathering information on the approved chemicals when

selecting vector control tools is vital to prevent such delays. In emergencies, some of the procedures can be fast-tracked or temporary approvals given when systems are recovering following a trigger event.

Transportation of insecticides or larvicide becomes complicated if they are liquid because air freighting liquids requires a special license and specific packaging. Regulations for air transportation of dry granular formulations, or prepacked liquid sachets, are usually less complex. This may become an important factor in the decision making process for emergency vector response.

4.4. Vector control target setting

IRS coverage has to be above 80% of households per target town/camp/urban community to achieve effective reduction in malaria transmission. For LLINs, the target for universal coverage is effectively one LLIN per two persons for the whole target community. For procurement, due to irregular household sizes, a ratio of one LLIN per 1.8 persons should be used.

Spatial considerations need to be made in emergencies: if enough data are available on 'hotspots' of disease transmission, the intervention should be implemented as priority in those focal areas instead of implementing blanket coverage. The timing of any interventions is key to maximising impact. Vector control activities should be in place prior to the high transmission period to have the largest impact on disease transmission. Many VBDs have transmission dynamics that are tied to the local ecology and therefore a sound understanding of the transmission pattern is required. For example, seasonal fluctuations in rainfall lead to changing numbers of mosquitoes and therefore burden of malaria. Onset of the dry season will lead to an increase of the sandfly population, and a corresponding increase in transmission of leishmaniasis.

4.5. Monitoring and Evaluation

Monitoring and evaluation (M&E) is an important aspect of implementing disease control programmes. M&E is fundamental to successful programming and should be integrated from the design stage through to the completion of the programme.

Monitoring

Monitoring is an on-going process of recording indicators during programme implementation and focuses on the inputs, outputs, processes and work plans (operational implementation). It tracks the key elements of a programme's performance for on-going programme management and improvement. This can be indicators such as how many houses are sprayed per day for IRS implementation.

Data for monitoring can come from routine surveillance systems, field observation reports, rapid assessments carried out, programme review meetings as well as any field reports undertaken. These types of data will be able to identify operational challenges occurring and monitor progress in comparison to expected timeline of delivery activities. Any programme delays can be identified and resolved to reduce their impact on programme outputs. Monitoring will track the inputs and the outputs resulting from interventions to the affected populations. Monitoring programmes will require routine reviews of reports and registers from healthcare facilities to track impact in VBD incidence or prevalence.

Evaluation

Evaluation is the periodic, objective assessment of the change in targeted results that can be attributed to the programme intervention. It looks at the effectiveness, relevance, impact and cost-effectiveness (population effects) of the programme. This will include aspects such as the percentage of houses sprayed by IRS, or the number of household water containers treated with larvicide, compared to the original targets.

The evaluation of programmes is a periodic assessment of programme performance to ensure

that the implementation of the project resulted in disease reduction. This requires good data collection and monitoring. Evaluation will use the same sources of data as monitoring, however it will also require robust measurements such as population-based surveys. This allows global comparisons to be made with baseline data. In order to determine impact, evaluation needs to employ a rigorous scientific design.

Emergency settings can make data collection and verification challenging, however they are vital, in order to determine how effective interventions are, and to provide good quality reporting to national partners and donors.

Further Reading

A summary of the key points of LLIN distribution in an emergency
<http://www.unhcr.org/53ba5cca9.pdf>

The WHO (2012) guide “Outbreak surveillance and response in humanitarian emergencies”
http://apps.who.int/iris/bitstream/10665/70812/1/WHO_HSE_GAR_DCE_2012_1_eng.pdf. The annexes have sample tools for data capture and recoding to feed into surveillance systems.

Some information adapted from the Salama 2004 review
http://conflict.lshhtm.ac.uk/media/Lessons_learned_in_emergs_Salama_Lancet_2004.pdf

4.6. Surveillance and Surveys

The success of communicable disease control in humanitarian response environments, as well as non-emergency environments, is having a comprehensive and robust disease surveillance system. A sensitive, communicable disease surveillance/early warning and response system is established at the beginning of public health activities set up in response to an emergency. The surveillance system should be simple, use standardised case definitions and be flexible, situation specific and widely accepted by the healthcare providers and humanitarian response organisations. The four main areas included in a health information system are mortality, morbidity, nutritional status and programme indicators.

Generally, three types of data are obtained:

- 1) Rapid health assessments, consisting of an initial overview of the immediate effect and needs. This is outlined in section 4 under rapid surveys and VBD risk assessment tools.
- 2) Surveys, defined as intermittent and focused assessments that gather population-based health data. These can include Knowledge, Attitude and Practices (KAP) surveys, and surveys to determine, for example, usage of vector control tools.
- 3) Surveillance is the ongoing, systematic gathering, analysis, and interpretation of health data. Baseline information collected in the beginning of a disease response in emergency operations can then be used to look at trends over time. This is important for data interpretation.

During humanitarian responses, a surveillance system is normally established early on. This will be done in collaboration with partners so as to collect the best quality data available and may require training healthcare workers where appropriate. Partners will have access to routinely collected data of importance from facilities they are supporting. Where this is not the case, setting up data collection and reporting systems may be required. Epidemiological outcomes are the most important when assessing the effectiveness of a given VBD intervention. However, in operational contexts it is often hard to account for many of the variables that affect these outcomes. It is therefore often useful to perform entomological evaluations, the results of which, when viewed alongside operational data

(such as coverage rates, percentage of houses sprayed) and epidemiological outcomes, will build an assessment of the effectiveness of interventions.

Surveillance for vector-borne diseases will be further broken down into the following areas:

Disease surveillance that tracks the number of infected human cases.

Vector surveillance that estimates the vector density at different life cycle stages (larval, pupal or adult). This could be tracking, for example, mosquito populations in areas of potential dengue or Zika virus risk.

Behavioural impact monitoring that observes whether disease transmission behavioural changes are adopted and sustained by the target community. For example, manual management of waste containers for *aedes*-borne disease control would be monitored.

Conducting surveys requires people with training and experience in all aspects of surveys: planning, sampling, supervision, data cleaning and analysis, and writing the final report.

Disease Surveillance

Disease surveillance is an important aspect of any disease control programme, including vector control programmes. In emergencies, those managing disease control and prevention may have to do specific training in order to strengthen disease surveillance so as to be able to detect any changes caused by vector control activities.

In order to determine whether a disease is increasing or not, data has to be compared to the previous years. For example, the incidence of dengue in health facilities has to be compared with data from the previous five years as transmission can change drastically between years. Incidence of malaria by month is compared with the same time from the previous year.

To monitor VBD disease trends, data from health care facilities is needed. The data has to be recorded appropriately and accurately using standardised case definitions as defined by the surveillance lead in the response. All treatment seeking numbers need to be recorded in order to assess specific disease trend over time, as a number of cases alone will not allow inferences to be made.

Vector Surveillance

Vector surveillance methods for *aedes* mosquito species are outlined in the webpage: http://www.who.int/denguecontrol/monitoring/vector_surveillance/en/. As well as naming the tool, the guide goes into details of the equipment required for the different surveillance indicators. Vector surveillance is important for determining whether vector control measures are working. Examples of these vector surveillance methods are the larval density index, used to determine whether interventions are reducing numbers of developing mosquitoes and container index, used to determine whether the manual management of containers is being performed correctly at a household level.

Larval surveys

House index (HI): percentage of houses infested with larvae and/or pupae.

Container index (CI): percentage of water-holding containers infested with larvae or pupae.

Breteau index (BI): number of positive containers per 100 houses inspected.

Pupae surveys

Pupa index (PI): number of pupae per 100 houses inspected.

Adult surveys

Estimating adult population density using ovitraps, sticky traps, human landing collections or any similar traps.

5.

Vector control tools

Part of vector assessment involves determining the mechanisms and scope for coordination and joint planning, which is especially important for VBD prevention activities as they intersect shelter/camp management, health, water hygiene and sanitation (WASH), and education programs. Multi-sector planning should be undertaken based on the disease risk and response capacity assessments.

The aims of a vector assessment are to identify the vectors causing the diseases of importance, the vector ecosystem and the factors that influence disease transmission. This is likely to require an entomologist who will be able to determine the vector feeding, breeding and resting habits and the resistance of the specific vectors if not known already. This information will be acquired through review of any existing entomological data for the area, and through entomological surveys where needed, and will require trained specialists. The more entomological information available at the start of the response, the better the VBD control planning and the greater the impact of vector control activities.

In relation to vector control the initial assessment should also ascertain the following: the tools available for implementation, the tools registered for approval in the country, the status of national control programs for the various diseases and operational and human resources available. There may be existing training and IEC material, approved insecticides or larvicide in addition to a coordinated country programme. It is common for other NGOs or INGOs to have ordered LLINs during a crisis. However, LLIN have long supplier lead times and consequently may not be on the ground in the first few months of the crisis, so planning needs to take into account these factors in order not to duplicate resources or leave gaps in the response.

5.1. Vector control tools available

IRS (Indoor residual spraying)

LLIN (Long lasting insecticidal net)

Insecticide treated materials

- Insecticide treated plastic sheeting (ITPS)
 - Insecticide treated clothing
 - Insecticide treated curtains
 - Insecticide treated wall linings
 - Insecticide treated blankets and hammocks
-

Larval source management

- Environmental management (manual management of breeding sites, use of container lids, etc)
 - Larviciding (chemical or biological)
 - Habitat modification
-

Fogging/ultra-low volume spraying

Fly control

Waste management

5.2. Vector control table

The Vector Control Table (Annexe 1) outlines the tools available for implementing IVM, all of which may be deployed in emergency settings. The selection of tools used will depend on the outcomes of the vector assessment, budgetary considerations and on the speed of deployment achievable in that particular setting. The aims of IVM are to use one or more tools to control one or multiple disease vectors. The Vector Control Table (Annexe 1) shows that vector-borne diseases overlap in the geographical areas they affect. This environment lends itself to an IVM method to maximise tools and their impact on vector burden.

The phase of the crisis will greatly affect what is feasible in the timeframe required for impact. For mosquito-transmitted diseases, the highest burden of disease transmission is in the rainy season, whereas diseases transmitted by sandflies will peak in the dry season, and diseases transmitted by fleas and domestic flies may be relatively constant in transmission. Vector control activities should aim to be implemented prior to the season in which vector populations expand, to stem their population growth in the specified area, and prevent or reduce disease transmission.

Shelter is one of the first commodities normally supplied to displaced victims of a new crisis. In geographical areas where VBDs are endemic, the shelter material should ideally be (such as ITPS) pre-treated with an effective insecticide, or the interior surfaces sprayed (IRS) as the shelters are constructed, to provide maximum protection from disease vectors and nuisance insects from the start of the camp occupation. IRS is the recommended first line VBD tool in emergency settings, for control of anopheline mosquitos (malaria and lymphatic filariasis), but will also play a key role in the control of sandflies (leishmaniasis), fleas (plague), mites, bed bugs, and, to some extent, also domestic flies and other mosquito species. IRS can effectively be delivered together with larvicide campaigns across at risk communities, targeting either *anopheles* or *aedes*, or both, mosquito breeding habitats, depending on the identified disease risks, from the earliest stages of the response. Fly control can similarly be instigated from early on, as the commodities required are few, and can be supplied in dry granular forms, and similar to IRS insecticides and larvicides, are relatively light to ship by air. This is in contrast to other VBD tools that are based on insecticide treated materials such as LLINs, LLIC, ITPS and wall linings which are normally manufactured to order, and require

sea freight and road transport. Lead and transport times for VBD chemicals such as insecticide for shelter, IRS, larvicide for water, and fly control growth regulators for treatment of open defecation sites (human and animal) and latrines, and can be relatively short. Procurement to point of delivery can take just a few weeks, if well organised, and local stocks may reduce that time frame.

Food and non-food items are normally delivered at relatively early stages of emergencies, and thereafter, periodically, depending on need. LLINs are often included in these kits but this is not an effective method of LLIN distribution as it is rarely accompanied by adequate IEC to encourage LLIN correct use, and subsequent loss and misuse rates of LLINs are likely to be high. Well planned LLIN distribution campaigns that ensure people understand the intended benefits of the LLINs, hang up and sleep under LLINs every night, and maintain them in good condition, in emergencies and stable settings alike, take significant time to organise and roll out. LLINs normally have long lead and transport times (often several months) for bulk LLIN procurement, requiring advanced planning for delivery, together with targeted IEC campaigns, as a second phase response in emergencies. This may be best timed to follow within the period of the protection (4-9 months, depending on the context) afforded to people initially through a combination of activities such as IRS, and insect breeding site control (larvicide and growth regulators for mosquito and fly control). Use of other treated materials such as curtains, cloths, blankets or hammocks etc. should be determined by the initial VBD risk assessment, according to the context, and diseases present in the emergency setting. For example, use of insecticide treated blankets in emergency phases where shelter materials are not treated, and LLINs are not hung (or cannot be supplied and hung), or in contexts where shelter is not available, may be very helpful for protection against night time biting disease vectors. Treated curtains installed into windows, doorways, and even eaves, may be introduced into local housing and some temporary shelter types, at later stages of humanitarian responses, to augment other strategies (IRS, LLINs, ITPS, wall linings etc.) for the control of vectors that enter houses in the day or night time to bite people.

Vector control tools should be selected based on their suitability for the context, housing type, efficacy against epidemiological parameters, and availability for the time frames needed in the response. Depending on how robust the surveillance system implemented is, limited data prior to the triggering event may mean assessing the impact of the IVM programme on disease outcomes is difficult, and disaggregating the individual contribution of one VBD prevention tool over another, impossible in an operational setting. However, collecting baseline data for entomological indicators and disease incidence and prevalence, then tracking these indicators after the roll out of VBD control campaigns will provide adequate data to track the general progress of the response, overall impact on target vectors and the overall disease incidence at health facilities. Evidence of VBD control efficacy against the vector may be useful in some circumstances but this does not always correlate with impact on disease and so should be viewed more cautiously, if viewed in isolation of health impact data.

5.2.1 Resource planning

Resource assessment and gaps identification is an important step in response planning. Different organisations may have mobilised various resources targeting different groups within the population. Some organisations may be giving LLINs as part of the refugee packs, some shelter may be ITPS, some IRS equipment may already be in the country from other organisations, or insecticide ordered. An inventory of all resources available for vector control should be made during the initial assessment phases (and reassessed regularly) as well as the human, technical and funding resources needed. Costing should be calculated based on a well-defined plan. Using the evidence available at the time of the assessment in order to determine the most appropriate vector control strategy for the response, is an important part of IVM. The organisations with funding for vector control can then assess what they can provide and the proportion they can cover using their available funding. Several factors will affect the vector control prevention approach that is

adopted in each humanitarian setting both technical and practical i.e. length of procurement. Aspects such as the availability of trained workers or available workers for capacity building, the funding available, the density of the population should be considered, as well as whether the population is accessible and accepting of the various methods available.

5.2.2 Guidelines for procuring public health pesticides

Public health pesticide procurement involves significant expenditure as it requires good technical and operational understanding. International organisations such as UNICEF and The Global Fund, and most NGOs, have their own procedures for procurement. Procurement officers are likely to require some specific in-house training and support in relation to procurement and shipping of VBD commodities, as this is a very specialised area, with specific considerations in relation to technical standards, efficacy of the chemical in the specific geographic area, approved suppliers, product formulations, regulatory approvals and shipping requirements.

Pesticide procurement for chemical control of vectors involves several steps: choice of the appropriate product, quantification of the stock requirement, selection of internationally approved suppliers and then the usual organisational procurement procedures. The guidelines below by WHO (2012) gives some guidance notes on this process, explaining what information would be needed in order to procure and have public health pesticides delivered.

All chemicals used in vector control should normally be chosen from amongst those recommended for use as a public health tool by WHO. WHOPES promotes and coordinates the testing and evaluation of pesticides for public health and provides a regularly updated list of recommended tools and products. WHOPES recommendations facilitate the registration of pesticides by Member States. Registration has to take place in each country; without registration of a product in a country's protocol, it cannot normally be procured there.

In emergencies, procedures are in place to enable rapid deployment of tools. Some tools inherently take longer to ship than others. For example, liquid insecticide, as opposed to powder or granular format, will be more difficult to ship as fewer cargo flights will have the facilities to carry it. IRS equipment is light and can be transported on regular cargo planes without needing special clearance. The country's pesticide legislation should have provisions for unregistered public health pesticides (subject to any specific conditions and procedure) to be imported for emergency use, with the permission of the competent authority. Manufacturers can be contacted to determine if they are registered in the country concerned, and if Ministry of Health and pharmacy board institutions are still functional, they can be contacted for information on approvals and potential waivers. This should be done prior to the procurement and shipment of any such commodities or they are likely to be held or detained at the point of entry into the country.

Further Reading

Guidelines for procuring public health pesticides - World Health Organization 2012
http://apps.who.int/iris/bitstream/9789241503426/1/44856/10665_eng.pdf

WHOPES evaluation and tools:
<http://www.who.int/whopes/en/>

5.2.3. Conclusion

Before implementing an IVM programme in an emergency these two questions need to be addressed:

Is vector control likely to be useful? In other words, how great is the disease burden? Where is transmission occurring? What is the risk and does it necessitate a pro-active rather than a reactive response?

Which methods are most feasible (depending on local vector species, access, security, population mobility, human resources, funding, and logistics)?

IVM is a management system that allows flexibility and requires adaptation to take into account conditions and change. The IVM method should follow a cyclical process with multiple rounds of situational analysis, planning, implementation and monitoring.

5.3. Indoor Residual Spraying (IRS)

Target

Anopheles mosquito (Malaria)

Sandfly (Leishmaniasis)

Triatomine bugs (Chagas)

to a much lesser extent also *aedes* mosquitoes (Zika, Dengue)

Flies and other nuisance insects

IRS implementation requires the spraying of a residual insecticide onto the surface of inner walls and sometimes also ceilings, or the underside of the roof and eaves of houses or shelters, in order to kill mosquitoes when they rest indoors following feeding. IRS is useful in specific contexts and requires substantial planning, logistics and resources and therefore particularly suits well organised settings such as transit camps. Hospitals, transit centres and latrines can also be sprayed in a campaign to further protect the population.

IRS is not suitable for protecting individual households scattered over large distances. Shelters with surfaces that cannot be readily sprayed would not be suitable for IRS, e.g. very open structures. IRS is best suited for protecting larger, non-nomadic populations in compact settings (urban settings, towns, camps etc), with housing constructed as enclosed shelters. The effectiveness of IRS will rely on good quality spraying operations (i.e. at least 80% of households in target communities must be properly sprayed) and is typically effective for 3–6 months, depending on the insecticide selected and the type of surface sprayed. IRS implementation will typically require an initial basic mapping activity to determine all the structures in the target area to be covered. Given the operational needs, IRS is most suited to communities to which there is good and safe access at household level and a receptive population.

The effectiveness of IRS depends on the quality of the IRS operations, the timely delivery of effective commodities, on-site expertise and capacity, good organisation and planning, well-trained staff, supervision, and appropriate health communications. Good-quality compression sprayers that comply with WHO specifications must be used for IRS. Compression sprayers are prone to

wear and tear and may need to be imported, together with spare parts and the insecticides. Importation requires time, and adequate planning is important, factoring in potential delays which may take place during the customs clearance procedure. Regular equipment maintenance is important to ensure that compression sprayers are efficient and their working life is maximised, and this will require training of supervisory level staff to ensure that it is carried out as needed.

Timing is the most critical factor in areas of seasonal transmission as at least 80% of shelters must be sprayed with insecticide, ideally before the onset of the expected peak transmission season. Operations that begin after the onset of the transmission season may have a reduced impact on transmission, thus this needs to be stressed when planning project timelines for donors and operations.

Planning steps for IRS campaign

Procurement and storage of equipment

Mapping

Water provision – are there enough clean water sources that can be used for the IRS campaign?

Procure the requirements

Team planning and recruitment from amongst the local communities

Sensitisation of the local authorities and the community

Training of spray team and organising campaign implementation

Monitoring and reporting

Spray teams require at least two days of intensive theoretical and practical training before they can start field operations and these operations must be closely supervised and monitored by experienced IRS campaign staff. WHO has produced an illustrated manual that can be used for the training of spray teams in the field.

Programme indicators to determine the quality and effectiveness of monitoring

Coverage: the number of structures sprayed / number of structures in the target areas (%).

Amount of insecticide used per structure: amount of insecticide used / number of structures sprayed (%) (to measure the efficiency and correct usage of the insecticide).

Maintenance: % of pumps that were correctly maintained and functioning well at the end of the campaign.

Acceptability: % of households that refused to have their homes sprayed.

Further Reading

IRS implementation manual: Indoor Residual Spraying - AN OPERATIONAL MANUAL FOR INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA TRANSMISSION CONTROL AND ELIMINATION. Second Edition (2015)

http://apps.who.int/iris/bitstream/9789241508940/1/177242/10665_eng.pdf

Training manual for IRS sprayers by President's Malaria Initiative (2009):
https://www.pmi.gov/docs/default-source/default-document-library/tools-curricula/irs_training.pdf?sfvrsn=4

WHOPES approved insecticides and equipment for application for IRS:
<http://www.who.int/whopes/equipment/en/> http://www.who.int/whopes/Insecticides_IRS_2_March_2015.pdf?ua=1

Monitoring and evaluation for IRS implementation:
http://www.who.int/tdr/publications/tdr-research-publications/irs_toolkit/en/

5.4 Long-Lasting Insecticidal Nets (LLINs)

Target

Anopheles mosquito (Malaria)

Phlebotomine Sandfly (Leishmaniasis)

Aedes-borne diseases*

* LLINs will not have a significant impact on disease as *aedes* mosquitoes bite mostly during the day with peaks at dusk and dawn. Day sleepers such as children, the old or those who are hospitalised would however benefit from having LLINs, but it would not be a tool for *aedes*-borne disease control alone. There is added value if the LLINs are already in place for malaria control as they can have a double function for protecting day sleepers.

LLINs are distributed to protect against vectors that are active at night and bite indoors. WHO recommends a coverage of 1 LLIN per two persons within a household. This would normally require a combination of campaigns (catch-up) i.e. community distributions, and routine (keep-up) distribution systems i.e. during antenatal consultations to sustain coverage.

In an acute emergency, LLIN distribution should aim for universal coverage of the most vulnerable communities. However, if insufficient LLINs are stockpiled, the highest risk groups should be prioritised. These include all beds/patients in hospitals and therapeutic feeding centres (TFCs), and households of TFC patients on discharge. Other priority groups include pregnant women, children under 5 years of age and populations living in areas of high transmission. Only WHOPES recommended LLINs should be procured for distribution, and country guidelines may have a list of approved and registered LLINs.

If used correctly, LLINs are highly effective in prevention of malaria in most settings and are accepted by malaria-affected communities worldwide. Sleeping under an untreated net provides a physical barrier against mosquitoes only if intact. However, mosquitoes can enter through any tears or holes and can also bite any part of the body that is touching the untreated net. WHO approved factory-treated LLINs retain their biological activity for a minimum period of time and number of washes, currently at least 20 standardised WHO washes and 2-3 years of recommended use under normal field conditions. However, the physical lifespan of a LLIN is highly variable and may require continuous distribution and monitoring, especially in harsh emergency settings.

Pyrethroids are the only class of chemical currently approved for use on LLINs. For other products currently under evaluation see: http://www.who.int/whopes/Products_Under_WHOPES_Evaluation_March_2016.pdf?ua=1. Newer products such as pyrethroid products which have PBO (piperonyl butoxide) adjuvant can be used in areas where pyrethroid resistance has been recorded. PBO acts by inhibiting some metabolic enzymes within the mosquito which detoxify insecticides before they exhibit their killing effect on mosquitoes. Having the PBO would in theory have a greater killing effect in mosquitoes which have that resistance mechanism. The current LLINs

with this function are from Vestergaard <http://www.vestergaard.com/permanet-3-0> and Sumitomo <http://sumivector.com/mosquito-nets/olyset-plus>. These LLINs have been acknowledged by the WHO as being more effective than those with pyrethroid alone. More information on LLINs with PBO can be found here <http://www.who.int/malaria/publications/atoz/use-of-pbo-treated-llins.pdf>. Close mesh (Demuria) LLINs have also been developed for use amongst communities that sleep outdoors, and have proven highly durable in some settings. These are available, but currently only manufactured to order by one manufacturer (www.vestergaard.com).

High coverage (>80%) of LLINs in communities, can also provide mass impact (i.e. provide some protection for those not sleeping under LLINs) by reducing the vector burden. If the insecticide on the LLIN is effective, it will have a killing or disabling effect on mosquitoes and other biting vectors (e.g. lice, fleas, ticks, sandflies) and so can be an IVM tool in areas where, for example, both mosquitoes and sandflies are disease vectors, or against sandflies alone. As sandflies are much smaller than mosquitoes, a small mesh size for the LLIN should be chosen.

Rigid or durable dwellings, e.g. mud huts, are most suitable for hanging LLINs, whilst tent structures are more difficult as their size or construction may not be suitable.

Planning steps for LLIN campaign

Assessment

Selection and Training of Workers

Transportation and Storage

Mobilisation and Awareness (IEC / Behaviour Change Communication)

Distribution

Supervision and Monitoring

It is important to organise and implement an effective community promotion campaign prior to distribution of LLINs. Good logistics are crucial for a successful LLIN distribution and the delivery system must be appropriate and well planned, with adequate information on the population size and location of houses. Procurement of LLINs can take several months as they are delivered by sea freight, thus ordering should begin as early as possible. Programme planning should factor in transport time and potential delays for importation procedures.

There are several ways to distribute LLINs, some more effective than others. In emergencies, mass distribution is an optional method, where beneficiaries are invited to a central location to receive LLINs. It also provides an opportunity for delivering IEC activities at the central distribution location, to the population while they wait to receive their LLINs. Another approach is a “hang-up and use” distribution where LLINs are installed on site by distributors. Although this method is slower, it often achieves greater levels of retention and use of the LLIN.

The problem of beneficiaries reselling their LLINs is encountered regularly. To reduce this, each LLIN should be removed from its packaging and marked with an ID number or name, linked to the receiving household. LLIN reception should also be signed for by the head of the household. Some LLINs are made with individual identifiers which assists the monitoring and evaluation of LLIN distributions.

Programme indicators to determine the quality and effectiveness of monitoring

There are standardised indicators to be recorded in order to determine the success of an intervention. Most of these indicators are operational indicators and are not designed to determine the health impact of an intervention.

Coverage: number of LLINs distributed/target population size (%);

Usage rate: number of people using LLINs/number of people given LLINs (%);

Retention rate: number of people retaining LLINs/number of people originally given LLINs (%);

Net failure rate: average number of holes per LLIN following WHO criteria as given in the WHO guidelines on monitoring LLIN durability.

Indicators of survivor, attrition, and failure of LLINs are defined further in

http://whqlibdoc.who.int/publications/2011/9789241501705_eng.pdf

Further Reading

Guidelines for monitoring the durability of long-lasting insecticidal mosquito nets under operational conditions (WHO, 2011)

<http://www.who.int/malaria/publications/atoz/9789241501705/en/>

LLIN tracking tool:

<http://www.rollbackmalaria.org/toolbox/tool-search#!/37/view>

5.5. Insecticide-treated materials

Target

Anopheles mosquito (Malaria)

Phlebotomine Sandfly (Leishmaniasis)

Triatomine bugs (Chagas)

Flies (Trachoma, diarrhoeal diseases)

Displaced populations may make some traditional vector control tools obsolete, especially in the acute phases of an emergency. Displaced populations have specific needs due to the lack of housing and, depending on the emergency, potentially being mobile. This differs drastically from communities in more stable environments when it comes to vector control. Insecticide treatment of materials such as tents, blankets, sheets, clothing and curtains may be more acceptable and feasible for displaced populations than conventional interventions. These insecticide treated materials are recommended for use in some emergency settings.

Insecticide- treated plastic sheeting (ITPS)

Tents, pre-treated with insecticide, have previously been manufactured and tested, but are not currently commercially available. Use of ITPS, or IRS or untreated plastic shelter material are the recommended alternatives.

Plastic sheeting is routinely provided in the early stages of humanitarian emergencies to enable affected communities to construct temporary shelters. ITPS is three-layered laminated polyethylene tarpaulin, of which the middle layer has been treated with insecticide during the manufacturing process. The insecticide then slowly migrates to both surfaces of the plastic. ITPS has the same mode of action as IRS against *anopheles* mosquitoes, killing indoor resting insects. However, it also kills insects that rest on the outside of shelters, and is therefore very useful for fly control in camp settings. ITPS is most effective when used to construct all the walls of a shelter, and ideally also the ceiling. ITPS is also useful for construction of latrine shelters, as it helps to reduce flies and culex mosquitoes that otherwise breed in or near by latrines.

Long-lasting insecticidal blankets and clothing

These are commercially available, and they use permethrin insecticide which is safe for skin contact, though has reduced efficacy against insects in many geographical areas. Products with alternative classes of insecticide are not currently available or recommended.

Insecticide treated targets

For Tsetse fly control – Appropriately coloured sheets either untreated or impregnated with insecticide: the colour attracts the tsetse vector, which becomes trapped in a mesh section of the trap, and desiccates and dies in the sun. Insecticide treatment is not required, but when used may augment the efficacy of the traps still further. This method has been used in many countries to suppress tsetse population. Traps are simple and highly effective, and can be manufactured locally and then deployed and sustained by communities themselves, with very limited support needs.

Further Reading

http://www.who.int/trypanosomiasis_african/vector_control/en/

Kimani E et al 2006

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1555594/pdf/1475-2875-5-63.pdf>

Malaria Control in Humanitarian Emergencies (WHO, 2013)

<http://www.unhcr.org/456c11bd4.pdf>

5.6. Larval source management (LSM)

Target

Aedes mosquito (Zika, Dengue, Chikungunya, Lymphatic Filariasis and Yellow Fever)

Black fly (Onchocerciasis)

Anopheles mosquito (Malaria)

55 Phlebotomine sandfly (Leishmaniasis)

LSM targets insects that breed in well identified, and easily accessible sites. Used alone, LSM may not provide adequate levels of disease reduction, but is very useful in supplementing other vector control methods as part of IVM. It has the added utility of being able to control several vector-borne diseases (cost effectiveness measure) if well implemented.

Figure 20: Community workers delivering chemical larvicide to household water storage containers (The MENTOR Initiative).



Larval source management (LSM) is the targeted management of vector breeding sites, with the objective of reducing the number of vectors in the early developmental stages (larvae and pupae). LSM can therefore contribute to reducing the numbers of both indoor and out-door biting vectors making it a particularly effective tool when implementing vector control using IVM. LSM is the principle strategy for control of *aedes* mosquitos. In malaria and leishmaniasis control pro-grams, LSM can be used in conjunction with other programme tools to reduce the mosquito and sandfly populations in disease hotspots.

In an emergency setting, larviciding even large water sources is feasible in a relatively short amount of time, as outlined in Case One: Aceh, Indonesia. This, alongside IRS and ITPS, proved to be an effective IVM strategy to control dengue and malaria.

Figure 20: Community workers delivering chemical larvicide to open mosquito breeding sites using hand-operated sprayers for liquid insecticides (The MENTOR Initiative)



There are four types of larval source management programs:

Habitat modification

involves a permanent change of land or water sources to prevent insects from using these as breeding sites. This can include draining surface water, covering large water storage containers (e.g. wells) with mosquito-proof lids and permanent slabs, building covered areas for potential breeding sites (e.g. shelters for tyres) or the complete coverage of water/waste fluid surfaces with a material that is impenetrable to mosquitoes such as expanded polystyrene beads.

Habitat modification

is a recurrent activity that includes water-level manipulation, drain clearance, proper disposal of rubbish as well as regular emptying and cleaning of domestic water storage containers and accidental water containers (e.g. flower pots, jars).

Larviciding

is the regular application of biological or chemical insecticides or biological agents to larval habitats. These normally target the aquatic stages of the vector, and are used to treat large water storage containers that cannot be manually emptied and cleaned every week.

Biological control

involves introducing a biological agent (fish or crustacean) which feeds on mosquito or other vector larvae into breeding sites, mainly water bodies.

Emergencies and emergency responses can generate risk through the creation of multiple surface water and waste water sites (e.g. installation of poorly drained emergency water distribution facilities, tanks and tap stands in arid zones). Newly displaced populations may inadvertently create insect vector breeding sites (e.g. through digging borrow pits for house construction, or water holes for cattle). Sudden environmental changes can create new breeding sites. *Anopheles sundaicus* was observed breeding more frequently in water formations caused by the 2004 Asian tsunami (see Case Study One: Aceh, Indonesia).

Larval control should only be considered where vector breeding sites are limited in number, relatively permanent, and can be easily identified and accessed (few, fixed and findable)²⁶. In semi-arid settings, this may be suitable in urban and rural settings. However, in tropical countries this would normally be limited to urban and peri-urban areas; in rural areas breeding sites tend to be widely dispersed and difficult to find, limiting the efficacy of larviciding as a vector control strategy in such settings.

Only WHO-recommended larvicides that are safe for humans or animals should be used for larvicide campaigns. Treatment cycles will need to be determined. They will vary depending on the properties of the chemical selected, as well as mosquito species, seasonality of transmission, rainfall patterns, and types of breeding site. Operational experience has generally shown that two to three treatments per year are likely to be required. These applications need to be carefully spaced between periods of rainfall. However, more frequent treatments will be required depending on water quality and exposure to sun. These elements will be determined from the results of the initial assessments for vector control implementation.

Personal protective clothing and visors are required for all workers involved in the application of insecticides for IRS, but for granular larvicide application are more minimal. Storage of all pesticides, should be separate from drugs and other non-related commodities. Stores should be secure, well ventilated, not sun lit, and with a concrete floor to avoid damp. Waste disposal of any chemical packaging or leftover insecticides and larvicide requires a clear plan to avoid subsequent misuse of packaging, or contamination of local water sources.

²⁶ http://www.who.int/malaria/publications/atoz/interim_position_statement_larviciding_sub_saharan_africa.pdf?ua=1

Further Reading

An operational manual has been produced by the WHO entitled - Larval source management – a supplementary measure for malaria vector control. An operational manual (WHO, July 2013)
<http://www.who.int/malaria/publications/atoz/9789241505604/en/>

WHOPES approved larvicide

http://www.who.int/whopes/Mosquito_Larvicides_25_Oct_2013.pdf

Malaria control in humanitarian emergencies. An inter-agency field handbook, Second edition
<http://www.unhcr.org/456c11bd4.pdf>

Emergency vector control using chemicals. Christophe Lacarin and Bob Reed, Water, Engineering and Development Centre Loughborough University 1999:

http://ec.europa.eu/echo/files/evaluation/watsan2005/annex_files/WEDC/evc/evc.pdf

5.7. Ultra-low volume spraying/fogging/ space spraying

Target

Adult insects that fly or rest outside during the daytime (*aedes* mosquitoes, sandflies, domestic/filth flies)

Ultra-Low Volume (ULV) spraying, commonly known as fogging, is a method of spraying pesticide into the atmosphere in built up urban or camp areas. It targets adult insects that are either flying or resting outside when the spray is conducted. The potential value is limited, suppressing epidemics at their early stage. The spray mixture is composed of diesel or other diluents together with a pesticide to kill adult insects. Space sprays are applied either as thermal fogs (10–50 l/ha) or as ultra-low volume applications in the form of a cold aerosol of droplets of controlled size ~20 µm at 0.5–2.0 l/ha.

Spraying a maximum of 1-1.5 km radius from the epicentre of outbreak is adequate. The duration of control measure should be limited to the disease transmission period to keep cost as low as possible. It must be used only for a limited period in clearly identified area²⁷. For rapid reduction in vector density, space treatment should be carried out every two to three days for ten days followed by further applications once or twice a week to sustain suppression of the adult vector population.

²⁷ http://karhfw.gov.in/PDF/Guideline_Fogging.pdf

Figure 21: Spray operator conducting fogging (The MENTOR Initiative)



The pesticide is delivered using a mechanical back-pack mounted or vehicle-mounted thermal or cold fogging machine. In emergency situations, ULV spraying may be considered for diseases such as dengue fever and other *aedes* borne diseases during epidemics. ULV, if deployed, must be repeated regularly over at least two weeks, in order to have any significant impact on the adult insect population. Professional entomological expertise is required if consideration is given to deploying this strategy. As ULV spraying targets only the adult insects, its use should always be accompanied by the other more sustainable and effective IVM strategies that target larval stages (i.e. LSM) and other potential personal protection approaches.

Fogging operations require strong management to ensure correct formulations. The target vector should be monitored to ensure the fogging is conducted only when the adult insects are active and accessible. Fogging should only be implemented by adequately trained staff, using WHO recommended pesticides, and as with IRS, good documentation of areas sprayed, and pesticide used is important. Equipment cleaning and maintenance are all essential. Fogging should generally only be considered in exceptional circumstances.

Further Reading

http://apps.who.int/iris/bitstream/1/68057/10665/WHO_CDS_WHOPES_GCDPP_2003.5.pdf

5.8. Water, Sanitation and Hygiene

During a humanitarian response, it is vital to address the WASH issues early as possible, especially additional activities related to reducing vector populations. In the early stages of an emergency, existing water and sanitation services may be severely disrupted. In some settings there may be no provisions in place for water and sanitation, i.e. population displacement. Rats, flies and other flying vectors are attracted to rubbish and poor sanitation conditions. Rainwater collects in any waste containers such as tins, plastic bags, old tyres etc, if they are not removed and destroyed or buried. *Aedes* mosquitoes will breed in the containerised water and increased transmission of *aedes*-borne diseases will occur.

Sanitation for fly control

Non-biting flies spread disease through mechanical transmission. If, for example, flies land first on human waste then on food to be eaten, diseases present in faeces can be transmitted when the food is ingested. Flies move quickly from faeces and rotting waste to exposed food and utensils, causing rapid spread of disease. Many of the organisms responsible for diarrhoeal disease, the second leading cause of death in children under five years old, are spread by flies landing on food. It is therefore essential that food stores are protected. During emergencies, waste sites in cities and open defecation sites need to be managed or treated.

Fly control within a camp type setting aims to:

Prevent access of flies to latrines/toilets

Treat (chemical insect growth inhibitors) open defecation sites, or open latrines

Destroy / remove other fly breeding sites (mainly managing rubbish and open defecation sites)

Eliminating contact between flies and children, food, and utensils

Waste management is under the directive of WASH cluster. In order to carry out specific activities for fly control therefore, this cluster would need to be consulted and appropriate permission obtained from the camp management.

In camps, latrines may be insufficient in number or incorrectly used; addressing these two issues should therefore be of paramount importance. Regular cleaning of the latrines should be organised to prevent them becoming a source of disease transmitting vectors as well as to minimise odour. Latrines also require a lid which should be in place whenever the latrine is not being used to keep out flies; Ventilated Improved Pit (VIP) latrines are the best design and help to reduce fly numbers. Expanded polystyrene beads can also be applied to water sources and pit latrines to inhibit insect breeding.

Domestic waste removal

In humanitarian crises, where waste removal may not be feasible, a recommended method is disposing of solid waste in a pit positioned away from living areas. Day-to-day rubbish and organic waste are the perfect breeding grounds for flies and must be managed properly for effective control. Waste can also collect water and become a breeding site for vectors such as mosquitoes.

Solid waste should be disposed of regularly, at least twice a week. However, in developing countries where feasibility is limited, strong community participation is required to ensure that household waste and any potential breeding sites are properly managed. This involves clearing up the rubbish into waste sites and either burning it, or covering it in a layer of earth to prevent flies breeding in it. Alternatively, pits should be sited at least 2 km (the maximum flight distance of most insects) away from residential areas.

Waste collection will require organisation of vehicles for transportation from households to waste sites and the human resources to carry out this activity. This is one of the more important activities in an urban setting as breakdown in regular public health measures such as waste collection, can result in large vector burden and increased disease transmission.

Waste items that act as containers amongst the domestic waste in households and the surrounding environment can collect and hold water long enough to create very viable breeding sites for some mosquito types. As outlined under the LSM section, containers that collect water either deliberately (drinking water storage containers) or accidentally (used plastic jars, bottles, cans, tyres, buckets, coconut shells etc.) provide perfect environments for *aedes* and sometimes *culex* mosquitoes to lay their eggs. All waste containers which may accumulate rain water must be thrown away, turned over, emptied or stored under a roof to prevent them filling with water. Household containers required for day-to-day use need to be emptied and scrubbed out to ensure that any eggs laid on the sides are removed, at least once a week. Tight lids or fine mesh can be used to prevent mosquitoes entering the container and laying eggs on the water surface. For *aedes*-borne diseases, e.g. dengue and Zika, this approach can achieve rapid reduction of insect populations and disease reduction, if conducted by the majority of households in urban / camp areas, every week, and sustained throughout the transmission period of the target disease.

This type of programme relies upon large scale community participation using trained supervisors to sustain household participation, reinforce and monitor the activity every week. This activity should be integrated with waste management across the same community. In the absence of any waste management services this can be achieved with volunteers conducting periodic waste/clean-up activities.

Further Reading

Minimum standards for solid waste management in humanitarian emergencies can be found at: <http://www.spherehandbook.org/en/solid-waste-management-standard-1-collection-and-disposal/>

http://www.unicef.org/cholera/Annexes/Supporting_Resources/Annex_9/WHO-tn7_waste_mangt_en.pdf

Sanitation and fly control

Sanitation falls under WASH (water supply, sanitation and hygiene) cluster during an emergency. This cluster will plan and install latrines as well as water supplies for the population according to Sphere standards: <http://www.spherehandbook.org/en/how-to-use-this-chapter-1/>. These minimum standards also cover standards for vector control and for shelter to reduce contact of the population with flies.

Ideally, latrines should be placed at least 6m from living area; if no latrines are available, e.g. early in an emergency, open defecation areas should be 500m away from living areas and 30m away from water. Full specifications for sanitation and latrine minimum standards are outlined in the Sphere handbook link above. If open defecation occurs, then it should be regularly treated with insect growth inhibitors to prevent flies from breeding in the human waste material (as their flight path exceeds 1 km) and spreading disease (i.e. trachoma, diarrhea, and worms).

Correctly designed pit latrines, e.g. VIP latrines to reduce fly entry, as well as good management of latrines and regular cleaning, will ensure minimal growth and spread of diseases through flies and other vectors. To keep the VIP free of flies and odours, regular cleaning and maintenance are required. Dead flies, spider webs, dust and other debris should be removed from the ventilation screen to ensure a good flow of air.

It is important to maintain VIP latrines as they are susceptible to failure/overflowing during floods. Stagnant water in pits may promote insect breeding.

Further Reading

<http://www.spherehandbook.org/en/excreta-disposal-standard-2-appropriate-and-adequate-toilet-facilities/>

Reducing contact with flies:

Installing screens in eating areas and healthcare facilities reduces the number of flies which enter. This can be done using screening on windows and doors or hanging beads in the entrance. Excluding flies from food, food preparation and eating areas is crucial. Proper storage containers for food will ensure flies have no contact with food, helping to reduce disease transmission as well as fly proliferation. Fly traps can also be used to capture and kill flies that land on them. In camps and other emergency settings, simple sticky paper traps hung from ceilings in food preparation areas are an inexpensive option, are quite effective, and just need regular replacement.

5.9.

Source reduction

Source reduction is the elimination of sites or containers that are favourable for oviposition (egg laying) and development of the aquatic stages of vectors. There are different ways of accomplishing this from fitting lids or covers on containers to chemical methods. Other methods can include domestic waste collection and clearing round the populations households.

Vector-proofing of water-storage containers:

In developing countries, there are limited functional water systems; household water, including drinking water, is stored in artificial containers of varying sizes. These water-storage containers provide perfect breeding sites for mosquitoes and other disease vectors. For example, eggs laid by female *aedes* mosquitoes on the water surface develop into larvae. In order to break this cycle, the water container should be covered with a tightly fitting lid. Lids can be an effective tool when used at public health scale, but this is easier to achieve in contexts where water containers are uniform. This is more commonly the case in Asian countries than in African countries.

Other ways to cover containers include using mesh or material with elasticated edging to hold the material in place. Expanded polystyrene beads can also be used if the containers empty from the bottom. Water containers that cannot be covered have to be emptied and the sides scrubbed out to remove any eggs.

Water management

Surface water is an important source of larval habitat for various vectors, especially mosquitoes. Waste and sewage systems, swamps and flooded areas can be sources of surface water where flies, and culex mosquitoes can lay their eggs. Waste and sewage disposal is essential for keep-ing vector burden minimal.

Water-storage containers can be designed to prevent mosquitoes from laying eggs on the surface of the water; water containers should also be covered with materials which prevent flies from entering. Containers can be covered with tightly-fitted lids or mesh screens to allow for rainwater to be harvested from roofs while keeping mosquitoes out. Removable covers should be replaced every time water is removed and should be well maintained to prevent damage that allows mosquitoes to get in and out. Household containers can also be covered with materials that prevent entry of mosquitoes or flies.

Larger containers, or permanent containers that cannot be emptied, need to be treated with larvicide or tools such as polystyrene beads. Expanded polystyrene beads used on the surface of water can prevent mosquitoes from laying eggs there. The water containers can be covered in Insecticide-Treated Plastic Sheeting (ITPS) materials or other mesh material. Again, mesh material allows rain water to be collected without the container becoming a breeding site.

Chemical management – Larvicide or Insect Growth Regulators (IGRs)

Flies, as well as mosquitoes, can be controlled using chemicals to treat human, animal and domestic waste. Good planning and management are required to ensure effective and timely application of chemicals. Activities should be coordinated with WASH and camp management partners. WHO-recommended IGRs such as dimilin, pyriproxifen, or larvicides, should be applied as per manufacturer specifications.

Further Reading

http://www.who.int/whopes/Mosquito_larvicides_March_2016.pdf?ua=1.

Factors to take into account when conducting a chemical fly control programme of larviciding:

The quantity of water should be sufficient to thoroughly wet the upper 10-15cm of the breeding medium

The granular formulation can be applied directly to breeding sites, like faeces, with suitable granule spreading equipment, or by hand. It is recommended to only use the granular formulations in wet fly-breeding sites, or to additionally wet the surface to ensure disintegration of the granules.

Repeat treatment every 2 to 6 weeks, depending of product specification

When a fly control programme starts on a population with many adult houseflies, the first di-flubenzuron application should be combined with an adulticide to immediately block the developmental cycle of the houseflies.

6.

Insecticide resistance

²⁸ <http://www.irac-online.org/about/resistance/>

Insecticide resistance can be defined as “a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species²⁸.”

Tools for insecticide resistance testing:

Guidelines can be found at: <http://www.who.int/malaria/publications/atoz/9789241505154/en/>. A short description of the approved tools for vector surveillance at a field laboratory level are summarised below.

WHO susceptibility test is used for monitoring resistance in adult mosquitoes. Mosquitoes are generally exposed to the insecticide for one hour and mortality is assessed after 24 hours. This approach is designed to avoid spurious reports of resistance in the field where none may exist. The kit/papers with instructions can be purchased here:

www.who.int/whopes/resistance/en/

CDC (Centre for Disease Control) bottle assay is used to detect resistance to insecticides in mosquitoes and other insects. A diagnostic dose is calculated at the start of the monitoring programme using a rate range study. CDC will provide, at no cost, premeasured amounts of WHOPES-approved IRS and LLIN insecticides, sufficient to conduct approximately 100 bottle assays for each.

http://www.cdc.gov/parasites/education_training/lab/bottlebioassay.html

Tests for resistance in larval stages are outlined here:

http://apps.who.int/iris/bitstream/10665/69101/1/WHO_CDS_WHOPES_GCDPP_2005.13.pdf

Chemicals are central to vector control. When vectors are exposed repeatedly to the same class of insecticide, they gradually develop resistance to that insecticide. This means that over time the same dose of insecticide will not kill as many or any of the target vector.

Only one class of chemicals (pyrethroid) is currently approved for use in LLIN but increased coverage of LLIN in recent years has led to increased exposure of mosquitoes to this chemical class, with resistance developing, as noted in the IR mapper tool, see: <http://www.irmapper.com/>.

Because of growing resistance to chemical vector control methods, there is an increasing amount of information on the prevention and management of insecticide resistance in vectors of public health importance. <http://www.irc-online.org/> is a useful resource for looking at the latest information on insecticide resistance in these chemicals.

In any vector control programme implementation, including in humanitarian emergencies, mitigating insecticide resistance should be an important aspect of the decision making process. For example, rotating pesticides in a protracted emergency. Background information on the insecticide resistance is important to avoid procurement of tools that will have no impact.

IVM can be employed to help mitigate the effects/reduce the risks of insecticide resistance. The Durham toolkit, the WHO handout, and GPIRM are all good sources of information on this.

The IR mapper tool collates results from WHO approved tests for insecticides as detailed above. There are only two, approved insecticide susceptibility tests for adult mosquitoes: WHO and CDC tests which can be conducted at a local laboratory level. <http://www.irmapper.com>

Strategies for insecticide resistance management as outlined by the Insecticide Resistance Action Committee (IRAC):

Rotation Method

Strategy based on the **rotation method**, over time, of two or more insecticide classes with different Modes of Action (MoA).

Mixtures Method

Using a single formulation containing two or more insecticides, or applying different insecticide formulations in the same spray tank, or LLIN or Insecticide Treated Material (ITM) treated with two or more insecticides with different MoA. This could be, for example, the combination of an LLIN or ITM with an IRS application in the same dwelling.

Fine scale mosaic method

using spatially separated applications of different MoA insecticides against the same mosquito population. For example, this could involve using two different MoA insecticides in different dwellings within the same village.

Insecticide resistance requires strong management and leadership during all stages of vector control implementation. In the acute stages of implementation, sustainability and insecticide resistance may be difficult to plan for, however it is essential to do this, especially in protracted emergencies.

Further Reading

http://apps.who.int/iris/bitstream/9789241508247/1/145673/10665_eng.pdf

CASE STUDIES

The five case studies presented here are used to show how Integrated Vector Management (IVM) in emergencies can be implemented in practice. The case studies are taken from the MENTOR Initiative's response to different emergencies and detail the diseases targeted and the tools used.

Case Study One

Aceh, Indonesia

Background

Indonesia had been undergoing a conflict between the Free Aceh Movement (FAM) and the government. The FAM aimed to make the province of Aceh independent from Indonesia. Since the beginning of the conflict in 1976, over 15,000 civilians were killed due to regular armed clashes and violence in Aceh. Security crackdowns by the government in 2001 and 2003 resulted in thousands of civilian deaths. The government began launching offensives into Aceh territory in November 2003 and a state of emergency was declared.

VBD (Vector-Borne Disease) background

The main VBDs of importance in Indonesia are malaria (transmitted by *anopheles* mosquitoes) and dengue fever (transmitted by *aedes* mosquitoes). Japanese encephalitis and lymphatic filariasis (transmitted by *culex* mosquitoes) are also diseases of importance in particular places. Indonesia is the only country listed as having endemic schistosomiasis in the WHO's South-East Asia region.

Trigger event

On December 26, 2004, an earthquake in the Indian Ocean caused one of the most destructive tsunamis of modern times. The earthquake's epicentre was off the west coast of Sumatra, Indonesia. The tsunami hit 13 different countries in both Asia and east Africa of which Indonesia was the worst affected. In Aceh, more than 120,000 people died; another 40,000 were declared missing; an estimated 500,000 people were made homeless. The rainy season immediately followed the tsunami, resulting in extensive flooding.

Situational analysis

Within weeks of the initial mass flooding and destruction in Aceh, VBDs, primarily malaria and dengue fever, posed the greatest communicable disease threats to highly vulnerable survivors living in Banda Aceh and along the whole west and east coast of the province. The extensive flooding increased potential breeding sites for the mosquitoes vector. The Ministry of Health (MoH) in Aceh was severely affected by the crisis: the majority of their communicable disease control team was killed, and all previous supplies and equipment were destroyed. Their capacity to respond was minimal.

On January 5, 2005, NGOs, donor organisations and commercial partners reached a united decision to launch a dengue fever and malaria prevention response in the 21 districts of Aceh. To support the MoH and the large humanitarian community responding to the tsunami, the MENTOR Initiative sent an emergency team into Aceh on January 7, 2005.

Response to VBDs

- The MENTOR Initiative trained a large, MENTOR spray team. Trained sprayers then worked in pairs to mobilise and train community sprayers across all areas at risk. Almost 200 MENTOR/ community IRS sprayers were in operation at any one time throughout the emergency phase, working systematically through targeted communities. Over 40 Indoor Residual Spray (IRS) supervisors were trained to supervise teams of sprayers for malaria control; some sprayers were also trained in larviciding for dengue control.
- Over 30,000 structures and family units were sprayed in Aceh Besar District and City of Banda Aceh, protecting a population of over 277,500; 13 IDP camps were also sprayed, protecting a further 36,500 people. 98 villages in West Coast Districts were also sprayed.
- 15,000 Insecticide-treated plastic sheeting (ITPS) were distributed to the affected populations, part of this supply was distributed to other NGOs, e.g. Oxfam, who were more directly involved in shelter provision to the displaced people. ITPS provided temporary shelter as well as protecting the people living in them from *aedes* mosquitoes.
- 874 Long-Lasting Insecticidal Nets (LLINs) were donated to International Committee of the Red Cross (ICRC) to distribute. These nets were distributed in paediatric and maternity wards and in some households.
- Larval Source Management (LSM): Larviciding activities were conducted using WHO-recommended larvicide throughout the districts of Aceh. Over 48 large water bodies or lakes were identified around IDP camps and barracks and treated (Mosquito breeding sites).
- Community mobilisation and education about malaria and dengue is a vital component of any long term disease control effort. IRS teams ensured that communities received basic malaria and dengue control education whilst their homes were being sprayed; (KAP) studies were conducted to determine gaps in knowledge.

IVM Approach

Diseases: Malaria, Dengue

Vector control tools integrated: ITPS, IRS, LLIN, LSM

This response was a hallmark of IVM: vector assessment was conducted prior to any implementation activities. Decisions on which vector control tools to implement were made in collaboration with the MoH and the different emergency response sectors (shelter, health, sanitation). The activities targeted two diseases: malaria and dengue; IRS and LLINs were used mainly to control malaria and LSM was used for mosquito larval stages which would protect against both Malaria and Dengue mosquito vector. An immediate response was required to mitigate further increases in disease transmission by targeting both the adult vector and the larval stages in the case of the malaria *anopheles* mosquito.

As was feasible monitoring and evaluation, baseline data was undertaken prior to implementation of activities however as paper based reporting had been in place and several facilities destroyed coupled with the fact that prior to the trigger event there was poor reporting of data and low usage of facilities among fever patients. Prior to the tsunami, few fever patients attended health facilities; paper-based records were for the most part destroyed during the tsunami, leaving little in

the way of baseline data before IVM activities were implemented. Community prevalence surveys and clinical fever surveys were undertaken in June and July 2005, with local health authorities to begin to increase monitoring and surveillance of malaria and dengue.

Impact/Results

These activities allowed the epidemic risk of malaria and dengue to be mitigated. Giving health-care workers training in case management and diagnosis, allowed prompt treatment of cases. It is estimated that through this coordinated inter-agency response, over 700,000 at risk persons were supported.

Further Reading

<http://odihpn.org/magazine/editors-introduction-indian-ocean-tsunami/>

<http://journals.plos.org/plosntds/article/metrics?id=10.1371/journal.pntd.0002449>

Case Study Two

Port au Prince, Haiti

Background

After gaining independence from France in the early 19th century, Haiti has experienced decades of poverty, environmental degradation, violence, instability and dictatorship ever since and is currently ranked the poorest nation in the Americas. In 2004, the United Nations Stabilization Mission in Haiti (MINUSTAH) was established to support the a transitional government, improve stability in the country and promote democratic elections. Due to its geographical location, Haiti is vulnerable to natural disaster: between 2001 and 2007, tropical cyclones and floods caused more than 18,000 deaths and caused 132,000 persons to be homeless. Approximately 6.4 million people - 64% of the population - were affected during this period.

Trigger Event

On January 12, 2010 Haiti was hit by an earthquake, the worst natural disaster in Haiti's history. Official statistics from Haiti's Civil Protection Department report that an estimated 220,000 people died, over 300,000 were injured and 1.5m people became homeless and were displaced across 1,191 sites.

At one point, over 600 organisations were providing humanitarian aid to Haiti of which 274 were conducting health-related activities across 15 regions of the country. Immediately following the earthquake, the first priority was to rescue people buried in rubble and to provide immediate emergency care for trauma patients. After the initial search and rescue period, the Health Cluster was well-established and several subgroups were created in order to best meet the needs of the population. A vector-borne diseases and Epidemiological Surveillance system was put in place with activities targeting malaria and dengue. Despite the presence of many organisations and resources, the lack of clear direction from the Haitian Government and communication between these organisations resulted in a slow, uncoordinated response in which several areas of need were neglected whilst others were duplicated.

Vector control activities

The Mentor initiative began working in Haiti at the end of February 2010. Mentor first signed MOU (Memorandum of Understanding) with the Ministry of Health (Ministère de la Santé Publique and Population) and other partners such as Population Services International (PSI) and AmeriCares. This helped to define clear roles and activities and to build strong operational relationships with other NGOs within the response (e.g. IOM, UNICEF, CDC) and key departments in Haitian government units.

On an operational level, the MENTOR Initiative prevention and medical teams conducted all the micro-planning necessary to ensure smooth programme implementation in order to improve national malaria and dengue control activities and ultimately reduce the burden of disease in Haiti. MENTOR took full leadership responsibility of the VBD-working group. This allowed coordination of VBD control activities within the response activities.

Training was first put in place to improve the knowledge and standard of delivery for malaria and dengue prevention, control and case management.

The programme team delivered 30 comprehensive training workshops to 612 individuals for 41 partner organisations. Training covered topics such as malaria case management, malaria and dengue prevention activities, and effective long-lasting insecticide-treated net (LLIN) distribution. Participants included all those conducting activities linked directly or indirectly to crosscutting malaria control activities (Water, sanitation and hygiene (WASH), health, camp managers, Information, Education and Communication (IEC) and distribution teams). Focus was on the Haitian vector behaviours and how to conduct a successful LLIN distributions.

These activities were implemented before equipment arrived. Between April and May 2010, an in-depth gap analysis was conducted, the results of which dictated the direction for the VBD group to take and the urgent needs to address.

Nationwide LLIN guidelines were produced and distributed to all organisations within the vector control working group. Mapping and demographic verification was completed with entomological surveys. This helped to make evidence-based decisions and to select appropriate and effective tools. High priority communities and households members were also identified i.e. children under 5 and pregnant women. In direct coordination and cooperation with the DPSPE (Department for the Promotion of Health and Environmental Protection), MENTOR was able to implement the Baseline Entomological Survey for Dengue across the earthquake-affected areas of Haiti. This survey involved the detailed mapping of breeding sites and larvae collection for insecticide sensitivity testing.

Vector control tools implemented

- IEC materials were developed on malaria and dengue prevention and on the tools that would be distributed.
- Camp management committees were briefed on LLINs and IRS activities to follow.
- Over 500,000 LLINs from different organisations were distributed
- Over 6,500 Insecticide impregnated curtains and 3.400 insecticide treated plastic sheeting were distributed
- Larviciding of *aedes* mosquitoes and fly breeding sites in IDP camps to control mosquitos and flies (diarrhoeal diseases).

- IRS of over 9000 shelters.
- Larviciding of *aedes* mosquitoes and fly breeding sites in IDP (Internally Displaced Persons) camps to control mosquitos and flies (diarrhoeal diseases).
- IRS of over 9000 shelters.

IVM Approach

Diseases: Malaria, Dengue

Vector control tools integrated: LLIN, IRS, ITPS, LLIC

Working in collaboration with local health actors as well as NGOs allowed vector control efforts to be coordinated. Entomological surveys and insecticide sensitivity surveys conducted allowed evidence-based decisions to be made.

From the gaps analysis, the appropriate tools that could be implemented were selected and a review was made of tools that had already delivered to the country e.g. over 300,000 nets from different partner organisations.

Advocacy, social mobilization, and empowerment of communities are important aspects of IVM. These aspects were addressed during the Haiti humanitarian response. KAP surveys were conducted to determine the targeting of IEC materials.

Further Reading

http://eeas.europa.eu/delegations/haiti/documents/page_content/keys_facts_and_figures_about_eu_humanitarian_response_in_haiti_en.pdf

Case Study Three

Yangon, Myanmar/ South-East Asia Region

Background

Civil wars have been a constant in Myanmar (formerly Burma) since it gained independence in 1948. Fighting consisted mainly of struggles for ethnic and sub-national autonomy, with the areas surrounding central districts of the country serving as the host setting for most of the conflicts. The country was under military rule between 1962 and 2010.

Trigger Event

On May 2, 2008, cyclone Nargis hit Myanmar, leaving at least 130,000 people dead in what has been described as the worst natural disaster to affect the country. The destruction caused by the cyclone and consequent disruption to all services became a risk factor for increases in infectious diseases.

Response to VBDs

The weekly epidemic surveillance system, “Early Warning and Rapid Response system (EWAR), detected no major outbreaks of any infectious disease in the cyclone affected areas during the months following May 2. In particular, the incidence of malaria and dengue remained low. However, conditions conducive to dengue transmission following cyclone Nargis indicated a high risk of epidemics in many parts of Yangon and Ayeyarwady division: these areas were affected by heavy flooding and damage to buildings.

Initial assessments identified a need for greater human resources in order to be able to respond to any dengue or malaria outbreaks. Capacity building activities were therefore the first activities to be implemented and ensuring that case management and vector control activities between all organisations and local health authorities were standardised.

Cyclone response efforts quickly identified dengue fever as one of the top causes of morbidity amongst affected populations. WHO, in collaboration with NGOs and local partners, drew up the ‘Scaling up dengue prevention and control for the cyclone Nargis affected populations’. These dengue control activities were focused in the dengue affected Ayeyarwady and Yangon Region townships.

The health department in Yangon Region, in collaboration with the MENTOR Initiative, decided upon the implementation of a community-based dengue source reduction project.

- Training of over 830 staff from MoH, local organisations and international response organisations.
- The training course focused on malaria and dengue prevention: vector entomology and how to implement vector control activities such as larviciding campaigns, IRS and LLIN distributions.
- Over 74,000 LLINs from various organisation were distributed to the affected communities.
- IRS campaigns were conducted by the MoH with support and donations from response organisations.
- Larviciding of 13 townships across the Yangon and Ayeyarwady Regions. This campaign involved distribution of the larvicide to households by trained volunteers (school teachers and public personnel) for use on water containers that could not be emptied or covered.

IVM Approach

Diseases: Malaria, Dengue

Vector control tools integrated: LLIN, IRS, LSM

For the dengue prevention activities ‘Training of Trainers’ courses were conducted: In this way, those trained were then able to conduct dengue prevention training and activities themselves, thus increasing human resources. Involvement of communities in activities for source reduction of breeding sites around households ensured effectiveness of these activities.

Baseline surveys were carried out prior to larviciding activities. Teams conducting the surveys were led by entomologists. This follows the IVM framework guidelines of making surveillance and evidence based decisions.

The integration of non-chemical and chemical vector control methods is an important aspect of IVM, as demonstrated in the above case study. During this response, operational research was

conducted to determine covers which could be mass produced and thus reduce the need of regular chemical applications on water containers.

Community participation and social mobilisation is an important aspect of dengue prevention activities. During this response, teachers and school children were trained on dengue prevention, in particular source reduction i.e. weekly emptying of temporary breeding sources such as empty drinks cans and other household rubbish.

Case Study Four

Maban, South Sudan/ North-East Africa

Background

After decades of civil war and unrest in Sudan in which over 1.5 million people died, South Sudan became an independent state in 2011. South Sudan is mainly inhabited by Christians and animists and considers itself culturally sub-Saharan, while Sudan is inhabited by Muslims who are culturally Arabic; this was the root of fighting between northern and southern Sudan throughout the civil wars. In December 2013, a power struggle broke out between South Sudan's President, Salva Kiir Mayardit, and his then deputy Riek Machar, causing further conflict. This has brought insecurity and logistical constraints which, coupled with heavy rains, have hampered the delivery of food and other essential items. South Sudan is also host to over 265,000 refugees from CAR, DRC, Ethiopia and Sudan, to which are added over 1.4 million South Sudanese IDPs.

VBD disease background / Trigger event

South Sudan has always had one of the highest malaria burdens in sub-Saharan Africa. Populations in refugee camps are vulnerable to disease vectors, especially during the wet season due to the lack of adequate structure in refugee housing. Another factor is the long malaria transmission season which lasts 7–8 months in the southern regions and 5–6 months in the northern regions. In addition, regular flooding in different parts of the country increases the number of vector breeding sites near refugee populations, sometimes requiring the movement of camps.

In response to the continued high burden of malaria in humanitarian camps, vector control initiatives were implemented. South Sudan IVM has been selected as the main platform for vector control with a focus on LLIN and IRS of houses if their structure is suitable. Most NGOs were distributing LLINs with refugee arrival kits, however coverage was insufficient.

VBD Response in Upper Nile

When the MENTOR Initiative began activities in Doro refugee camp, Maban in 2013, LLINs had been distributed with high coverage. The situational analysis and assessment carried out using qualitative interviews revealed that refugees in the camp were staying up late socialising and so were not protected under LLINs at a time when anopholes mosquitoes bite, making them more vulnerable to malaria. As well as this, the distribution of LLINs was not accompanied with IEC on their use and care due to the urgent need to distribute quickly.

Given the situational analysis, it was deemed that IRS would be used to reinforce vector control and would protect if the refugees stayed outside late because mosquitoes rest indoors after

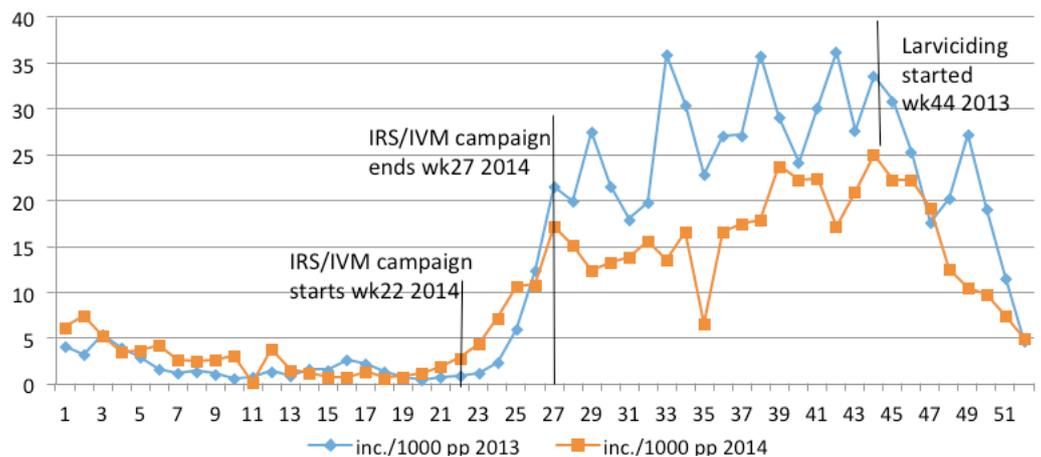
feeding. The MENTOR Initiative's activities began in Week 44, 2013. LSM was used to target the immature aquatic stages of mosquito development.

The aim of the MENTOR Initiative's work was to control malaria and other vector-borne diseases such as yellow fever (transmitted by the *aedes* mosquito) and visceral leishmaniasis (transmitted by sandflies). Flies were also present as a major pest and vector for trachoma and diarrhoeal diseases. The vector control activities had to be integrated in nature to achieve impact and target these different diseases.

Impact

Graph 1 shows the data from the preceding year 2013 before IVM activities began. In 2013 there were high coverages of LLIN. In 2014 the IRS campaign started just as the rainy season began, a time when you would expect to see a rise in cases of malaria (as seen in the graph). The 2014 trend graph shows fewer incidences of malaria/1000 pp compared to 2013 despite a continued increase in malaria cases overall in South Sudan.

Graph 1 : Comparative malaria incidence in 2013 and 2014 in Doro refugee camp, Maban



The IVM campaign was carried out just before the expected peak in malaria transmission in 2014. The cases in 2014 are almost halved when compared to the peak transmission season in 2013. Malaria incidence reduces sharply after the IVM campaign finishes in week 27 of 2014. This can also be seen after the first larviciding campaign in week 44 of 2013. In 2014, huge malaria peaks that can be seen in 2013 are not present in the main transmission season. This is evidence of good mosquito control, keeping the populations steady and low. This graph shows how important IRS and larval control is in this location, where >98% LLIN coverage had not adequately succeeded in reducing malaria. This demonstrates the need for continued IVM, rather than relying solely on LLINs.

Further reading

<http://www.unhcr.org/pages/4e43cb466.html>

Case Study Five

Syria/ Middle East

Background

Until 1960, prevalence of the sandfly transmitted disease, cutaneous leishmaniasis was restricted to two areas of Syria: Aleppo and Damascus. Prior to the conflict starting in 2011, disease incidence was around 23,000 cases per year. However, in early 2013, an alarming increase in cutaneous leishmaniasis cases was reported from areas which were not normally hot-spots for the disease. This is attributed to mass internal displacement of populations and disruptions on sandfly vector habitats, both as a result of the conflict.

Conflict and the subsequent breakdown of healthcare provisions have left large areas of Syria vulnerable to outbreaks of infectious disease. Sandfly numbers have multiplied as a result of increased breeding sites: rubble from buildings destroyed by bombing and cracks in walls, as well as waste build-up. This is coupled with a reduction in public health control measures, breakdowns in the WASH, and reduced access to healthcare and medicines.

The leishmaniasis transmission season begins in March and normally ends with the onset of cold weather in early September/October.

IVM activities

Selection criteria for those areas to be sprayed were based on case incidence, demographics and safety for workers.

- Waste management: local councils were supported to have the capacity to carry out waste management activities, using three waste compacter vehicles to take refuse from the main city area to landfill sites.
- Emergency responses were mounted in relation to visceral leishmaniasis (VL) cases.
- IRS campaigns: 22 spray teams were trained, with each team comprising of 8 spray operators, 8 IRS assistants and a supervisor for these operations.
- 209,000 LLINs, donated by WHO, were distributed in two locations: Abu Kamal district in Deir ez-Zur and Afrin in Aleppo.
- IEC activities alongside interventions:
 - 1) general posters to be placed throughout the villages and towns
 - 2) health posters displayed in supported health facilities
 - 3) general information brochures to be placed in health facilities and given out to patients
 - 4) mobile clinic banners
 - 5) health facility banners
 - 6) IRS and LLIN double-sided flyers, printed in colour
 - 7) vehicle-mounted public address systems
 - 8) mosque talks.

- Technical and or material support by MENTOR included: on-the-job training, distribution of medication and consumables, and case number collection. Health workers given training in three-day laboratory and microscopy diagnosis. Training was also given to improve data collection for epidemiological monitoring.

Further reading

Al-Salem W, Pigott DM, Subramaniam K, Haines LR, Kelly-Hope L, Molyneux DH, et al. Cutaneous leishmaniasis and conflict in Syria [letter]. *Emerg Infect Dis*. 2016 May [23/05/2016]

http://wwwnc.cdc.gov/eid/article/0042-16/5/22_article

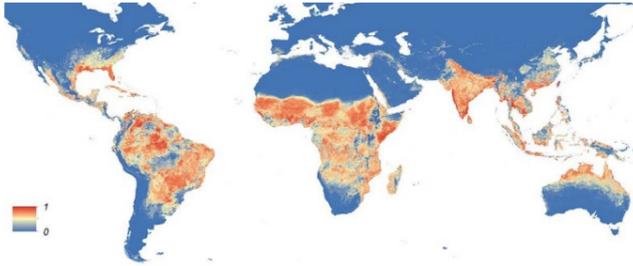
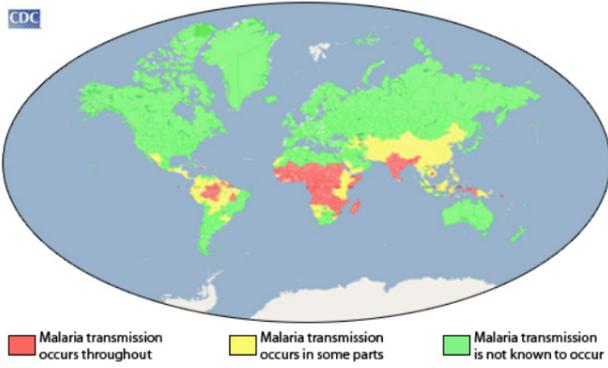
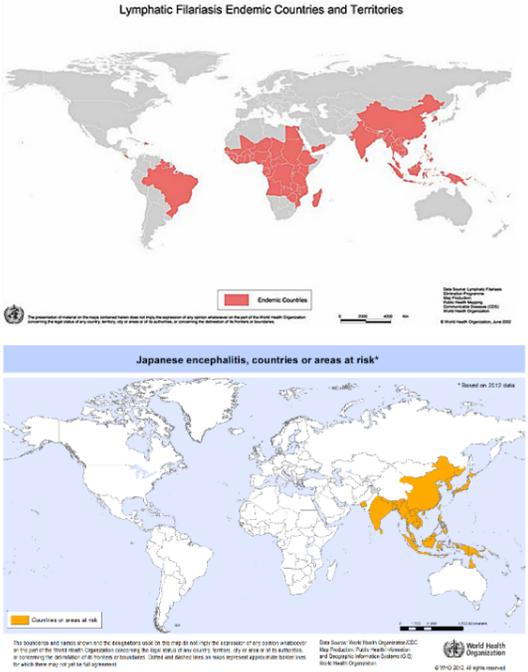
Vector Borne Diseases & Vector

Mosquito

Aedes

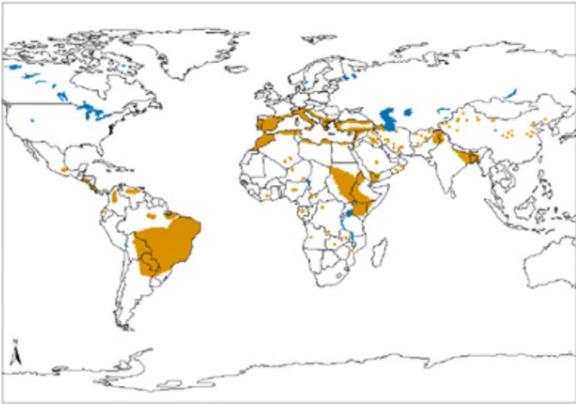
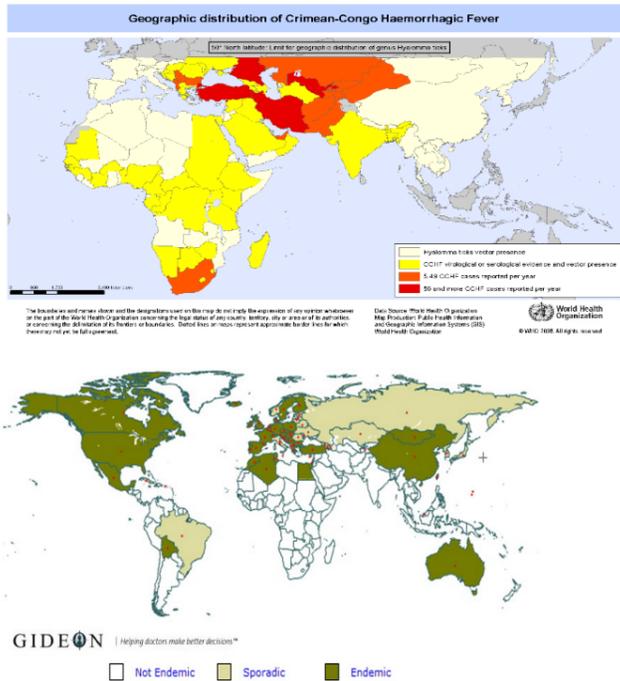
Anopheles

Culex

Diseases	Chikungunya, Zika, Dengue, Yellow Fever	Malaria, Lymphatic Filariasis (some species in some rural foci)	Japanese Encephelitis, Lymphatic Filiriasis
Affected Regions	Africa, Asia, Europe & America's	Africa, Asia, Latin America, and the Middle East Sub-Saharan Africa carries a disproportionately high share of the global malaria burden. In 2015, the region was home to %88 of malaria cases and %90 of malaria deaths. MAPS: http://www.cdc.gov/malaria/about/distribution.html	JE- South-east Asia, Western Pacific Region. LF - Currently, 1.23 billion people in 58 countries are living in areas where lymphatic filariasis is transmitted and are at risk of being infected. Approximately %80 of these people are living in the following 10 countries: Bangladesh, Côte d'Ivoire, Democratic Republic of Congo, India, Indonesia, Myanmar, Nigeria, Nepal, Philippines and the United Republic of Tanzania (WHO, 2015) MAPS: http://www.antimicrobe.org/new/b141.asp http://www.who.int/ith/diseases/japanese_encephalitis/en/
Maps			
Who Recommendation	IRS, Other impregnated materials (clothing) , LSM (chemical or manual environmental modification), Environmental management (container removal, water container cover, container larviciding) , fogging (epidemic), insect traps , perifocal spraying, LLIN, social mobilisation campaigns (education/public relations). EPIDEMIC MITIGATION : Aerial and truck mounted space spraying, Topical repellents	IRS, LLIN, Larval Source Management (supplementary tool)	IRS, LLIN , LSM, Environmental Sanitation, ITPS
Evidenceto Recommend Use In Some Settings	Indoor ULV spraying, LLIN, Insecticide treated curtains /screening	Insecticide treated sheeting/wall lining, insect traps, Insecticide-treated clothing or sheets	
Insufficient Evidence To Recommend Use		Larvivorous fish, Spatial repellents, Topical repellents	

Vector Control Method

Vector Borne Diseases & Vector

	Sandflies	Ticks	Triatomine bugs
Diseases	Leishmaniasis, Sandfly Fever	Crimean-congo haemorrhagic fever, Lyme Disease, Rickettsial diseases (spotted fever & Q fever)	Chagas disease (American trypanosomiasis)
Affected Regions	America's, East Africa, Europe, Asia, Meditaranean basin	CCHF is endemic in Africa, the Balkans, the Middle East and Asia, in countries south of the 50th parallel north (geographical limit of the tick) LD - Countries at risk, Europe & the America's https://www.iamat.org/risks/lyme-disease MAPS: http://www.who.int/csr/disease/crimean_congoHF/Global_CCHFRisk_20080918.png?ua=1 , http://abled.com/08/09/2013/abledhealth-lymedisease10-x-bigger-threat/	Mostly in Latin America but increasingly beign detected in United States of America, Canada, and many European and some Western Pacific countries (March, 2015). MAPS: http://www.infectionlandscapes.org/04/2011/trypanosomiasis-part-2-chagas-disease.html
Maps			
Vector Control Method			
Who Recommendation	IRS, LLIN, insecticide treated curtains, reservoir management (zoonotic and sylvatic cycle)	Tick control with acaricides (Tick insecticides) for well organised farms, repellent on the skin and clothing, protective clothing (long sleeves, long trousers)	IRS, Housing improvements, LLIN
Evidenceto Recommend Use In Some Settings	Environemtal modification/waste management		
Insufficient Evidence To Recommend Use		77	

Vector Borne Diseases & Vector

Tsetse flies

Fleas

Blackflies

Diseases

Sleeping sickness (African trypanosomiasis)

"Plague (transmitted by fleas from rats to humans)

Onchocerciasis (river blindness)

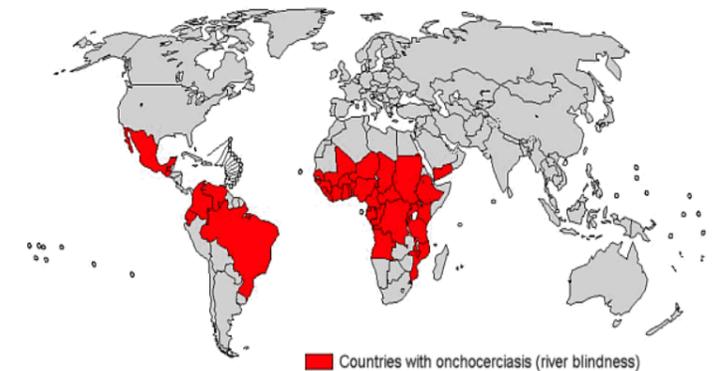
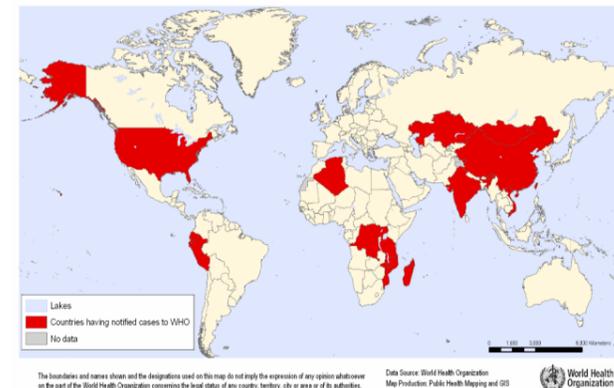
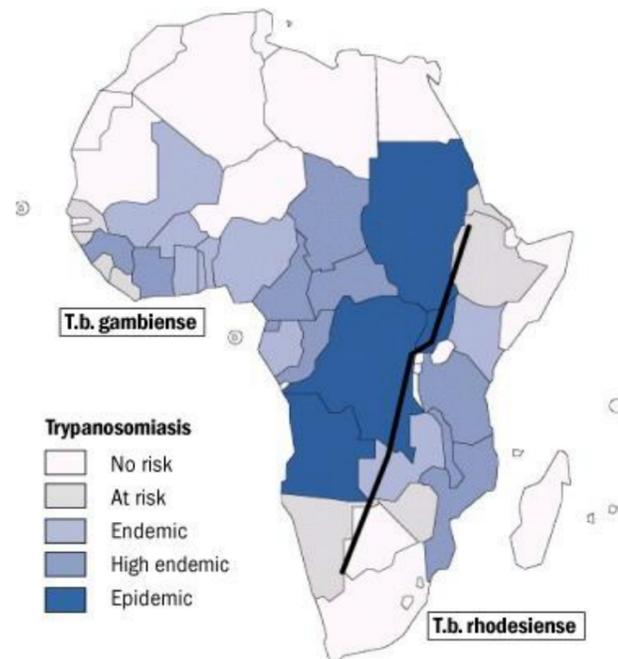
Affected Regions

Sub-saharan Africa (May, 2015) MAP: http://www.who.int/csr/resources/publications/CSR_ISR_2000_1tryps/en/

Africa, Asia, and South America but since the 1990s, most human cases have occurred in Africa. The 3 most endemic countries are Madagascar, the Democratic Republic of Congo and Peru. MAPS: <http://www.rmg.co.uk/discover/behind-the-scenes/blog/world-health-organisation-modern-plague>

More than 99% of infected people live in 31 African countries; the disease also exists in some foci in Latin America and Yemen (March, 2015). These blackflies breed in fast-flowing rivers and streams, mostly in remote villages located near fertile land where people rely on agriculture

Maps



Vector Control Method

Who Recommendation

Traps & Targets

Rodent control, IRS (floors and rodent holes), insecticiding rat runways . Bait boxes

Preventative chemotherapy (Ivermectin), Larviciding (aerial larviciding)

Evidenceto Recommend Use In Some Settings

Insecticide treated cattle , aerial spraying, Sterile insect technique

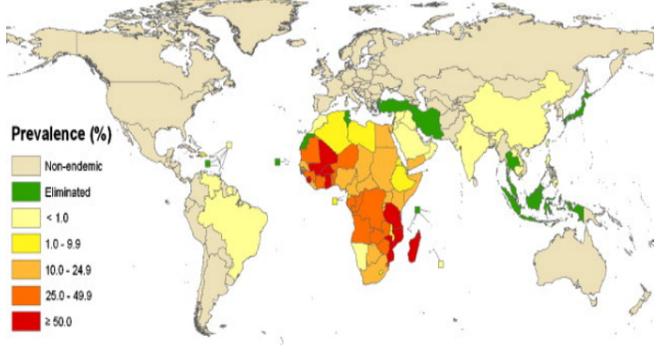
Insufficient Evidence To Recommend Use

<http://www.who.int/csr/resources/publications/plague/whocdscsre92b.pdf?ua=1>

Vector Borne Diseases & Vector

Aquatic snails

Flies

Diseases	Schistosomiasis (bilharziasis)	Trachoma,
Affected Regions	Africa, Asia, Middle East, Carribean, Brazil, Venezuela and Suriname (February, 2016) http://www.who.int/mediacentre/factsheets/fs115/en/ MAPS: http://www.infectionlandscapes.org/06/2012/schistosomiasis.html	Distribution of Trachoma world wide WHO - 2012. Africa http://gamapserver.who.int/mapLibrary/Files/Maps/Trachoma_2012.png
Maps		
Vector Control Method	Who Recommendation Preventative chemotherapy (Ivermectin), Water, Sanitation and Hygiene, health education, molluscides, Environmental management	SAFE strategy - Surgery, Facial cleanliness, Environmental change (sanitation/latrine provision, physical and chemical methods), proper disposal household waste. Fly control
Evidenceto Recommend Use In Some Settings		
Insufficient Evidence To Recommend Use	Biological control using fish, molluscidal plants	