सत्यमेव जयते

MANUAL ON

INTEGRATED VECTOR MANAGEMENT IN INDIA

National Center for Vector Borne Diseases Control

(National Vector Borne Disease Control Programme)

22-Sham Nath Marg, Delhi - 110054

Directorate General of Health Services

Ministry of Health & Family Welfare

Government of India

2022

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Abbreviations

AES	Acute Encephalitis Syndrome
AS	Aqueous Suspension
ASHA	Accredited Social Health Activist
CDC	Centers for Disease Control and Prevention
CHIKV	Chikungunya Virus
DBC	Domestic Breeding Checkers
DDT	Dichlorodiphenyltrichloroethane
DENV	Dengue Virus
DF	Dengue Fever
EC	Emulsifiable Concentrate
EW	Emulsion-in-water
FIFO	First in, First out
GoI	Government of India
GR	Granules
HIA	Health Impact Assessment
HIV	Human Immunodeficiency Virus
ICMR	Indian Council of Medical Research
IDSP	Integrated Disease Surveillance Programme
IEC	Information, Education and Communication
IGR	Insect Growth Regulator
IHR	International Health Regulation
IRS	Indoor Residual Spraying
IVC	Integrated Vector Control
IVM	Integrated Vector Management
JE	Japanese Encephalitis
LSM	Larval Source Management
MT	Metric Ton
MTS	Malaria Technical Supervisor
NCVBDC	National Center for Vector Borne Diseases Control
NFCP	National Filaria Control Programme
NMCP	National Malaria Control Programme
NMEP	National Malaria Eradication Programme
NVBDCP	National Vector Borne Disease Control Programme
OP	Organophosphate
Pf	*Plasmodium falciparum*
PPE	Personal Protective Equipment
Pv	*Plasmodium vivax*
PKDL	Post Kala-Azar Dermal Leishmaniasis
ROH&FW	Regional Office for Health and Family Welfare
SPO	State Programme Officer
SC	Suspension Concentrates
UTs	Union Territories
WDP	Water Dispersible Powder
WHO	World Health Organization
WP	Wettable Powder
ZIKV	Zika Virus

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MESSAGE

Vector Borne diseases (VBDs) contribute significantly to the morbidity burden, and particularly affect the economically marginalized sections of society. The climatic conditions of the country are congenial for proliferation of vectors. Factors like rapid urbanization, concurrent population growth and movement also play crucial role in geographical spread and disease intensity. Prevention and control of these diseases require multiple approaches including disease and vector management.

India is currently in a stage of health transition. In the last decade, progress has been made in the elimination of three vector borne parasitic diseases namely Malaria, Kala-Azar and Lymphatic Filariasis. At the same time, mosquito borne viral diseases like Dengue, Chikungunya, Japanese Encephalitis and Zika have emerged as a threat to health and economic security. The role of vector management has become relevant in view of elimination target and for timely containment of outbreaks of VBDs. In 2016, the National Center for Vector Borne Diseases Control developed "Operational Manual for Integrated Vector Management" which was shared with the States for implementation and resulted in capacity building at various levels. The manual has been updated, based on field experience and recent developments and recasted as "Manual on Integrated Vector Management in India".

I hope that the bringing of this manual will help the States in further improving the vector control interventions and reduce the VBDs related morbidity and mortality with optimal utilization of available resources and tools.

(Dr. Mansukh Mandaviya)

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Message

The Vector borne diseases are a group of communicable diseases transmitted by mosquitoes and other vectors. Transmission and risk of vector borne diseases are rapidly changing due to unplanned urbanization, increased movement of people and goods, environmental changes and biological challenges such as vectors resistance to insecticides and evolutions of pathogens.

Vector control is a powerful tool for Malaria, Lymphatic Filariasis and Kala-azar targeted for elimination from the Country and also for prevention of arbo-viral diseases which do not have any specific drug for treatment. It was felt that for better implementation of National strategies, the entomological aspects including surveillance and vector control need to be geared up aligning with the evidence based global strategies to achieve the targets for vector borne diseases prevalent in the Country.

The goal of Integrated Vector Management is to manage or eliminate VBDs by making vector control more efficient, cost-effective, ecological, sustainable, and culturally acceptable. The "Operational Manual for Integrated Management" developed in 2016 by National Center for Vector Borne Diseases Control has now been updated as "Manual on Integrated Vector Management" which will prove a milestone in this endeavour. I hope that this manual will also help the States in better planning and effective vector management for elimination of the targeted diseases and combating other outbreak-prone vector borne diseases.

(Dr. Bharati Pravin Pawar)

''दो गज की दूरी, मास्क है जरूरी''

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Message

Transmission and risk of vector borne diseases are rapidly changing and are dominated by various factors mainly unplanned urbanization, increased movement of people and goods, environmental changes, increased construction activity and inadequate water supply leading to inappropriate storage of water which provides suitable environment for vector breeding. While climatic conditions in tropical and sub-tropical areas encourage vector proliferation, rapid, unplanned urbanization in these areas render large populations at risk of vector borne diseases. These diseases mostly thrive in conditions of poverty and social burden of these diseases on individuals, households and economies are immense.

To achieve the targets set for control and elimination of vector borne diseases, there is a need to strengthen vector control as a key public health intervention and to integrate it across other sectors. This requires availability of effective, evidence-based vector control interventions which will also lead to achievement of disease-specific national goals.

For effective vector control, the "Operational Manual for Integrated Vector Management" was developed in 2016 and shared with the States for implementation. In view of recent developments in the field, the existing manual has been updated as "Manual on Integrated Vector Management" by the National Center for Vector Borne Diseases Control in such a way so as to provide variety of options to be used in isolation or in combination depending on the ground situation. I hope this manual will enable scaling up of vector control activities and will equip the States with appropriate practical strategies for vector control measures

Place : New Delhi
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MESSAGE

Vector Borne Diseases (VBDs) have a large impact on morbidity and mortality across the globe and pose economic burdenon public health system.Though, impressive gains have been made towards achievement of elimination targets for Malaria, Lymphatic Filarisis and Kala-azar, yet many milestones are yet to be achieved. Outbreaks of arbo-viral diseases like Dengue, Chikungunya, Japanese Encephalitis have increased over the years. Reporting of Zika from new areas a concern.

Vector control is the most vital component for control of Vector Borne Diseases and an integral part of National Center for Vector Borne Disease Control (NCVBDC). Interventions for vector management have been accepted and involved under National Program after careful evaluation following standardized methods. Yet they require updates from time to time both from a scientific and implementation point of view. The principal objective of a National Program is to combine interventions that are tailored to achieve sustainable impact in different settings. Technical guidance is required to decide upon the appropriate intervention, planning and allocation of resources.

Manual on Integrated Vector control was first brought out in the year 2015 and was released by Hon'ble Health Minister in February, 2016.

Integrated Vector Management (IVM) is a rational decision making process that optimizes the use of available resources for vector control. Considering the fact that there are numerous vector borne diseases in India that require involvement of numerous state and district level agencies, it is vital to integrate their efforts for effective outcomes.

One of the most vital link of integration happen to be entomologists. They are the guiding light for numerous activities such as entomological surveillance including monitoring for insecticide resistance. While they guide on one side, they help and assist vector control experts at various levels.

Factors which affect vector behaviour include urbanization, climate change (global warming) and emergence of new infections. Hence the need for periodic revision of the manuals. This revised manual is being released by Hon'ble HFM during the Malaria day celebrations in 2022. I congratulate the NCVBDC under DGHS and thank Hon'ble HFM for doing the honours.

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MESSAGE

The vector borne diseases pose a burden to the public health not only in India but in many other tropical and sub-tropical Countries. Since the inception of National Health Mission in 2005, the activities for prevention and control of vector borne diseases have been accelerated in the country. However, different components of Vector Management have been under implementation, as singular intervention or in combination, in different settings. Therefore, an updated comprehensive document on integrated vector control with concept, components and specific strategies for different diseases was needed. In view of this, vector control strategies have been revisited and the manual on Integrated Vector Management has been developed by the National Center for Vector Borne Diseases Control. This document envisages to help the States in improving the vector control interventions for elimination of Malaria, Lymphatic filariasis, Kala-azar and for combating Dengue, Chikungunya, Japanese encephalitis and Zika with optimal utilization of available resources and tools in an effective manner.

I believe this document will be beneficial for all those who are involved in policy making, planning, management and research on prevention and control of vector borne diseases. I appreciate the efforts by NCVBDC in coming out with this manual and confident that this will provide support to programme managers to adopt the strategies most appropriate and impactful for different settings in the geographically diversified areas.

(Vikas Sheel)

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April 21, 2022

Message

Vector Borne Diseases are significant public health issues in the country. Since its inception, the National Vector Borne Disease Control Programme (NVBDCP) has been implementing vector control strategies for managing the disease transmission and it still remained as the mainstay. The vector control concepts have been reviewed from time to time in line of global updates as per need depending on the changing bio-ecology, vector bionomics, climate, epidemiology and recent advancements in the vector control. Tailoring of interventions to specific scenarios as informed by local entomological and epidemiological data, preparing a vector control plan in close collaboration are keys of success to control the vector borne diseases.

I am sure, that this manual on Integrated Vector Management will provide strategic guidance to the States for strengthening vector control as a fundamental approach to preventing diseases and responding to outbreaks. I take this opportunity to put on record my appreciations for the team involved in development of this manual and look forward to the States to strengthen their mechanisms to ensure adherence to the important entomological parameters for improving the effectiveness of the programme implementation at all levels that are accountable and responsive to the needs.

21/04/2022

(Dr. Harmeet Singh)

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FOREWORD

In India, Vector Borne Diseases are significant public health issues and co-exists in all geographic areas. The National Vector Borne Disease Control Programme (NVBDCP) under National Center for Vector Borne Diseases Control (NCVBDC) has been implementing important interventions like entomological surveillance, vector control (IRS, LLINs and larval source management) under vector control strategies for managing the disease transmission.

Tailoring of interventions to specific scenarios based on the surveillance data and preparing a vector control plan is a key to achieve elimination of targeted vector borne diseases and containment of arbo-viral diseases. Integrated Vector Management ensures that the endemic areas are covered by the appropriate interventions, based on local context to achieve the disease specific goals for vector borne diseases.

The present manual on vector control concepts has been reviewed by subject experts in line with global updates as per changing bio-ecology, vector bionomics, climate, epidemiology and recent advancements in the vector control. I am sure, that this "Manual on Integrated Vector Management in India" will provide strategic guidance to the States/UTs for strengthening vector control as a fundamental approach to prevent disease and respond to outbreaks. This document will also render technical guidance to the programme managers, implementing agencies, stakeholders, research organizations, inter-ministerial and inter-sectoral partners for effective vector control.

I congratulate the team of NCVBDC and experts involved in development of this manual and look forward to the States/UTs to strengthen their vector control interventions and adhering to important entomological parameters for effective programme implementation.

(Dr. Tanu Jain)

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PREFACE

Vector control is a crucial component and plays an important role to reduce the incidence of vector borne diseases (VBDs). Without the vector control interventions, these diseases would proliferate unchecked and risk of geographical spread will increase with population movement. The vector surveillance and control activities are implemented at various levels, thus Integrated Vector Management (IVM) is needed for ensuring rational decision-making process to optimize the use of resources. It transforms the vector control procedures by making them more evidence based and participative.

IVM is being implemented with its various components aligning disease specific priorities; however, efforts have been made in this document to provide all components of IVM under its framework. For technical guidance to the States, the 'Operational Manual for Integrated Vector Management in India' was developed in 2015. As there are newer developments in the programme policy and strategy in recent years, a need was felt for updating the existing IVM manual. Accordingly, the present 'Manual on Integrated Vector Management in India 2022' has been developed incorporating inputs from subject experts having vast experience in the field. The manual provides background concept of IVM, entomological surveillance, techniques, monitoring, analysis, interpretation and decision-making process to use available tools and adopt feasible methods to combat the vectors. The purpose of this manual is to provide guidance to the programme officers alongwith other stakeholders on vector control interventions for effective coordination and optimal use of resources.

This manual will be of immense help to entomologists and vector control experts in strengthening their skill for implementation, monitoring and supervision more efficiently.

(Kalpana Baruah)
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& Scientist 'V'

Acknowledgements

Integrated vector management (IVM) is one of the important keys to achieve the national targets set for elimination/control of vector-borne diseases. In the context of journey from prevention to elimination of malaria, lymphatic filariasis, kala azar and in the face of increasing challenges of Arbo viral diseases, it was necessary to update the existing IVM manual developed during 2015-16 for the programme.

The updated version has been prepared jointly by Dr Kalpana Baruah, former Additional Director & Scientist ”V”, Head, Entomology & Vector Control Division, NVBDCP (currently NCVBDC) with technical support of Dr P.K. Srivastava, former Joint Director, Head Entomology & Vector Control Division, NVBDCP through a series of deliberations, and his valuable contributions are gratefully acknowledged.

NCVBDC is extremely grateful to Padma Shri (Prof) AP Dash, Vice Chancellor, AIPH University, Bhubaneswar and former Regional Advisor (VBN) to SEAR, WHO for his valuable suggestions, reviews and technical inputs throughout updation of the manual.

NCVBDC is grateful to the contributors Shri Sridharan Subramanian, Former Chief Entomologist, Tamil Nadu; Sh George Kurien, Former State Entomologist, Gujarat; Dr J.C. Paliwal, Former State Entomologist, Madhya Pradesh and Dr R S Sharma, Former Additional Director & Head, Centre for Medical Entomology and Vector Control Division, National Centre for Diseases Control, Delhi for their critical technical inputs.

The draft has been critically reviewed by Dr M.M. Pradhan, Additional Director, Department of Health & Family Welfare, Government of Odisha, Dr Himmat Singh Pawar, Scientist ’E’, ICMR-NIMR, New Delhi and Dr K. Jayalakshmi, Asst. Professor, Dept. of Life Sciences, Central University of Tamil Nadu, Thiruvarur. NCVBDC duly acknowledges their suggestions and inputs on this manual.

This document is the result of suggestions by Prof (Dr) Sunil Kumar, Director General of Health Services, Government of India. NCVBDC is grateful for his thought-provoking guidance.

Confidence and trust placed by Dr Tanu Jain, Director NCVBDC to undertake the developments of this important document along with continued motivation during finalization of this document are much appreciated and sincerely acknowledged.

Inputs provided by NCVBDC Consultants Dr Amit Katewa and Dr Gavendra Singh, Shri Irrusappan Hari, Shri Ankit Kumar, Dr Achintya Srivatsa and Dr Abhijit Sharma of CHRI, are duly acknowledged. Support of Ms Nandini Arora and Shri Sachin Verma is also acknowledged.

NCVBDC sincerely acknowledges the valuable support of GCPL and CHRI for bringing out this manual.

Last but not least, comments/ suggestions provided by participants of the Malaria and other VBD entomology trainings are also acknowledged.

1 Introduction

Vector-borne diseases (VBDs) have been affecting the community adversely in terms of health and socio-economic development. The advancements towards diagnosis and surveillance of many VBDs in recent past have resulted in improved reporting, thereby increasing not only the number of cases, but the new areas that attracted the focus of attention. VBDs, such as Malaria, Dengue, Chikungunya, Zika, Japanese Encephalitis, Lymphatic Filariasis and Visceral Leishmaniasis (Kala-azar), remain in the limelight as National Vector Borne Diseases Control Programme under National Center for Vector Borne Diseases Control (NCVBDC) looks after the prevention and control of these diseases. However, other VBDs like Scrub Typhus (Mite borne), Tick Typhus, Kyasanur Forest Disease (KFD), Crimean Congo Hemorrhagic Fever (CCHF–Tick-borne), Plague (Flea borne), Cutaneous Leishmaniasis, Chandipura viral fever, Sandfly fever (Sand fly-borne), Lyme disease and other vector-borne viral, bacterial, parasitic diseases are spreading, millions of people are at risk for such infections.

Unprecedented population growth, primarily in the cities, facilitated transmission and geographic spread of VBDs. This uncontrolled urbanization and crowding resulted in deterioration in housing conditions (increase in slums) accompanied by a lack of basic amenities (e.g., water, sewerage, and waste management). Population growth has been a major driver of environmental change in rural areas as well (e.g., deforestation, agriculture land use, and animal husbandry practices). All of these changes contributed to the increased incidence of vector-borne diseases. Urbanization of rural areas is one of the most important factors in spread of Dengue and Chikungunya in rural set up too. The various factors related to increased burden of VBDs are human behaviour, lack in technical competence, operational feasibility of strategic approaches in different ecological settings and availability of inadequate financial resources etc. Since the spread of these diseases affects all sections of society, a multi-sectoral approach for sustainable development to reduce the burden of VBDs needs to be advocated and implemented. The reduced burden of VBDs will contribute significantly to overall reduction of communicable diseases.

Conventionally, the control of disease vectors relied on chemical insecticides, however, in the early1980s, the concept of Integrated Vector Control (IVC) was recognised. It was essentially a vertical plan focusing on the use of one or more methods of vector control against the targeted disease. In the early 1990s, the concept of 'selective vector control' was introduced, which envisaged the application of targeted site-specific and cost-effective activities to reduce malaria morbidity and mortality. Later, 'comprehensive vector control' was conceptualised aiming to control vectors of two or more co-prevalent diseases using the vertical approach involving management of similar or different methods. The concept of reduced reliance on insecticides for the control of VBDs was brought in the 50th World Health Assembly in 1997. It advocated the promotion of the Integrated Pest Management (IPM) approach. The

Stockholm Convention on persistent organic pollutants (POPs) 2001 recommended phasing out Dichlorodiphenyltrichloroethane (DDT) and other POPs and advised reducing dependence on pesticides for vector control.

The World Health Organization (WHO) in 2004 advocated the Integrated Vector Management (IVM) strategy emphasising that "effective control is not the sole preserve of the health sector but requires public-private, inter-sectoral collaboration and community participation." Therefore IVM was described as a rational decision-making process for the optimal use of resources for vector control.

The public health system largely tends to promote a narrow sectoral approach for interventions for individual diseases. Inter-sectoral and inter-disciplinary approaches can help control multiple diseases without disturbing the ecosystem. The ecosystem is usually impacted due to the actions taken to control VBDs. In that context, IVM is a suitable method considering health and environmental factors. The strategies used under IVM are targeted interventions to remove or control vector breeding sites, disrupt the life cycle of the vector and minimise vector-human contact without disturbing the ecosystem.

The measures of vector control and prevention include mainly Indoor Residual Spraying (IRS), Insecticide Treated Nets (ITNs)/Long Lasting Insecticidal Nets (LLINs) and or fogging/space spray to control adult mosquitoes, source reduction and treatment of breeding sites with chemical/biological agents towards larval source management (LSM).

At the central level, National Center for Vector Borne Diseases Control (NCVBDC) facilitates the process of framing the policy and developing the strategic plan for implementation by States/Union Territories (UTs). The infrastructure for implementation is provided by the States/UTs, and financial resources are shared by both central and state governments, as per policy.

Complacency and less priority for infectious diseases as public health problems in the 1970s and 1980s resulted in a redirection of resources and, ultimately, a decay of the public health infrastructure required to control these diseases. The existing disease-specific vector control programmes and surveillance services emphasise integration within the decentralised health system. This approach requires new skills and capacities for analysis and decision-making. The availability of adequate medical/public health entomologists is crucial for tackling VBDs as vector experts or entomologists are best to deal with the complexities of vector management. The available health or public health staff in districts, Primary Health Centres (PHCs), sub-centres and villages needs to be trained in the technical, operational and managerial aspects of IVM in making them more capable and taking some decisions based on local situation within overall guidelines of the programme.

The capacity should also be developed so that a linkage of vector control and vector surveillance activities under IVM is maintained and sustained at the central and local level. This will bring health services closer to the community and motivate the health staff because, in this process, vector control becomes more sustainable as local decision-makers are more accountable. Even within the decentralised health systems, vertical programmes or its activities, with effective coordination at the district and local level, is essential for establishing and maintaining an IVM strategy. For example, the persons engaged in indoor residual spray at the district and sub-district levels can work together with the local authority or partners in source reduction and other implementation activities. The programme allows such flexibility in district planning based on local circumstances, with accountability to local representatives.

IVM strategy also requires collaboration between the health, other sectors and the civil society with roles, responsibilities and terms of reference laid out for all stakeholders. Health impact assessment of ongoing or new projects is crucial to identify any risks for VBDs and address them. Various departments with construction activities need to be sensitised to prevent vector breeding by adopting appropriate strategies or technology. With their active participation, partnerships at the state and district levels require intensive capacity-building and advocacy. This does not mean shifting the responsibility of vector control from the health department. They have overall responsibility and should continue to acquire the skills to facilitate the partnership and guide its activities. Other stakeholders like civil society organisations and communities also play a role in implementing the activities. Technical support for IVM strategy should be with the central and State governments.

The inclusion or exclusion of tools or technologies is guided by evidence and research. Operational research conducted for the programme provides support in ensuring amendments in guidelines and managing resources. Support from the Indian Council of Medical Research (ICMR) and the National Centre for Disease Control (NCDC) in operational research is considered under the programme through their institutional mechanism. The technical support by ICMR, NCDC and evidence generated for the inclusion of any public health products under the public health programme are deliberated in a constituted expert group of the programme. The expert group recommendations are referred for consideration by Technical Advisory Committee (TAC). The recommendations made by TAC are submitted to the Ministry of Health & Family Welfare, Government of India for approval to include and use the product under the programme. Only after approval of Government, the products are included for use under programme. The technical specifications, dose and the method to prepare ready-to-use suspensions/solutions are shared with States and UTs.

It is to emphasize that three VBDs under the programme are targeted for elimination which need proper implementation of IVM during elimination and post-elimination phase. The important components of IVM are situation analysis (epidemiological and entomological), adequate skilled human resources, adequate logistics in terms of tools and financial support to implement the strategy properly. However, during the elimination of a disease or in the post-elimination phase when the disease burden is considerably reduced below the threshold, the priority for deployment of human resources and financial support is either altered/ put on hold or reduced. This has to be avoided so that the impact on the success gained through IVM is sustained. It must be clearly understood that though a disease may no longer be a public health problem, the management of vector population should be sustained to avoid any outbreak or upsurge that might occur due to weak surveillance and vector control. IVM, therefore, should be considered as an investment not as an expenditure, especially in a public health programme.

The area under influence of multiple vectors and VBDs often pose challenges to the health professionals working in the system across the country in controlling vectors responsible for different VBDs. The implementation of IVM therefore requires institutional arrangements, regulatory framework and skilled human resource. Capacity strengthening is a continuous process and involvement of other sectors or partners needs to be embedded in the system. The programme has recently released a document “Mosquito and other Vector Control Response”

(MVCR) in 2020 which envisages the need for assessment of vector control including technical human resource, capacity building and supervised implementation. Therefore, IVM needs to be embedded in the health system holistically including National Health Policy.

This manual on IVM aims to elaborate on the concept, principle, planning process and implementation tools, its execution and monitoring. Analysis and reporting have also been detailed in this manual to strengthen the capacity of the persons engaged in field, thereby creating a pool of skilled human resources.

2

Integrated Vector Management

Integrated Vector Management (IVM) is a rational decision-making process to optimise the use of resources for vector control. It requires a management approach that improves the efficacy, cost-effectiveness, ecological soundness and sustainability of vector control interventions with the available tools and resources. IVM facilitates resources to be used more efficiently to control multiple VBDs thereby impacting significantly on public health than doing control programmes focused on a single disease. The multi-disease strategy under IVM is applicable to other VBDs with integrated approach. IVM thus translates the conventional system of vector control by making it more evidence based, integrated and participative. However, it requires changes in roles, responsibilities of various stakeholders and institutional mechanism for implementation of IVM.

Key elements of IVM are advocacy, social mobilisation, strengthening of regulatory and legislative controls for public health, empowerment of communities, collaboration within the health. Other sectors are in planning, decision-making, use of available resources for vector control, implementation of evidence-based strategies and capacity-building.

Advocacy and inter-sectoral collaboration at both national and local levels facilitates in cost savings as single platform is used for such activities. The important stakeholders like agriculture, environment, mining, industry, public works, local government and housing, need to be sensitized on benefits of IVM so that they incorporate IVM and vector control into their own activities to prevent vector proliferation and disease transmission.

The planning and implementation of IVM involve assessment of epidemiological and entomological (vector related) situations at country level, analysis of local determinants of disease, proper vector control measures, requirements, resources and thereafter designing appropriate implementation strategies. IVM strategy requires skilled staff and adequate infrastructure at central and local level. IVM, therefore, requires a complete list of essential functions and staff within the organizational structures for prioritization of financial, human and technical resources to control/eliminate VBDs.

The basic concepts for IVM implementation are:

- Which mosquito species are locally important as vectors of human diseases?
- Which mosquito species are important as the primary source of annoyance?
- What are the important breeding sites of different mosquito species?
- What is the seasonal pattern of mosquito breeding?
- What are the resting places of adult mosquitoes?
- What are the feeding preferences of vector mosquitoes?
- To map out and locate all potential breeding sites

- To identify the mosquito/sand fly species present
- To predict the time and location of effective control strategies

Though different integrals of IVM have been under implementation in isolation or in combination in specific situations, a comprehensive document describing concept, components of IVM and strategy for each diseases is required. The National Vector Borne Disease Control Programme (NVBDCP) aims to achieve effective vector control by using appropriate biological, chemical and environmental interventions of proven efficacy, separately or in combination, as appropriate to the area through optimal use of resources. Efforts are made in collaboration with various public and private agencies and community participation for vector control so that IVM is done by using identical or different vector control measures to control VBDs viz., malaria, dengue, chikungunya, Japanese encephalitis, Kala-azar (Visceral Leishmaniasis) and lymphatic filariasis.

STRATEGY: IVM includes implementing all feasible strategies safely with or without insecticides to manage the vector population in such a way that disease transmission is kept under check. It also includes the management of insecticide resistance by rotation within the same or different groups. The multiple strategic components recommended and used under the public health programme are shown in Figure-1.

Figure-1: Vector control measures used under programme

3

IVM Framework

The framework of IVM explains various steps recognised for the successful implementation of IVM. There are five major steps viz., assessment of the disease situation, vector control tools, needs and resources, implementation, and its monitoring & evaluation. Each step has various components viz., disease situation analysis includes epidemiological and entomological assessment, identification of local determinants of disease and stratification of areas at risk. The selection of vector control methods depends on available public health products, feasibility of their use under programme and government regulatory policy regarding the use of such products. The need assessment includes logistics, skilled human and financial resources for proper implementation of the activities envisaged under IVM. Needs and resources should be mapped at district and state levels so that IVM strategies are properly planned and implemented.

The implementation of IVM using different tools and technology is very important step. The embedded components are essential for ensuring that the programme quickly responds to the situation. The vector control interventions should be selected based on the vector assessment, efficacy of vector control methods, insecticide resistance and cost-effectiveness. The programme activities should be monitored during implementation and evaluated to determine its effect on the targeted disease(s). IVM being a decision-making process for the management of vector population, needs to be clearly understood by the policy makers, administrators, and technical experts so that it is implemented smoothly with the combination of administrative, managerial and technical approach. The various steps of IVM framework which are shown in Figure- 2 have been elaborated in subsequent chapters of this document.

The figure highlights the main steps that are required to be conducted at all levels, including national, state and districts. A broad-level analysis is needed to stratify areas of the country according to the diseases prevalence, disease incidence or risk of infection even if cases have not been reported from the area, vector species, its bionomics and ecology. The country needs to be stratified into states, similarly the states into districts and further below upto sub-centre level wherever feasible. While narrowing down the areas for focused intervention, stratification up to block level (sub-district) and village level may be attempted. Locally, the eco-epidemiology of the disease, including human determinants, should be explored.

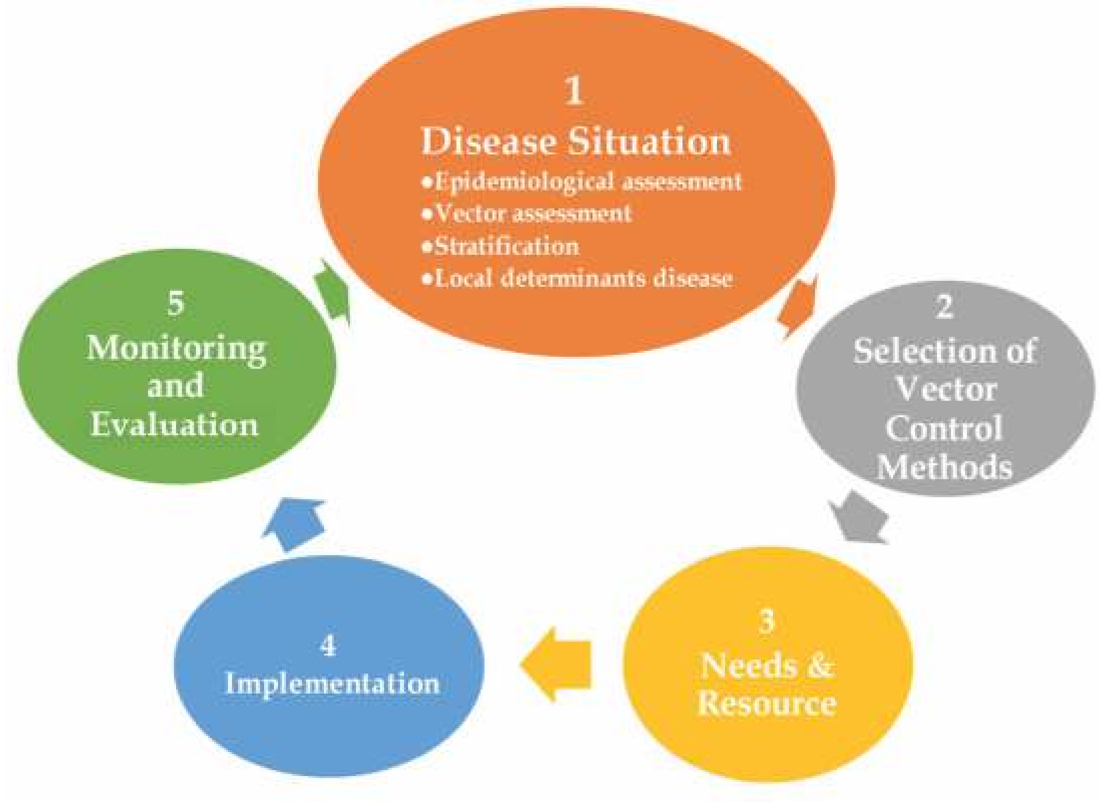


Figure-2: Steps in IVM planning, implementation, monitoring, and evaluation
(Source: IVM Manual, WHO 2012)

4

Situation Analysis

What should a situation analysis cover?

It is important to understand the distribution of VBDs, their transmission and responsible vectors so that vector control can be planned within available resources and prioritised as per disease burden. The pathogen, vector, human, environmental, and in some cases, animal determinants are important factors which need to be considered by the programme during assessment of disease(s). The situation analysis should be performed to assess diseases, vectors and determinants of disease at different administrative levels. A broad-level analysis looks at disease and vectors present at the State & district levels, while a sub-district level analysis looks at the disease, vectors and factors in greater detail to identify appropriate intervention. The situation analysis should be undertaken regularly using updated information as disease incidence may change over time, vectors or diseases may be introduced or re-introduced and disease determinants may vary over geographic areas. A situation analysis should address the following:

At the state and district level:

1. The presence of VBDs which are endemic in the area. The foci and hotspots of infections/cases with details of village/town, PHC and district. The risks for spread of the infection and the factors responsible for it.
2. The differences in disease burden by geographic area (state and district) and its monthly/weekly trend over a period of 3-5 years.
3. List of diseases or infections which are co-endemic in the area.
4. Local vectors are responsible for transmission and bionomics, including their response to control measures like insecticide resistance status.
5. Stratification of areas based on endemicity of disease(s) at state, district level.
6. The priority diseases and geographic areas for intervention.

At sub-district level:

1. At sub-district level, mapping of hotspots for disease(s).
2. The trend analysis of disease incidence over period of 3-5 years.
3. The local determinants of disease transmission e.g., vector, human, environmental, human vs cattle ratio and presence of animal reservoir.
4. Stratification at sub-district level viz., block or village.
5. The priority for control or elimination of disease(s) in geographic areas and population group.

Epidemiological Analysis of disease situation

Epidemiological data on the distribution of VBDs, vectors, stratification of the areas based on epidemiological local factors are analysed to plan control, selection of tools and prioritise resources. Programme managers must consider all these factors while considering a diseases situation analysis. To describe and analyse disease situation, the life cycle of VBDs is important. The details of six VBDs under programme are shared below:

Malaria transmission: Malaria parasite is transmitted by a female *Anopheles* mosquito bite that has been infected through a blood meal taken from an infected person. A single infected vector, during its lifetime, may infect several persons. After nearly a week of taking an infected blood meal, mosquito can transmit malaria. The malarial parasite undergoes two cycles of development-the human cycle (asexual cycle) and the mosquito cycle (sexual cycle). Humans are the intermediate host, while mosquitoes are the definitive host. Malaria infection begins when the infected female *Anopheles* vector mosquito injects sporozoite stage of human malaria parasites into the blood stream while feeding.

The sporozoites reach to the human liver where they multiply asexually into merozoites in next 7 to 10 days, but the infection remains asymptomatic. The parasites in the form of merozoites are released from the liver cells , invade the red blood cells (RBCs) and multiply again until the RBCs burst. This cycle to infect RBCs is repeated, causing fever each time parasites are released and invade RBCs. After repeated cycles, some of these in RBCs develop into sexual forms called gametocytes. The gametocytes circulate in the bloodstream and get ingested by female mosquitoes when it sucks blood. These gametocytes develop further into mature sex cells known as male and female gametes. The fertilization takes place inside stomach of female *Anopheles*, and the fertilized female gametes develop into actively moving ookinetes that burrow through the mosquito's midgut wall and form oocysts. Inside the oocyst, thousands of active sporozoites develop. The oocyst finally bursts, and the sporozoites are released into the body cavity of vector mosquito. The sporozoites travel to the mosquito's salivary glands, and the cycle of human infection begins again when such an infected mosquito bites another person (Figure- 3).

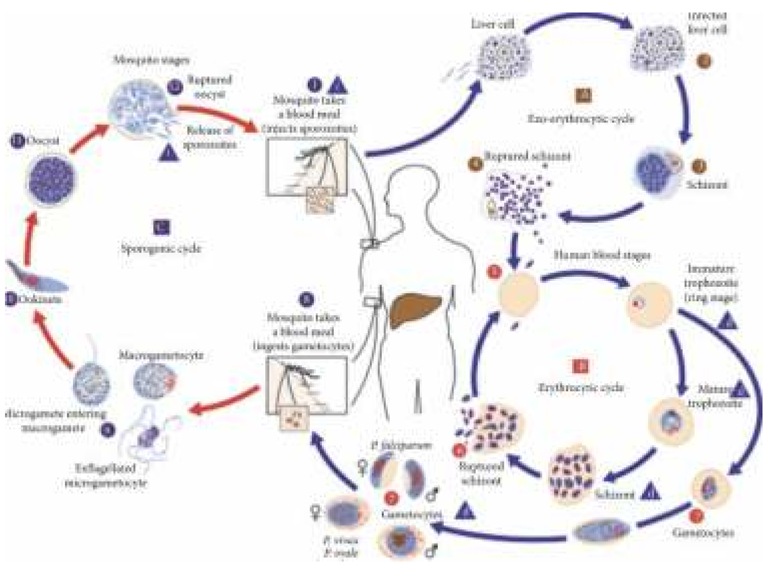


Figure-3: Malaria Transmission Cycle
(Source: CDC)

The disease is transmitted by nine species of *Anopheles* in India, out of which, six are primary vectors namely *Anopheles (An.) culicifacies, An. stephensi, An. baimaii (previously known as An. dirus), An. fluviatilis, An. minimus* and *An. epiroticus* (previously known as *An. sundaicus).* The other three vectors namely *An. annularis*, *An. varuna* and *An. philippinensis* play a secondary role in local transmission of malaria.

Lymphatic filariasis transmission: Lymphatic filariasis in humans is caused by three species of parasitic worm, *Wuchereria bancrofti* , *Brugia malayi* and *B. timori*, that have generally similar life cycles. In the human body, adult worms (male and female) live in nodules in the lymphatic system and after mating, produce numerous microfilariae, which circulate in the bloodstream. Unlike malaria, in filariasis transmission humans are definitive host while the mosquitoes are intermediate host. The lifespan of adult worms is 4–6 years. Microfilariae migrate between the lymph system and blood channels to reach the peripheral blood vessels often at times that coincide with the peak biting activity of local vectors. The microfilariae are picked by female mosquitoes while feeding which later develop in thoracic muscles. The larvae grow and moult into second-stage larvae (L2) and again to third-stage larvae (L3). This process takes 10–12 days from the L1 to L3 stage. The infective larvae migrate to the mosquito's proboscis and remain coiled on it. These are dropped on the skin while mosquito is feeding, and then the parasites find their way through a bite wound. L3 develop into fourth-stage larvae (L4) as they migrate through the human body to the lymphatic vessels and lymph nodes, where they develop into adult worms (Figure- 4).

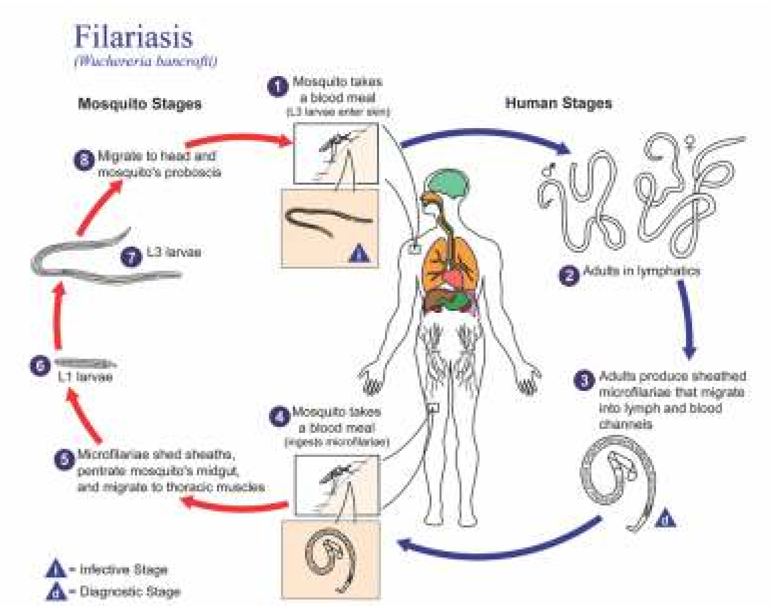


Figure-4: Filariasis Transmission Cycle
(Source: CDC)

The transmission dynamics of lymphatic filariasis is complex, involving two genera of parasite (*Wuchereria* and *Brugia*) and several genera of mosquito vectors. The four main genera are *Anopheles, Culex, Aedes* and *Mansonia*. The biological features of the vector–parasite relationship should be understood to define the entomological variables critical to lymphatic filariasis transmission and the threshold for interrupting transmission. Unlike the transmission of malaria and arboviruses, the transmission of lymphatic filariasis is inefficient, and many bites from infectious mosquitoes are required to initiate a new infection with microfilaraemia. Many factors contribute to the inefficient transmission of lymphatic filariasis. Firstly, microfilariae do not multiply in the mosquito body, hence, the number of L3 is limited by the number of microfilariae ingested. Secondly, only those mosquitoes that survive more than 10 days will contribute to transmission of the parasites. Those mosquitoes that die before the L3 develops cannot play a role in the transmission cycle. Thirdly, the L3 are deposited on the skin and have to find their way into the bite wound (rather than being injected with the mosquito saliva like malaria sporozoites).

Visceral leishmaniasis (Kala-azar) transmission: Visceral leishmaniasis or Kala-azar is transmitted by the bite of infected sandflies. *Phlebotomus argentipes* is the only known vector of kala-azar in India. The seasonal prevalence of this species varies from area to area depending upon the ecological conditions. Disease transmission is the highest in the rainy season. Kala-azar in India has a unique epidemiological feature of being anthroponotic, i.e., human beings are the only known reservoirs of infection. The female sandflies pick up the amastigote stage (LD bodies) of the parasite while feeding on an infected human host.

The parasites undergo development and multiplication in the gut of sand flies to become numerous flagellates (Promastigote or Leptomonad stage) which migrate to their mouthparts. The cycle in the sand flies is completed in about 8 days. Infection is transmitted to healthy human beings when such infective sand flies bite them. Kala-azar being a chronic disease has a long incubation period which varies from 1-4 months, however, in India, the range varies from 4 months to 1 year. The extrinsic incubation period (EIP) in the vector sand flies vary from 4-25 days which is the time required for the vector to become infective after an infective blood meal. The parasite primarily infects reticulo-endothelial system and may be found in abundance in bone marrow, spleen, and liver. Post-kala-azar dermal leishmaniasis (PKDL) is a condition in which the *Leishmania donovani* invades cells of skin and develops lesions. This results in skin manifestations of Post Kala-azar dermal leishmaniasis (PKDL). Some of the kala-azar cases manifest PKDL after a few years of treatment.

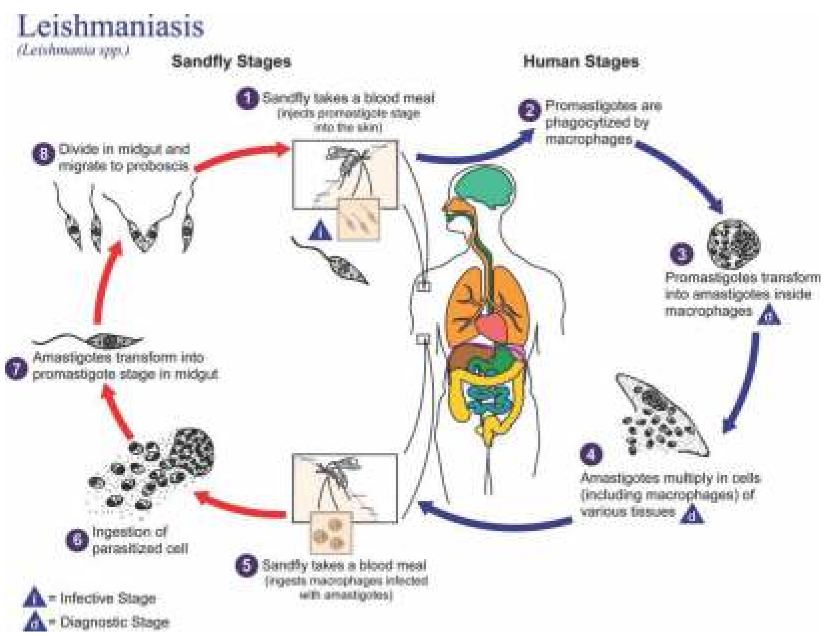


Figure-5: Kala-azar Transmission Cycle
(Source: CDC)

Dengue transmission: Dengue viruses are transmitted from infected person to others by the bite of female *Aedes* mosquitoes. Transmission of dengue depends upon a complex relationship between epidemiological factors viz., agent (virus), host (man and mosquito) and the environment (abiotic and biotic factors). The complexity of relationship among these factors eventually determines the level of endemicity in an area. In India, *Aedes* (*Ae.*) *aegypti* is the main vector in most urban areas; however, *Ae. albopictus* is also incriminated in many states. The chain of dengue transmission is shown in the Figure- 6. The female *Ae. aegypti* becomes infected with dengue virus when it takes blood meal from a person during the acute febrile (viraemia) phase of dengue illness. The virus then disseminates into the mosquito body by passing first into the midgut then crossing the intestinal barriers, amplifying into the haemocoele and eventually reaching the ovaries and the salivary glands.

The infective cycle starts when the virus is ingested and ends when the virus reaches the salivary glands which is called as extrinsic incubation period (EIP), generally 8-10 days process that is influenced by ambient temperature, viral strain, and mosquito competence. The mosquitoes become infective if the salivary glands are infected, and they can spread the virus to another person while blood-feeding. The viraemic phase ranges from 2 to 12 days with an average of 4-5 days. A dengue-infected person can pass on dengue virus to vectors during this period. The mosquito becomes infective for the rest of its life and can infect anyone it bites or probes while seeking for blood meal. Vertical transmission occurs whenever a virus-infected female mosquito transmits the virus to its offspring via eggs.

Transmission dynamics of dengue is correlated to the abundance of vector density. During monsoon and post-monsoon, the preponderance of vector is higher due to abundance of breeding habitats in rain fed containers. Though, dengue cases are reported round the year by many states, the disease has a seasonal pattern i.e., the cases peak after monsoon. The *Ae. aegypti* mosquito prefers to bite humans and is easily disturbed by the movement of host during feeding. Thus, an *Aedes* mosquito bites several persons to complete a blood meal. During the process, *Aedes* infects several persons in the same household or in proximity, resulting in clustering of cases.

The complexity of the relationship among these factors eventually determines the level of endemicity in an area. *Ae. aegypti* has an average adult survival of fifteen days. During the rainy season, when survival is longer, the risk of virus transmission is greater.

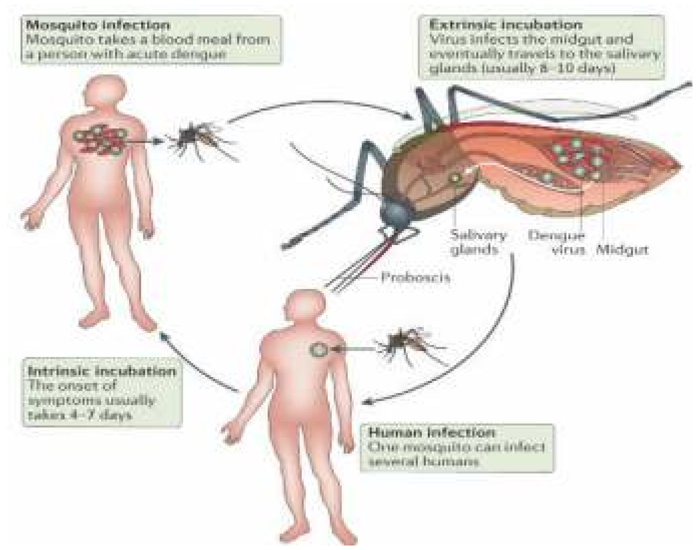


Figure- 6: Dengue Transmission Cycle
(Source: Guzman et al. 2016)

Chikungunya transmission: The causative vectors for the transmission of Chikungunya virus (CHKV) are *Ae. aegypti* and *Ae. albopictus* vector mosquitoes, which bite mostly during the daytime in early morning. Other than *Aedes* vectors, the virus continues a sylvatic cycle in reservoirs which are chimps, monkeys, baboons, rodents, birds, squirrels etc. where the chikungunya virus can survive for a long time before causing sickness in people.

During the mosquito feed, transmission occurs in two ways: mosquito to man and man to vector. The virus can enter the vector's salivary gland & body cavity and develop inside the vector's body (EIP 2-9 days, average 7 days). After the incubation vector becomes capable of transmitting the CHKV to the uninfected person. The virus enters humans during the mosquito bite. After an intrinsic incubation period of 4-7 days (average 2-12 days), the infected person becomes vireamic and develops symptoms. Then uninfected vectors pick up the CHKV from the infected person during the blood-feeding. This dynamic transmission cycle continues to the next cycle (Figure- 7).

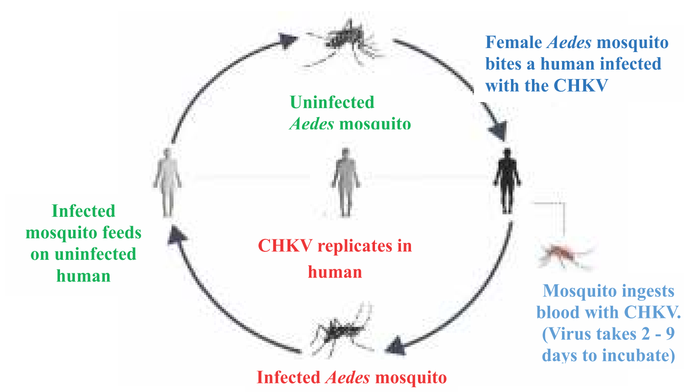


Figure-7: Chikungunya Transmission Cycle
(Source: WHO)

Zika virus transmission: Zika virus transmission can takes place via a vector or a non-vector pathway. The Zika virus spreads to humans mostly through mosquito bites from infected *Aedes* species (*Ae. aegypti* and *Ae. albopictus*), the mosquitoes that spread the dengue and chikungunya viruses. *Ae. aegypti* is highly anthropophilic, often lives near people and bites numerous persons in a single blood meal.

For the uninfected mosquito vector that bites primarily during the daytime, humans act as carriers and sources of the virus. Once implanted into the human host following a blood meal, the virus goes through an intrinsic period of incubation for 4-5 days. The virus replication depends on temperature and humidity. Rise in temperature shorten the extrinsic incubation time in mosquitoes and is linked to increased vector feeding and leading to higher transmission risk.

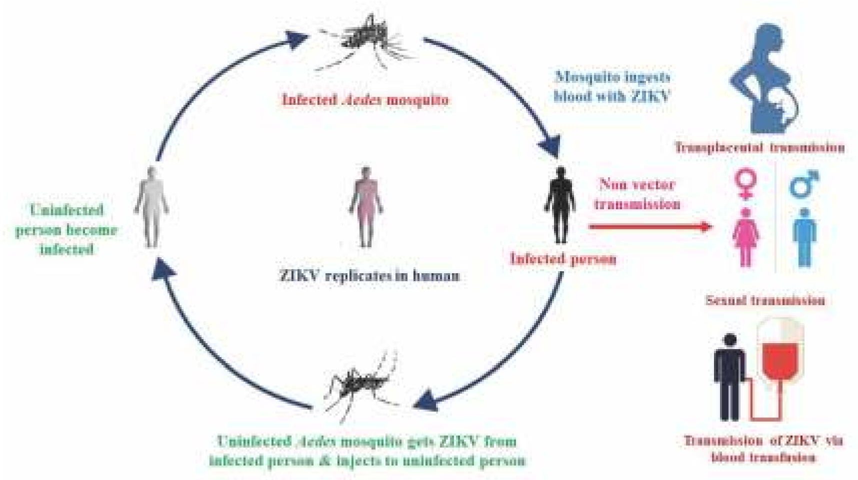


Figure-8: Zika Virus Transmission Cycle
(Source: WHO)

Non-vector transmission: Zika virus (ZIKV) non-vector transmission can also occur from mother to child, sexual transmission, blood transfusion, or direct transmission. ZIKV can be transmitted vertically from an infected woman to her unborn foetus at any time during pregnancy. The virus can infect foetal neuronal tissue and antigens in foetal brain tissue, as well as the amniotic fluid, by crossing the placental barrier. In several cases involving tourists from endemic areas, sexual transmission of ZIKV has been observed. Direct transmission of the ZIKV is assumed to occur through contact with an infected host's skin and mucous membranes, as evidenced by the virus's presence in saliva and nasopharyngeal swabs. This is not, however, a primary mode of transmission (Figure- 8).

Aedes mosquitoes are highly adaptable and exploit hard to find domestic and peri-domestic habitats. Therefore, *Aedes* control is primarily targeting the elimination of aquatic stages.

Japanese encephalitis (JE) transmission: JE virus is transmitted to humans through the bite of infected *Culex vishnui* group of mosquitoes, particularly *Culex tritaeniorhynchus*, which extensively breeds in paddy fields. In India, JE virus has been isolated from *Cx. tritaeniorhynchus, Cx. vishnui, Cx. pseudovishnui* and *Cx. bitaeniorhynchus, Cx. epidesmus,* *Cx. fuscocephala, Cx. gelidus, Cx. quinquefasciatus, Cx. whitmorei, Cx. infula, An. paeditaeniatus, An. barbirostris, An. subpictus, An. vagus, Mansonia*(*Ma.*) *annulifera, Ma. indiana,* and *Ma. uniformis.*

The main reservoirs of the JE virus are pigs and water birds. In its natural cycle, virus is maintained in these animals. Human is an accidental host and does not play a role in JE transmission. After 9-12 days, mosquitoes transmit disease to other vertebrate hosts. Epidemics occur during monsoon and post-monsoon period because the vector density is high due to paddy cultivation. However, in endemic areas, sporadic cases may occur throughout the year (Figure-9).

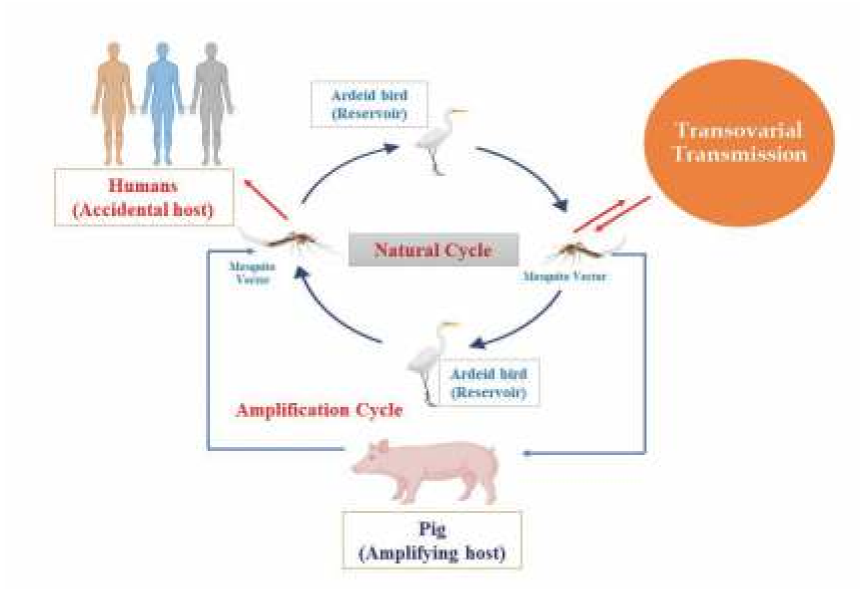


Figure-9: JE Transmission Cycle
(Source: NVBDCP, 2006)

The influence of prevalence of multiple vector-borne diseases in states in India is shown in the map below.

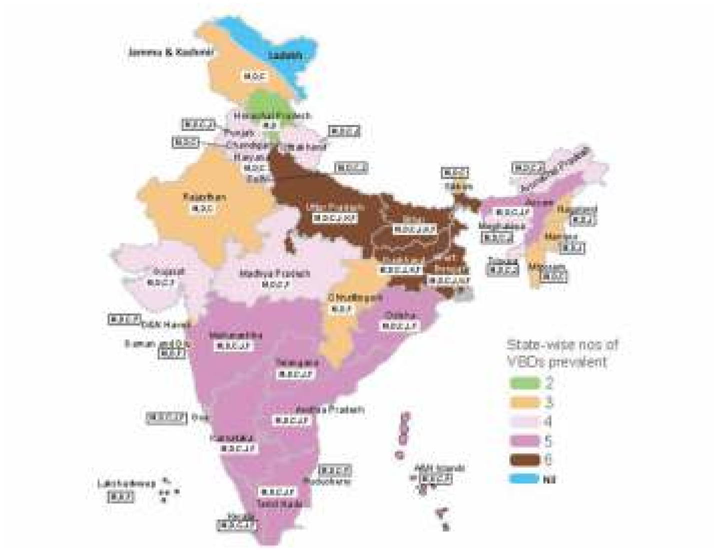


Figure-10: Prevalence of Multiple Vector-Borne Diseases in India
(Source: MVCR, NVBDCP, 2020)

Based on the transmission cycle, epidemiological data available, the epidemiological situation needs to be assessed and mapping should be done keeping following key points:

Points to be considered

- Which vector-borne diseases are endemic?
- Where are the cases occurring and is there risk of infection?
- What are the risks for infection?
- Are some diseases or infections co-endemic? If so, where are they found?
- Are there differences in disease risk by geographical area?
- Which vectors are responsible for transmission and where are they found?
- What is bionomics of different vectors responsible for different VBDs?

Points to note for doing situation analysis

- Identify the determinants of disease ecology: Determine where diseases occur and how this is related to factors such as population density, socio-economic conditions and environment (e.g., elevation, land use, water bodies and potential animal reservoirs of infection).
- Assess vector distribution: Based on published/unpublished documents/ reports and identify the main vectors of disease (s) in the area.
- Identify potential animal reservoirs: Determine where cattle or wildlife are concentrated.
- Undertake additional surveys if evidence on disease endemicity is weak suboptimal or patchy and prepare
    - Maps indicating the areas
    - Population-based surveys to confirm the absence of this disease

Situation analysis: key points

- Difference in disease incidence within districts at block/sub-centre/ village/ town level
- Distinct difference in environmental and human factors in states or within districts
- Presence of any hot-spot area within district and why it is hotspot e.g.,
- Technical: drug or insecticide resistance, defective tools
- Managerial: inadequate supply of logistics, inadequate human resource, suboptimal capacity and capability of system
- Implementation failure: Suboptimal treatment compliance, surveillance, insecticidal spray (larval & adult control) and LLIN coverage
- Human behaviour: inability of service providers to visit in difficult and inaccessible areas, community acceptance and cooperation

Looking beyond maps in stratification

- Maps are a good guide to disease burden or risk for infection, but mostly based on epidemiological data
- If the maps show gaps due to inadequate epidemiological data owing to sub-optimal surveillance, then local surveys and data collection should be done
- Consider assessing population density
- Urban ecosystems provide a different habitat for vectors and VBDs
- Rural and urban population (density or proportion) needs to be assessed

5

Vector Assessment

Information on vectors, their prevalence, distribution and bionomics are crucial components in planning and implementation of IVM. The information available in published/ unpublished documents or reports needs to be collected and assessed to identify the main vectors of disease(s) in the area. The understanding of vector bionomics helps in identifying temporary and permanent potential breeding sites in different ecological settings. It includes study on feeding behaviour which indicates whether the vector prefers feeding on animals (zoophilic) or on human beings (anthropophilic). The assessment therefore should include the collection of information on animals in the vicinity of human population. The ratio between human and cattle population helps in understanding the significance of animal reservoirs in transmission dynamics.

Vector bionomics

The term bionomics is defined as the inter-relationship of an organism to its biotic and abiotic environment. Climatic factors play an important role in species distribution, behaviour, survival and vectorial status. The relative number of vector species in an area determines the transmission of pathogens to the human population. An understanding of vector bionomics is important in epidemiology of VBDs and planning methods of vector control. The environment of immature species and adult vectors are interdependent since the adult vector must have access to water for egg laying. The aerial environment is necessary for mating and dispersal. Terrestrial environment provides habitats for feeding, resting and completion of the life cycle of ovarian development from blood meal to egg laying. The transmission dynamics is governed by environmental factors that affect the vector-human-pathogen interaction. IVM relies on several factors, but foremost is the selection of proven vector control methods based on knowledge of local vector biology and ecology, disease transmission and morbidity. The details on different vectors are explained below:

Vectors of Malaria

There are about 465 species of *Anopheles* mosquitoes throughout the world, of these, around 70 species are of major importance (the number may vary in some studies). Anopheline mosquitoes are found in all parts of India from the sea level up to an altitude of 2000 to 2500 meters. There are records of mosquitoes found in deep mines particularly culicine mosquitoes. They have been found at depths of over 1000 meters in the Kolar gold mines in Karnataka. However, anophelines have been found only at depths of 90 to 180 meters in the coal mines of Bihar. Anophelines are found all over the Indian subcontinent, from Ladakh in the north to Kanyakumari in the south, and Andaman and Nicobar Islands in the Bay of Bengal to Lakshadweep in the Arabian Sea.

In India, out of 58 species of *Anopheles* mosquitoes, 9 species are vectors of malaria.

1. *Anopheles culicifacies*
2. *Anopheles fluviatilis*
3. *Anopheles minimus*
4. *Anopheles baimaii (dirus)*
5. *Anopheles stephensi*
6. *Anopheles epiroticus (sundaicus)*
7. *Anopheles annularis*
8. *Anopheles philippinensis*
9. *Anopheles varuna*

An. culicifacies, An. fluviatilis, An. minimus, An. dirus (baimaii), An. stephensi and *An. sundaicus (epiroticus)* have been considered as primary vectors of malaria, whereas, three species are secondary vectors viz. *An. annularis*, *An. philippinensis* and *An. varuna* being of local importance in the transmission of the disease. *An. stephensi* is mainly involved in transmission of malaria in urban areas, whereas, remaining vectors play their role in rural areas.

An. culicifacies

Distribution: The species is widely distributed in India.

Breeding places: It breeds in rainwater pools and puddles, borrow pits, riverbed pools, irrigation channels, seepage, rice fields, wells, pond margins, sluggish streams with sandy margins. Extensive breeding of *An. culicifacies* is generally encountered after monsoon.

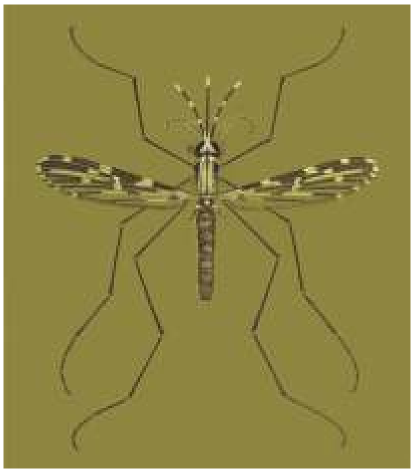
Resting habits: It rests during daytime in human dwellings and cattle sheds.

Biting time: Biting goes on throughout the night, but peak biting occurs from19.00 to 04.00 hrs.

Feeding habits: A zoophilic species, feeds on human when high densities are build up.

Flight range: About 1-3 kms.

An. fluviatilis



Distribution: The species is widely distributed in the foothill areas including both peninsular and north-east India. It plays a major role especially in Odisha.

Breeding places: It breeds typically in slow running streams, seepages and irrigation channels; also recorded from rice fields and shallow wells. During heavy rains, the breeding is often flushed out.

Resting habits: It rests indoors in human dwellings and cattle sheds.

Biting time: Generally, the vector species enters houses at dusk and completes feeding before midnight with peak from 09.00 to 11.00 hrs.

Feeding preferences: This species is in general highly anthropophilic, however, zoophilic nature has also been reported from northern India.

Flight range: It has limited flight range.

An. minimus

Distribution: The species has restricted distribution to the north-eastern states. This species was thought to have been eliminated because of insecticidal spraying in 1950s and 1960s but reappeared in late 1970s.

Breeding places: *An. minimus* breeds in shaded slow flowing streams with grassy margins, swamps, ditches, channels, shallow earth wells; occasionally found to breed in borrow pits, rice fields and seepage from flowing water.

Resting habits: It rests inside houses, preferring to rest on the lower portions of walls.

Biting time: Peak biting activity occurs from 18.00 to 19.00 hrs outdoors and 24.00 to 02.00 hrs indoors. Biting time may vary from one locality to the other and seasonally.

Feeding habits: A highly anthropophilic species and therefore, a very efficient vector of malaria.

Flight range: Normally 0.5 km but can disperse up to 2 kms from the original locality.

An. baimii (dirus)

Distribution: Its distribution is restricted to the forested areas of the north-eastern states.

Breeding places: Breeds in pools, rainwater collections in deep forest, forest fringes, stream margins with decaying organic matter and animal footprints during monsoon.

Resting habits: Enters human dwellings to bite and rest but has a tendency to leave houses soon after blood meal.

Biting time: The peak biting activity is from 22.00 to 02.00 hrs.

Feeding habits: High preference for human blood but also bites monkey, other primates and cattle.

Flight range: Flight range varies from 1 to 2.5 km in forests.

An. stephensi

Distribution: This species is distributed across India except at higher altitudes; found sporadically in the north-east.

Breeding places: Breeds in wells, overhead and ground level water tanks, cisterns, rainwater collections in roof gutters, peri-domestic containers and underground water storage tanks. In Rajasthan's desert, it breeds and rests in the water storage tanks called tankas in the rural areas.

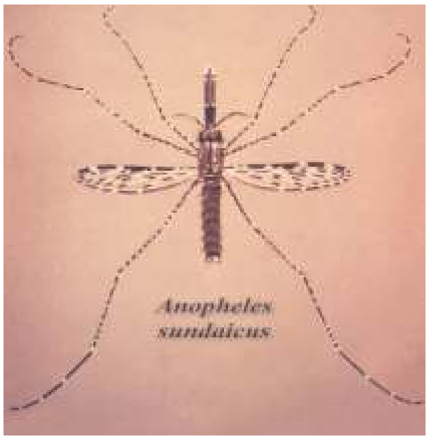
Resting habits: Rests in human dwellings and cattle sheds. Inside human dwellings, it may rest on hanging objects, behind curtains, etc. Outdoor resting has been observed in wells and underground cement tanks.

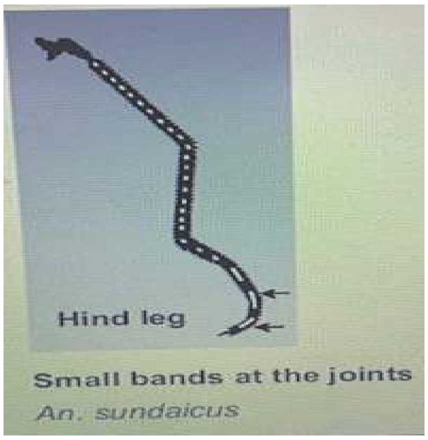
Biting time: Biting varies from area to area and seasonally, but peak biting activity is generally from 22.00 to 24.00 hrs.

Feeding habits: An indiscriminate feeder and bites both man and animals.

Flight range: Limited flight range in the urban areas but in rural areas the flight range may be up to 3 kms.

An. epiroticus (sundaicus)





Distribution: Reported from coastal Odisha, Andhra Pradesh and West Bengal in 1950 s. At present, it is restricted to Andaman and Nicobar Islands.

Breeding places: Breeds in brackish water pools with algae, margins of mangroves and lagoons and swamps. *An. epiroticus (sundaicus)* can tolerate salinity levels from 0.08 to 2.6 percent and pH from 7.7 to 8.5.

Resting habits: Rests indoors in human dwellings, cattle sheds and mixed dwellings.

Biting time: Biting goes on throughout the night, but peak biting is from 20.00 to 02.00 hrs.

Feeding habits: An opportunistic feeder, prefers to bite man.

Flight range: About 1-3 kms.

An. annularis

Distribution: This species is found all over the country.

Breeding places: Breeds in still waters with abundant vegetation in a variety of water bodies; also breeds in wells, moats (a deep, wide ditch surrounding a castle or fort filled with water), tanks, borrow pits, rice fields and other water bodies such as lakes and stream margins with vegetation.

Resting habits: During daytime it rests in houses, cattle sheds and mixed dwellings and also rests outdoors in small numbers.

Biting time: Peak biting activity takes place from 22.00 to 24.00 hrs.

Feeding habits: A zoophilic mosquito; biting human is infrequent.

Flight range: Normally up to 1 km.

An. philippinensis

Distribution: This species is distributed in West Bengal, north-eastern states. It was reported from Andaman and Nicobar Islands.

Breeding places: Breeds in tanks, swamps, ditches, rice fields, pools, leaf axils, shaded lake margins, inundated drains and water bodies generally with good growth of vegetation.

Resting habits: During daytime, the adults rest in cattle sheds and human dwellings.

Biting time: Biting outdoors and indoors throughout night with two biting peaks from 20.00 to 22.00 and 02.00 to 04.00 hrs.

Feeding habits: Predominantly zoophagic but also bites human.

Flight range: Normally up to 0.8 km.

An. varuna

Distribution: Distributed widely in the country from northeast plains to peninsular India and Lakshadweep islands.

Breeding places: Breeds in rainwater pools, tanks, ponds, rice fields, drains, irrigation channels, wells and slow-moving streams with plenty of shade provided by overhanging vegetation.

Resting habits: Rests indoors during daytime in human dwellings, cattle sheds and mixed dwellings. It rests outdoors near stream banks.

Biting time: Biting goes on throughout night but the peak biting activity is from 24.00 to 02.00 hrs.

Feeding habits: Resting habits may differ from area to area.

Flight range: About 1 km.

Vectors of dengue and chikungunya

Aedes aegypti

Aedes aegypti is common vector for dengue and chikungunya.

Distribution: In India, the density of *Aedes* mosquito is higher during monsoon and post-monsoon season. In dry area or water scarcity areas, the vector density is linked to water storage practices.

Breeding places: *Ae. aegypti* is the main vector in urban, semi-urban and rural areas. *Ae. aegypti* mosquitoes prefer to breed in man-made containers such as water storage containers, water tanks (cement tanks, overhead tanks, underground tanks), exterior extensions of building, coolers, discarded buckets, bottles, tyres, coconuts shells, etc. in which water stagnates for more than a week. In unfavourable conditions, the eggs can be viable for over a year in a dry condition, which allows the mosquito to re-emerge after winter or dry spell. The eggs (up to 100-120) are laid singly on damp surfaces just above the water line.

Resting habits: *Ae. aegypti* prefers to rest in dark corners of the houses, on dark clothes, umbrellas, under furniture & beds, shelves, coolers, behind hangings, shoes, besides household articles, curtains etc but rarely on walls.

Biting time: A day biting mosquito has to bite many times to complete blood meal as during daytime, mostly humans are active. This is also known as indiscriminate feeder.

Feeding habits: The species is strongly anthropophilic having high preference for human blood.

Flight range: Average flight range of *Aedes* is 100-300 meters. The flight range for *Aedes* is generally 100 meters but it can fly up to 400 meters.

Aedes albopictus

Distribution: It is the secondary vector in sylvatic areas. It is a feral species and spreads the disease in built-up areas, particularly in parks and gardens. It also co-breeds in peri-domestic water collections. The species feeds on human and other animals.

Breeding places: *Ae. albopictus* mosquitoes prefer to breed in natural habitats like tree holes, latex collection cups of rubber plantations, leaf axils of pineapple plants, coconut shells etc.

Resting habits: *Ae. albopictus* mosquito rests outside in bushes, shrubs, long grasses in and around peri-domestic situations. It is sometimes found in domestic conditions as well.

Biting habits: The *Ae. albopictus* feeds on different vertebrate hosts including human beings. It is also a day-biter.

Flight range: The flight range for *Ae. albopictus* is up to 400 meters. It may also disperse to newer areas through passive transportation (especially eggs).

Vectors of Japanese encephalitis

Culex vishnui subgroup mosquitoes, comprising *Cx. tritaeniorhynchus, Cx. vishnui* and *Cx. pseudovishnui* have been implicated as major vectors of JE in India. *Cx. tritaeniorhynchus* is the primary vector. *Cx. pseudovishnui, Cx. whitmorei, Cx. gelidus, Cx. epidesmus, Anopheles subpictus, An. peditaeniatus* and *Mansonia uniformis* are suspected to play some role in the epidemiology of JE.

Distribution: These mosquitoes are usually found in rural rice growing and pig- farming regions but can also be found at the outskirts of cities in close proximity to human populations.

Breeding places: They prefer to breed in rice fields. A conducive ecosystem comprising of irrigation canals, rice fields, ponds, ditches and lakes favour JE vector breeding particularly in rural areas. However, in semi urban areas, breeding of *Culex vishnui* group of mosquitoes found in small ponds and ditches with water hyacinth and other aquatic plants.

Resting habits: Main vectors of JE rest outdoors.

Biting time: JE vectors bite during night time.

Feeding habits: JE vectors are mainly exophilic and exophagic in nature.

Flight range: Flight range varies from 1 to 3 km.

Vectors of Lymphatic filariasis

Distribution: *Culex quinquefasciatus* breeds in association with human habitations. It is the most common house frequenting mosquito.

Breeding places: Breeds in many types of habitats including fresh, clear, brackish, turbid and polluted water with decayed organic matter from garbage and human waste accumulations in ground pools, ditches, drains sewages, septic tanks, etc. Various kinds of artificial containers (bottles, cans, flowerpots, vases, bowls, jars cement tanks, etc. both indoor and outdoor are also preferred breeding sites.

Resting habits: Enters houses for feeding at night and for resting during daytime i.e., endophilic and endophagous. Rests in dark corners of walls, hanging objects, cobwebs, inside shoes, cupboards, under cots, tables and chairs, bathrooms etc.

Biting time: Blood feeding takes place within 24-48 hrs. after mating from sunset until dawn. Highest peak is in the late night or third-quarter night. It is endophagous as well as exophagous.

Feeding Habits: Highly anthropophilic; may also feeds on birds and other domestic animals.

Flight Range: Average flight range of *Cx. quinquefasciatus* is about 2-3 km. Males are weak fliers.

Mansonia Species

Important species: *Mn. annulifera, Mn. uniformis* and *Mn. indiana*

Distribution: *Mn. annulifera* is the main vector but *Mn. uniformis* also plays a role. Both species found throughout year but slightly higher during June-August. *Mn. uniformis* density is higher where Salvinia host plants are completely replaced by Pistia.

Breeding places: Breeding of *Mansonia* species is restricted to freshwater ponds, lakes, swamps and channels with floating vegetation and high organic pollution with a pH range of 6.2- 6.8. *Pistia stratiotes* is the most preferred plant for breeding of *Mn. annulifera*, but*Salvinia* plant is preferred by *Mn. uniformis*. *Mansonia* species lay eggs as clusters of 80-120 on under surface of floating water plants. Tips of pupal breathing trumpet are modified for attachment to the plant. Larvae and pupae get available oxygen from air spaces of the floating vegetation.

Resting habits: *Mn. annulifera*, endophilic & endophagous, rest in dark corners of house, *Mn. indiana* mostly confined to cattle sheds and other outdoor situations.

Biting time: Active throughout night with peak biting activity in the first and second quarters of night. Endophagous in nature.

Feeding Habits: *Mn. annulifera* is highly anthropophlic; *Mn. uniformis*, more zoophilic.

Flight Range: Not strong fliers, easy to catch due to hopping like sandflies. Silent in flight with limited flight range.

Vector of Visceral Leishmaniasis (VL)

Phlebotomus argentipes, commonly known as sand fly is the only vector of VL in India. Adult sand fly small, fuzzy, delicately proportioned, 1/4th the size of mosquito. Length ranges from 1.5 to 3.5 mm.

Distribution: In India, distribution mostly on the eastern half of the country though reports of its prevalence have also emerged from other parts as well. *Ph. argentipes* found throughout the year in majority of areas of prevalence with complete absence in winter months. Though sand flies are not found at the altitude above 600 meters, sporadic occurrence in India has been recorded in Kasauli at a height of 1200 meters and at 1300 meters in Pauri Garhwal in the Himalayas.

Breeding places: Humid soil rich in organic matter, near cattle sheds and mud- houses.

Resting Habits: Resting sites include cracks and crevices, burrows, tree holes, termite hills, earthen mounds, under stone and foliage, etc.

Biting habits: Opportunistic feeder and mostly zoophilic in nature.

Flight range: They are poor fliers and mostly hop covering a distance of less than half metre.

6

Local Determinants of Disease

IVM local determinants: The interaction between pathogens, vectors, humans (animals in some cases) and the environment determine the burden of Vector-borne diseases in any area. There are many determinants that can influence VBDs. The different interactions result in wide variation in time and space in which diseases occur. The geographical distribution of diseases may vary for different diseases and from year to year. The distribution of diseases may also vary among the population due to differences in risk of individuals and communities. For example, in malaria-endemic areas, people who sleep close to breeding sites tend to have a higher risk of exposure. The first stage of situation analysis is to understand about vectors, pathogen, endemicity of disease and transmission cycle. Further, the knowledge about local environment, its natural features along with human behaviour are crucial, which, needs to be assessed. It is important to consider these determinants and their interactions to understand the reasons for diseases occurrence and appropriate control measures. Five categories of determinants of VBDs are parasite or pathogen, vector, human, animal disease and environment. The entomological analysis facilitates in identification of these local determinants of the transmission and prevalence of VBDs.

- Parasite-related determinants indicate about parasites or pathogens causing disease. These are answered by parasite surveillance.
- Vector-related determinants indicate about vectors responsible for transmission and their characteristics. These can be answered by vector surveillance.
- Human-related determinants indicate about the distribution and structure of the population, vulnerable groups, populations settled close to the vector breeding habitats, patterns of population migration, local perception, practices and attitudes towards vector-borne diseases.
- Another important determinant is to find out whether alternative hosts of the pathogen are present in the area.
- Environment-related determinants are to assess the rainfall patterns, local ecosystems, land use and breeding sites.

The above-mentioned information needs to be collected through local surveys, interviews, and participatory exercises. Capacity and capability of system and human resource to generate data on vector characteristics, parasites, and disease transmission need to be strengthened for existing human resource available at national and sub-national level at the earliest.

The first step is to know about parasites or pathogens causing disease and then find out the prevalence of vector-borne diseases in the area. The available options for prevention (e.g., vaccines or preventive chemotherapy) and treatment of the disease in the area may be considered.

- Knowing endemic vector-borne disease in the area will be the evidence to plan and implement vector control. The distribution of vector-borne diseases may be shown in map. The epidemiological data should be supplemented to prioritize control or elimination strategies.
- Assessment of available medical options may facilitate to use appropriate measures timely. For example, vaccines and preventive chemotherapy are available for some vector-borne diseases. A vaccine is available for Japanese encephalitis. Preventive chemotherapy is the commonly used control measures for a number of vector-borne diseases, including lymphatic filariasis. The options for treatment, guidelines on choice of drug and dosing should be followed. The status of drug resistance should also be considered while implementing the treatment schedule. In case of non-availability of effective drugs for some diseases like dengue and chikungunya, only supportive care is recommended and knowledge on all such above determinants facilitates in choosing appropriate control measure.
- To know the parasites or pathogens causing disease, the diagnostic capacity should be built to distinguish between parasites, such as *P. falciparum* and *P. vivax* and co-infection within e.g., *Leishmania* and HIV.

Vector Related Determinants

- The main vectors must be identified, and the regular re-assessment is also necessary for species composition as it may change over time, due to climatic and environmental change.
- The determinants like place and time of the occurrence of vectors help for focused vector control operations in the areas and the times during which the vector is present.
- The presence of suitable habitats and seasonal changes in weather such as temperature or rainfall determine the vector abundance.
- Behavioural characteristics of vectors (e.g., diurnal /nocturnal periodicity, endophily/exophily, anthropophily/zoophily) are crucial as these determine the efficacy of some control methods. For example, ITNs or LLINs are effective against indoor, night-biting mosquitoes; while IRS is effective against mosquitoes that rest indoors. Some vectors feed on both humans and other animals while some are mainly zoophilic or anthropophilic. The effectiveness of vector control measures may vary for such behaviour of vectors. The behavioural characteristics of vectors should therefore be assessed regularly over time, as vectors may adapt in response to control measures.
- Breeding sites and potential breeding places are another important determinant to choose where anti-larval operations can be instituted. Larval stages of vectors cannot run or fly away thereby making it suitable targets for vector control, provided the breeding sites are “few, fixed and findable”. Therefore, larval source management can be used against mosquito larvae for control of malaria, dengue, chikungunya and Zika in limited areas depending on feasibility and resources.
- The susceptibility to insecticides is important so that the impact of insecticide is evident. It is crucial determinant and important to monitor the susceptibility of vector populations to insecticides, because, if their susceptibility is reduced, vector control may be less effective. Besides, insecticide resistance, the specific

mechanisms involved, and the intensity of resistance should also be investigated to take a decision on change of insecticide.

Human-related determinants

Human determinants are important as they can influence:

- Co-existence of vectors and human commonly seen in poor housing conditions or population movement into new areas. It is important to understand whether transmission occurs in houses, during travel or at work. This will require understanding of population movement and vector behaviour in the high-risk areas.
- Disease transmission, in the suboptimal or absence of preventive/control measures.
- Infectious reservoir in low socio-economic group with poor nutrition or co-morbid conditions and having poor access to health care and effective treatment. Low socio-economic status is often associated with poor economic and housing conditions, high population density, overcrowding, poor sanitation and hygiene which are all risk factors for vector-borne disease transmission.
- Local practices and attitudes towards vector-borne disease are other determinants to be understood, as their practices and behaviour, such as water storage methods, outdoor sleeping giving more exposure to mosquito bite may affect disease incidence. The reluctance or poor adherence to preventive measures such as LLINs increases the risk of transmission. These conditions should be identified in the population and addressed.
- Access to diagnosis and treatment is very crucial as capacity and capability of health services differs by location. The capacity in rural and remote areas is often suboptimal due to various reasons viz., distance between health facilities and communities, expenditure to be incurred on travel and acceptability etc. People in remote and inaccessible areas may seek medical care from traditional healers, public or private health sector, from pharmacies and drug sellers available locally who may not follow the treatment policy.

Environment-related determinants

- The environment plays crucial role for transmission of vector-borne diseases and therefore local ecosystems needs to be studied. Vector species are adapted to specific ecological settings as different ecosystems viz., forest, forest fringe area, urban, rural areas, project and tribal areas etc. influence the abundance of vectors. In addition to ecosystem, other environment related determinants are indicated below:

- **Land use:** Agricultural practices may alter vector habitats and increase the risks for vector-borne diseases. For example, commercial forest plantations create habitats for malaria vectors that prefer to breed in shaded and slow running streams available in forests. Irrigation often increases mosquito populations, especially *An. culicifacies* which is one of the primary vectors of malaria in India. Urbanization alters breeding sites and can lead to increased prevalence of vector-borne diseases such as dengue and *An. stephensi* related malaria.

- Local weather like rainfall and temperature affects the life cycle of many vector species. Understanding these determinants and seasonality of disease transmission facilitates to initiate control activities at appropriate time.
- For example, in areas of intense seasonal transmission, LLIN distribution or mass drug administration should be done at the beginning of the rains.
- Larval source management with larvicides may suppress larval habitats during the dry season but can be avoided in rainy season as the larvicide may be washed off or diluted.
- In areas where outbreaks of dengue or malaria occur, close monitoring of the rainfall patterns may help in planning and preparing for any possible outbreak. Vector control interventions should be in place throughout the transmission period.
- Information on breeding habitat, its nature (fixed and permanent), the number of breeding sites, determine its importance which helps in planning larval source management within available resources.
- The combinations of interactions among pathogens, vectors, humans and the environment determine the abundance of vector-borne diseases. Understanding these complex interactions is very important because it strengthens the programme managers to understand why the diseases occur and how it can be controlled.

Animal-related determinants

Some vector-borne diseases are zoonotic (diseases occurring in animals). Therefore, it is important to determine which wild or domestic animals are carriers of vector-borne pathogens. Following points are important in understanding these determinants.

- The common species of wildlife in the area. Wildlife is infected with many different pathogens, some of which may also infect humans. Birds, rodents and small mammals can act as reservoirs of infections for human diseases.

- The domesticated animals or birds in certain situations, facilitates vector-borne disease pathogens. The natural cycle of Japanese encephalitis virus is maintained in ardeid birds and the pigs are amplifier host. Human beings are the dead-end host as human-to-human transmission is not possible.

7

Selection of Vector Control Tools

Core vector control interventions recommended for prevention of malaria are LLINs and IRS. Interventions are based on local epidemiological, entomological information, including insecticide susceptibility status of vectors. Larval source management (LSM) is a useful supplement, but it is recommended only in locations where breeding sites are "few, fixed and findable". In India, LSM (commonly known as anti-larval and source reduction) is recommended in mainly in urban localities.

Supplementary interventions like housing improvements by screening or use of mesh on doors and windows are usually practiced.

Vector control interventions recommended for lymphatic filariasis is mainly LSM where culicines are responsible for transmission.

For dengue, a combination of vector control methods is recommended (chemical, biological or environmental) for targeting immature and adult vectors.

In case of Kala azar, LLINs and IRS are effective for control of sand fly vectors biting or resting indoors.

Strategies such as larviciding and environmental management are recommended in some settings to reduce mosquito numbers without use of insecticides, thereby, reducing selection pressure for insecticide resistance.

It is important to consider the following factors while selecting the most appropriate vector control method or combination of methods:

1. Effectiveness of the control tools
2. Local ecology and behaviour of vectors
3. Resources available for implementation in terms of human, financial and material
4. Tradition and culture of society to use effective behaviour change communication for better output
5. Feasibility of implementation tools and coverage

Tools: Many tools are available and recommended for vector control. Some are used for personal protection and some in combination are used as public health measures. These can be broadly classified as source reduction, biological and chemical control for adults and larvae. Tools for environmental manipulation and modification can be selected depending on feasibility and risk hazards.

Key points

- There is a wide range of vector control tools that can be broadly classified as chemical based and non-chemical based.
- Vector control tools should be chosen primarily on the basis of their efficacy against epidemiological parameters (prevalence or incidence of disease), although evidence of efficacy against the vector may be useful in some circumstances.
- Vector control tools may be effective against multiple diseases, for example, IRS/LLIN/Fogging/LSM is useful against malaria, lymphatic filariasis, dengue and kala-azar.
- A number of other factors should be taken into account in choosing vector control tools, including vector characteristics, Insecticide resistance, implementation, affordability, cost-effectiveness, community participation, human and environmental safety.

Vector control programme in India, similar to many anti-malaria programmes in the world, relies mostly on using natural and synthetic chemical molecules that have the potential to kill the target mosquitoes. Presently, different formulations of synthetic chemical insecticides are in use for vector control. Wettable powder (WP) formulations are used for indoor residual sprays while emulsion concentrate (EC) formulations are used for larval control. For IRS, insecticides in use are DDT 50% WP, Malathion 25% WP and synthetic pyrethroids. Synthetic pyrethroids include Deltamethrin 2.5% WP, Cyfluthrin 10% WP, Lambdacyhalothrin 10% WP, Alphacypermethrin 5% WP and Bifenthrine 10% WP. The synthetic pyrethroids are also used for impregnation of bed nets. The insecticides having residual effect are used during IRS to reduce their longevity. The mosquitoes pick up insecticide particles sprayed on the walls while resting after the blood meal and do not survive long enough to become infective. In areas where the vectors are strongly endophilic, i.e., they tend to rest indoor, IRS of human dwellings can provide effective control. Vectors that are exophilic i.e., tend to rest outdoors but tend to feed or rest indoors, can be effectively controlled by IRS with insecticides that have good airborne effect. In areas where vectors are strongly exophilic and/or exophagic, i.e., rest and bite outdoors, other control methods such as use of LLINs/ITNs, or outdoor space spraying (for emergency control) should be considered. In practice, the effectiveness of house spraying for malaria control depends on adherence to the specified criteria of the insecticide and application procedure, public acceptance of spraying, availability of well-maintained equipment and adequately trained spray personnel. Its effectiveness depends on local customs and traditions for example mud plastering after spray and white wash during the local festivals coinciding with the transmission season reduces the effect of IRS. The points to be considered for effective vector control are the distribution of malaria and its vectors, presence of active breeding sites, the flight range of the vectors and demographic features.

Selection of insecticides

Several factors need to be considered in the selection of an insecticide for spraying including availability, cost, residual effectiveness, safety, vector susceptibility and excito-repelency.

Tools for Adult Vector Control

Adult mosquito control in routine is done for reducing their density and longevity by IRS and/or LLINs. One tool is undertaking indoor residual spray (IRS) with Insecticides and use of LLINs.

Insecticides used under NVBDCP for IRS

The following formulations/compounds are used under the programme for prevention, control and elimination of malaria.

DDT

In India, DDT has been used for malaria control since 1946. Since DDT persists for a long time in the environment, there has been apprehension that it will adversely affect human health. DDT has already been banned for use in agriculture and under phasing out for use in public health programme.

The Government of India has constituted a mandate committee on DDT that reviews the use of DDT in public health and decides the quantity to be released for the malaria programme every year.

The requirement of DDT 50% WP is 150 MT per million population for two rounds of spray. In areas where a third round is proposed, the additional requirement is estimated to be 75 MT per million population.

Malathion

Malathion 25% WP is used under the programme in areas with DDT resistance. The disadvantage of using malathion is that three rounds are required annually to cover transmission period. The long exposure to organophosphorus compounds such as Malathion, which is a cholinesterase inhibitor, may result in acute toxic symptoms leading to lethal effect on the exposed individual. Therefore, the persons engaged in spraying organophosphorus compounds should be given elaborate protective gear and their blood cholinesterase level should be checked periodically to assess the toxic impact of the compounds.

Requirement of Malathion 25% WP is 900 MT per million population for three rounds of spray. In areas where an additional round is proposed, the additional requirement is estimated to be 300 MT per million population.

Synthetic pyrethroids

These are new insecticides introduced to control VBDs in India. The cost of these insecticides is higher than the cost of DDT and Malathion. Currently, the insecticides in this group registered with Central Insecticide Board for use in the programme are Deltamethrin 2.5%WP, Cyfluthrin 10%WP, Alphacypermethrin 5%WP, Lambdacyhalothrin 10%WP and Bifenthrine 10%WP.

Requirement of synthetic pyrethroids: The requirement of Deltamethrin 2.5%WP is 60 MT per million population for two rounds of spray. In areas where an additional round is proposed, the additional requirement is estimated to be 30 MT per million population.

The requirement of Cyfluthrin 10%WP is18.75 MT per million population for two rounds of spray. In areas where an additional round is proposed, the additional requirement is estimated to be 9.375 MT per million population.

The requirement of Lambdacyhalothrin 10% WP is 18.75 MT per million population for two rounds of spray. In areas where an additional round is proposed, the additional requirement is estimated to be 9.375 MT per million population.

The requirement of Alphacypermethrin 5% WP is 37.5 MT per million population for two rounds of spray. In areas where an additional round is proposed, the additional requirement is estimated to be 18.75 MT per million population.

Change of insecticide

If a change of insecticide is warranted, the state government should support their choice of alternative insecticide by documenting data on vector resistance studies and field observations on epidemiological impact of spray in respect of insecticide in use. The change of insecticide is decided in consultation between SPO, RoH&FW and the Directorate of NVBDCP now renamed as NCVBDC. Insecticide ideally should be procured for next year's spray operations in advance and its delivery should be ensured in such a manner that the insecticide should reach the periphery before starting the first round of spray operations.

Long Lasting Insecticidal Nets (LLINs) are mosquito nets that have the insecticide incorporated in its fibre, so that it is not removed till 20 washes. Because these nets have an even and quality-controlled insecticide application, they are generally more effective than conventional ITNs. Furthermore, LLIN is more cost-effective (as it can be used for 3 years) than distribution of conventional bed nets and treating them with insecticide twice a year.

Tools for larval source management (LSM): The control tools as anti-larval measures recommended under the programme are:

Biological control

1. **Fish:** Larvivorus fishes (*Gambusia affinis* and *Poecilia reticulata*) have been extensively used for the control of *An. stephensi* and/or *Ae. aegypti* in large water bodies or large water containers/wells. The applicability and efficiency of this control measure depends on the type of containers.
2. **Bacteria:** Two species of endotoxin-producing bacteria, *Bacillus thuringiensis* serotype H-14 (*Bt.* H-14) and *Bacillus sphaericus* (*Bs*), are effective mosquito control agents and do not affect non-target species. Currently, two formulations of Bacillus thuringiensis var. israelensis (Bti) i.e., wettable powder (WP), aqueous suspension (AS) are recommended under the programme.

Chemical larviciding

1. **Mosquito larvicidal oil (MLO) -**Its action on larvae is due to suffocation by producing a surface film which cuts off their supply of air by blocking their respiratory tubes by particles of oil and reduces surface tension, making it difficult for larvae to remain at surface, thus, causing them to drown. The oiled breeding sources tend to deter the adults from depositing their eggs.

2. **Temephos 50% EC** -Temephos is an organophosphorous compound with very low mammalian toxicity. It is used as 50% emulsifiable concentrate in the programme. The product acts as a contact poison and has a prolonged residual effect. This is very safe chemical which is not toxic to fish and other aquatic life, if used in the recommended doses.

3. **Temephos 1% GR-** These granules are used in stored water like coolers for control of vectors of dengue, chikungunya and Zika. Dosage of 1 ppm is effective against mosquito larvae in containers. This formulation has not undergone the process of approval under the programme but is used mostly in desert coolers.

Insect growth regulators (IGR)

1. **Pyriproxifen 0.5% GR** -It is an insect growth regulator. It mimics natural insect hormones that stop young insects from maturing into adults.

2. **Diflubenzuron 25% WP** - It is a benzoylurea- type insecticide of the benzamide class. It is a chitin synthesis inhibitor, which is another type of insect growth regulator. The chitin synthesis inhibitors interfere with the normal synthesis of insect exoskeletons during moulting or at the time of hatching of eggs. The vector control staff using IGRs should be properly trained to identify the flaking in the cuticle and swelling of head and thorax of the larvae, as there will not be a visible larval mortality in the breeding sites. Since the mortality of larvae by IGR compounds is not as it is noticed in case of other chemical larvicides, so monitoring of its use is tricky. The same has been described in the subsequent chapter on monitoring and evaluation.

Tools for outbreak/epidemic containment

Space spray

1. Every house in all the affected villages should be covered.
2. Indoor space spray with pyrethrum/cyphenothrin should be carried out for 7 to 10 consecutive days or till IRS is completed in all houses of the locality. Hand operated micro-discharge fogging machine or hand operated atomizers (flit pump) should be used for space spray.

Key points

Besides the programme guidelines, the advisories under NHM are also issued for use of untied funds and Annual Maintenance Grant for Primary Health Centres (Page 9- Point 5 Bullet 12) towards larvicides. The concerned authorities need to be sensitized in this regard regularly.

http://nhm.gov.in/images/pdf/communitisation/vhsnc/order-guidelines/vhsnc_guidelines.pdf.

Outdoor fogging

Outdoor fogging with malathion technical/cyphenothrin should be carried out for 7 to 10 consecutive days initially followed by weekly and fortnightly till the current transmission is contained.

IRS

1. IRS should be started simultaneously with indoor space spray.
2. The insecticide of choice will be the insecticide to which the local vector is susceptible as per the best available information.
3. Insecticide spray should be done at the recommended dose.
4. All rooms of all houses and mixed dwellings should be sprayed.
5. Care should be taken to remove all the photographs (if any) from the wall before spray.
6. All the underside of the furniture/cot should be sprayed.

Key points

- Under programme, IRS and LLIN are recommended for adult control in routine for the areas qualifying for such intervention (API>1).
- Larval Source Management was recommended earlier for urban areas/towns covered under Urban Malaria Scheme/National Filaria Control Programme.
- Currently, Larval Source Management is recommended for *Aedes* mosquitoes (vectors of dengue, chikungunya, Zika) and *An. stephensi* (Malaria vector) in urban areas and urbanized rural areas.
- Fogging (Thermal/Cold) is recommended for outbreak containment and not as a routine vector control measure.
- Approved insecticides under programme need to be used only.
- Insecticide resistance Monitoring by entomologists is crucial for change of insecticide and therefore data need to be generated on yearly basis.

8 Needs & Resources

Needs and resources are the most important component of the IVM framework as it governs the success of implementation of activities. Like other plans, the IVM implementation also requires the resources in terms of human, finance and the capacity to deliver the services. The planning for need and resources required to implement includes a budget estimate covering all feasible and recommended activities within a timeframe.

After doing the situation analysis and selection of vector control method, the next step is to work on the requirement of commodities, tools, activity plan including core and supportive interventions, outbreak containment, human resources and financial implications.

The programme guidelines on preparing an annual plan for each activity and its financial norms have been widely circulated under the overarching umbrella of National Health Mission.

Besides allocation of financial resource from central, state and local governments, various stakeholders and donor partners showing interest need to be identified and their resources be explored. Such partners usually come forward to support various activities like capacity building, advocacy, commodities or newer tools. The research organizations and academic institutions may also support in data generation especially on insecticide resistance monitoring, vector bionomics and feasibility of inclusion of newer insecticides etc., under programme. These organizations may do such activities out of their financial resources in limited areas or with minimal support required from programme which need to be worked out for pooling of resources and its mechanism.

Key points

- Make an inventory of the financial, human resources, infrastructure available and required for VBD control at national, regional or district level.
- Resources should be shared with other sectors, depending on the type of interventions. Such issues need to be flagged in inter-sectoral meetings so that different stakeholders create a budget line and make provision for financial resources to implement IVM within their jurisdiction.
- A number of tools are available for resource planning.

The other factors to consider for needs and resources are:

- Partnership approach with the private sector in VBD control activities and developing trust so that the programme activities are extended beyond the government health system.

- The corporate sector needs to be made aware of the economic loss that occurs if employees fall sick due to VBDs. The reputation of the company towards social responsibility and good corporate citizenship will also be affected if measures for VBD control are not taken timely.

- These organizations need technical guidance for planning and implementation which need to be supported from programme.

Key points

- Vector control under IVM is implemented by various stakeholders, therefore, programme should consider partnering with the private sector in VBD control activities.
- There are economic (reduced direct and indirect costs on VBDs), and social benefits of businesses investing in VBD control.

Key points

Skills and resources of entomologists in VBD control programme need to be shared among all stakeholders to expand:

- Vector surveillance activities
- Monitoring insecticide resistance
- Vector sampling tools, methods or areas for sampling

9 IVM-Implementation

Implementation of IVM requires assessment of possible challenges of VBDs to be managed in a locality and associated factors. IVM is implemented essentially to reduce the elements or risk of disease transmission by reducing breeding, abundance, longevity of the vector and human-vector contact. Effective application of IVM must be based on understanding of the ecology, bionomics and behaviour of the target species and its relation to its host and environment. It is to be implemented where vector population aggregate for the sake of feeding, resting or breeding etc.

The implementation of IVM involves following important intervention activities:

- Entomological surveillance in sentinel and random sites at regular intervals (monthly, quarterly, biannual or yearly depending on resources and planning).
- Appropriate use of recommended insecticides during IRS under supervision following programme guidelines.
- Distribution and use of LLIN to achieve universal coverage in identified areas.
- Treatment of community-owned bed-nets, wherever available and used.
- Intensified anti-larval operations in urban and peri-urban areas.
- Scaling up use of larvivorous fish involving local community.
- Promoting source-reduction, minor engineering, etc. with involvement of Panchayati Raj Institutions at the village level.
- Supportive interventions including information, education and communication (IEC) and behavior change communication (BCC) activities are implemented through:
    - o Village Health Sanitation and Nutrition Committee meetings on a monthly basis.
    - o Inter-sectoral collaboration meetings in the district and blocks for prioritising the areas based on following main indicators:
- Involvement of other sectors for social mobilisation towards prevention and control with coordinated efforts of district-level programme managers.
- Training to ensure that all stakeholders including implementers are trained in a structured and planned manner.
- Monitoring and supervision for the activities as well as for timely performance need to be undertaken by those who are aware of the guidelines and amendments issued from time to time.

For IVM, interventions are to be selected targeting specific stage of the vector life cycle (immature/larval stages or adult stage).

Available tools for IVM are as under :

Chemical control

1. Chemicals have been used to control *Ae. aegypti* since the turn of the century. In the first campaigns against the yellow fever vector in Cuba and Panama, in conjunction with widespread clean-up campaigns, *Aedes* larval habitats were treated with oil and houses were fumigated with pyrethrins. The use of pyrethrum flowers extract for fumigation and space spray towards anophelines and *Aedes* started in 1911-12. During 1920-30, they were used against mosquitoes during the construction of 'Sarda Canal'.

2. Major breakthrough for adult mosquito control was seen when the insecticidal properties of DDT were discovered in the 1940s, this compound became a principal method of *Ae. aegypti* eradication programmes in the Americas and later in malaria control/eradication programme. When resistance to DDT emerged in the early 1960s, organophosphate insecticides, including malathion and fenitrothion were used for adult control and temephos as a larvicide.

3. Current methods for applying insecticides include adulticides through indoor residual spray (IRS), LLINs and larvicide, however, to contain outbreaks, insecticidal application through space spraying or fogging is recommended so that the older vector mosquitoes harbouring parasite and ready to transmit the infection are reduced quickly.

Biological control

Using biological control agents that are directed against the larval stages of mosquito vectors have been restricted to urban areas mainly due to its feasibility in urban areas and its high financial implication in rural areas on account of innumerable breeding sites. Different biological agents are effective and some are recommended in the programme:

- **Fish:** Larvivorus fish (*Gambusia affinis* and *Poecilia reticulata*) and some indigenous larvivorous fishes can be used in permanent water bodies-the breeding sites for vector mosquitoes.

- **Bacteria:** *Bacillus thuringiensis var. israelensis* is recommended and used as per the dose approved under NVBDCP.

> The states/UTs including municipalities and corporations should look for amendments/ inclusions under programme.

Adult Vector Control

1. Long Lasting Insecticidal Nets (LLINs)

LLINs have been used mainly in malaria control or elimination programme but have limited utility in dengue control programmes, since the vector species bites during the day. However, such nets can be effectively utilised to protect infants, pregnant women, elders and night workers who sleep by day. They can also be effective for people who generally sleep in the afternoon. The use of LLINs is scaled up to get universal coverage and its regular use, especially in high malaria-burden areas. However, for best effectiveness in the community, coverage of population at risk with LLINs must be as close to 100% as possible with high utilization rate (>80%). LLINs are manufactured by either incorporation of the synthetic pyrethroid insecticide into the net's fibres or coating or impregnation of the insecticide on the fibre with a wash-resistant binder system.

The timing of LLIN distribution should be shortly before the start of the rainy season. Comprehensive and regular health education campaign (Behaviour Change Communication) is necessary to not only ensure high uptake, but also to promote correct use and maintenance of LLINs. Those involved in LLIN distribution should demonstrate the method of correct hanging of LLINs as well as how to use them for sleeping outdoors by tying them to four sticks and proper tucking at the bottom.

Universal coverage with LLINs for all people at risk of malaria is recommended. For mass campaigns, one LLIN should be distributed for every two persons at risk of malaria. However, for procurement purposes since many households have an odd number of members, the calculation needs to be adjusted when quantifying at the population level. Therefore, an overall ratio of one LLIN for every1.8 persons in the target population should be used. Sometimes it becomes necessary to be little flexible during distribution in order to match the persons with LLIN e.g., in case of single person in a house, only single net is to be provided or in case of two person's family of higher age where man is sleeping outside, two nets are to be distributed.

2. Indoor Residual Spraying (IRS)

IRS is one of the cost-effective control measures for malaria and kala-azar in India. It interrupts the transmission by reducing the number of infective vectors and their longevity. This can be achieved by ensuring safe and correct application of the insecticide to indoor surfaces of houses and animal shelters. For malaria, only human dwelling, and for kala-azar, both human dwelling and animal shelters, are covered. Regular rounds of IRS are done in malaria and kala-azar affected areas. Focal spray is also done around malaria positive cases.

The success of IRS operations depends on the planning and implementation. IRS plans should be developed before the end of the year so that there is no last-minute rush during implementation. IRS planning should be done based on the capacity for achieving complete and uniform coverage. When there are resource constraints, it is preferable to prioritize the area for spray operation and achieve quality coverage.

IRS for malaria

At present, IRS is carried out in high-risk areas with API ≥ 1. Two rounds of spraying are recommended for DDT and synthetic pyrethroids to provide protection throughout the transmission season. In the case of malathion, three rounds of spraying are required. Additional or third round may be resorted only in case of perineal transmission and if situation demands.

With the upscaling on the use of LLINs in high-risk areas and declining malaria incidence, the regular rounds of IRS will be reduced. The focus will therefore be on improving the quality of IRS with meticulous micro planning and intensive monitoring and supervision. High-quality

IRS helps in reducing the number of infective mosquitoes, especially endophagic (indoor feeders) and endophilic (indoor resters), thereby, interrupting the transmission and showing disease reduction in 2-3 years. Such impact is expected to bring areas previously qualifying as high risk to low risk. This would bring about a decline in the requirement of insecticides to be sprayed in the following years. The unit for IRS in malaria is sub-centre, however, many states have done village-wise stratification and based on that has made village as unit of IRS.

All the 5 walls (including ceiling) must be fully sprayed.

The existing IRS strategy is:

- for areas having perennial transmission or more than 5 months transmission in a year is 2 rounds of IRS with DDT/SP or3 rounds with Malathion, depending on the vector susceptibility;
- for areas having less than 5 months transmission in a year, have1 round of IRS with DDT/ SP or Malathion before start of the transmission season, and
- focal spray whenever and wherever needed.

Focal spray as IRS is usually done in and around50 houses of malaria positive case, in case of more than one case, it may overlap. The insecticide used in regular round of IRS need to be used.

IRS for kala-azar

The entire village needs to be covered if selected for IRS. Following criteria are applied while selecting areas for IRS:

- All villages within a block PHC that have reported kala-azar cases in the past three years.
- New villages that reported cases during year of spray.
- Villages free of kala-azar, but during search, were found to have cases conforming to the case definition.

The use of DDT 50% in IRS for kala-azar has now been replaced with synthetic pyrethroid. Currently, alphacypermethrin 5% WP is used, however, anyone of recommended synthetic pyrethroids under programme may be used. Spraying should start before the onset of kala-azar transmission season which coincides with time of build-up of vector population. The build-up in vector population usually starts in March and peak kala-azar transmission season is from June to October. The effectiveness of synthetic pyrethroids lasts for about 6-8 weeks. Two rounds are recommended to control the vector population and to protect during entire transmission season. The schedule may be modified based on local weather conditions.

> It is important that while preparing the micro action plan for IRS by the district, provision of additional 10% enhanced budget is kept in the Annual Action Plan to cover any new area or village(s) during the spray round.

For kala-azar elimination, insecticide is sprayed up to a height of six feet only as the sand fly vector usually hops up to this height. Cattle sheds should be covered to interrupt the transmission of kala-azar. The veranda and areas with full sun light should not be sprayed, but dark and humid areas, may be covered. Kala-azar vector prefers dark humid areas, ill ventilated rooms for resting. Therefore, special attention needs to be paid to cover these dark humid areas during the spraying process.

Stirrup pumps are mostly used for IRS in malaria-affected areas in India. Hand compression pumps are also recommended and can be used after proper training. Currently, hand compression pumps are used for IRS in kala-azar affected areas as supported by donor agency.

Hand compression pumps have advantage over stirrup pumps since two workers are required to operate one stirrup pump, whereas a hand compression pump can be operated by one person. The state can choose any other pumps at their discretion. The Expert Committee on Malaria-1995 recommended 260 workers i.e., 52 squads for five months spray period to cover one million population (for stirrup pumps).

1. Each spray squad can cover 60-80 houses a day (i.e., 30 to 40 houses per pump).
2. In hills/foothills, a squad can cover 50 to 60 houses per day (i.e., 25 to 30 houses per pump). Each spray squad comprises of:
   - Five field workers (unskilled)
   - One pump man, one spray man for each stirrup pump and one man for bringing water to prepare suspension for two pumps
   - One superior field worker (supervisor-skilled labourer) who will supervise the spray and maintain records.

Table-1: Requirement of equipment and accessories for each squad

Stirrup pump squad	Hand compression pump squad
Stirrup pumps - numbers 2	Hand compression pumps-numbers 3
Spray nozzle tips for spray pumps -2 plus additional 2 as spare	Spray nozzle tips for spray pumps - 3 plus additional 3 and Control flow volve as spare
Bucket 15 litres (4) /10 litres (1)	Bucket 15 litres - (3)
Asbestos thread (3 metres)	NA
Measuring mug (1)	Measuring mug (1)
Straining cloth (1 metre)	Straining cloth (1 metre)
Pump washers (2)	NA
Plastic sheet 3X3 metres (2)	Plastic sheet 3X3 metres (3)
Register for records (1)	Register for records (1)
Writing material to identify households covered by IRS	Writing material to identify households covered by IRS
Tools for minor repairs (pliers, screwdriver, spanner, etc.)	Tools for minor repairs (pliers, screwdriver, spanner, etc.)
Personal protection equipment (PPE) for each member of the squad including a pair of gloves	PPE for each member of the squad including a pair of gloves
Flashlights one per squad and one per supervisor	Flashlights one per person and one per supervisor
Spare parts at the district and block level 10%	Spare parts at the district and block level 10%
Human resource 2 per pump	Human resource 1 per pump
Supervisor -1	Supervisor - 1

Note: The pros and cons of using both kinds of pumps are crucial as it affects quality, coverage and financial implication.

1. To estimate the amount of insecticide required for an IRS spray round, the following calculations may be done (WHO Manual on IRS):

https://apps.who.int/iris/bitstream/handle/10665/177242/9789241508940_eng.pdf?sequence=1&isAllowed=y

N: number of houses to be sprayed (expressed as the percentage of modern and traditional structures).

S: average sprayable surface per house in m^2.

C: concentration of the active ingredient in the formulation (% a.i.); and

Y: target dosage expressed in g/m^2 (application rate) of insecticide to be used

Once this information is gathered, Q, the total quantity of insecticide needed (kg) is calculated as shown below:

$$Q = \frac{S \times Y \times 100}{C} \times N = XXX, g$$

Note: The quantity of insecticide thus calculated should be increased by 10% to overcome any possible shortage.

Example:

i. Determine the amount of insecticide formulation required to treat 11,607 formal structures with an average sprayable surface area of 300 m^2.

ii. The insecticide formulation selected is lambdacyhalothrin 10% WP. The dose to be applied (application rate) is 0.025 g of a.i. per m^2.

$$Q = \frac{300 \times 0.025 \times 100}{10} \times 11,607 = 870525 \text{ gm } (870.5 \text{ kg})$$

iii. 870.5 kg of insecticide formulation are required to spray 11,607 structures/houses; + 10% buffer stock = 87 kg. The total amount of lambdacyhalothrin required: 957.5 kg.

2. The spray operations of one round should be completed in 45-60 days. This requires thorough planning and proper deployment of staff otherwise the duration of first round is prolonged which will create problems in carrying out the second round in time, particularly with monsoon period closely following the first round of spray.
3. The spray squads should be supervised well to ensure quality (correct dose, uniformity and completeness of application) of the IRS.
4. The spray personnel should be well trained.
5. The supervisor of the spray teams should be a regular staff member of the spray

squad team.

6. A spray squad (for stirrup pump) comprises of 5 field workers and one superior field worker. The number of houses to be sprayed is determined by the terrain in which the team is operating.
7. The population to be covered should be divided by five since each household has an average of five members.
8. Calculate the number of spray teams that would be required in each district based on the number of houses to be sprayed.
9. Each spray squad should be supervised by a suitably trained health worker/ supervisor. This individual is different from the spray squad supervisor. The task of supervision of the spray squads should not be assigned to health workers who are expected to provide general health services. This is because the quality of services will suffer if the health workers are taken away from their work to supervise IRS. One supervisor is required to be responsible for adequacy of work of five teams.

Training of spraying squads and supervisors

The training of IRS comprises training of the health workers who are responsible for supervising the spray operations and training of the spray teams. District focal point for malaria and kala-azar is responsible for organizing such training. The training should be hands on and at least for three-days. The training curriculum should include following components:

- Importance of uniform and complete spraying
- Obtaining cooperation from the community
- Safe storage of the insecticide
- Preparation of insecticide suspension
- Correct use of the equipment & CFV
- Maintenance of the equipment
- Safety precautions and personal protection measures to be observed during the spraying operations
- Safe disposal of insecticide waste

The training of the supervisors should emphasize:

1. Community involvement for ensuring community acceptance and participation, which in turn is expected to achieve the completeness of coverage in all the targeted structures.
2. Supportive supervision, which includes the use of a standard checklist and problem solving.

- Each district proposed to be covered by IRS should develop a training plan.
- The training should be completed one week before the first spraying.
- Avoid a long interval between the spray operations and the training.

Spray programme

- The district plan should include a plan developed for IRS on the basis of endemicity of the areas identified for spraying.
- The plan should include identification of dates when the selected villages are proposed to be sprayed.
- The plan should be used to calculate the requirement of the insecticide, which should be supplied and safely stored at least one week before the spray.
- Every team should have route chart for effective supervision and monitoring.

In practice, the spray schedule is circulated from the centre to the states every year based on the data and previous schedule. The states are requested to follow the spray schedule. However, flexibility may be incorporated if state shows justification to defer the schedule or dates considering the local and focal situation. Thereafter, each supervisor develops a plan for each spray team.

Spray operations

- Spray operations comprise of estimating the needs for each squad, correct use of spraying technique, full coverage of all the targeted households, proper maintenance of the spraying equipment and preparing daily reports with stock checking.
- The estimated amounts of insecticide based on the requirements should be given to each spray squad.
- This should be distributed to the spray team and the team supervisor should be asked to maintain an account.
- Based on the plan for IRS, the sub-centre-wise and within the sub-centre, a village-wise programme should be developed by the supervisors with indication of the number of households to be covered in each village.
- A copy of the spray schedule should be kept by the supervisor. This would facilitate the supervision of the operations.

Spraying technique

- It is extremely important that the technique to prepare the suspension and spraying meets the recommended procedures.

Preparation and spraying methods

- The suspension of insecticide for spraying or other insecticide should be prepared when the team is ready to start the spraying. Primarily, the insecticide formulations used under programme are WP or water dispersible powder (WDP). It is supplied as powder packed in small pouches or bigger packings except Lambdacyhalothrin 10% which is supplied in self-dissolving sachets and packed in small pouches.
- The first step is to make the loose powder into a thick paste (DDT & Malathion) followed by preparing suspension carefully so that sufficient quantities of the insecticide are sprayed.
- Prepare 10 litres of suspension at a time. It is enough to cover 500 meters square

surface area with usual stirrup or hand compression pumps conventionally used under programme.

- Place the required quantities of insecticide in a 15-liter bucket.
- Add enough water using a measuring mug to make a paste of DDT, malathion or other insecticide as appropriate. Do not put too much water at this stage.
- Once the paste is made, pour water on the paste and keep mixing vigorously to make a uniform suspension and add measured volume of water i.e., 10 litres.
- Filter the suspension through a clean cloth to remove dust and other particles to avoid block in nozzle.
- From this point, action will be different for a stirrup pump and hand compression pump.
- If using a stirrup pump, the barrel of the spray pump is placed in the bucket containing the spray suspension. One person operates the pump and the other is responsible to spray.
- If using a hand compression pump, the ready-to-use suspension is filtered and poured into pump, lid is closed and pressure is created. In a traditional hand compression pump, which is fitted with pressure gauge, the pressure with strokes of handle is created till 40 lbs. Hand compression pumps can be operated by one person.
- The spray lance should be kept 45 cms (18 inches) away from the surface to be sprayed. The swath should be parallel.
- Spray is applied in a vertical swath of about 53 cms (21 inches) width as per programme guidelines (new HC pumps fitted with a control flow volve of 1.5 bar, the swath of 75 cms is produced).
- Spraying should be done from the top downwards. In case of kala-azar, the top should be restricted to six feet from the ground.
- The correct distance and angle of spraying are critical in depositing the correct concentration of insecticide on the sprayed surfaces. Spray operators should:
  1. stand in front of the spray surface area.
  2. maintain a body position of an average of 1m from the surface to be sprayed.
  3. maintain a distance of 45 cm (or 1.5 feet) between wall and nozzle.
  4. be aware that due to reduced deposit at the edges of the spray pattern, a 5 cm overlap needs to be maintained in order to achieve an even coverage of adjacent spray patterns of swaths.
  5. always begin spraying at the top of the swath, moving down and then up and from the left-hand side towards the right-hand side of the area to be sprayed;
  6. maintain a smooth comfortable action with the hand and elbow. The arm should be extended fully at the top and bottom with elbow bent in the middle to maintain a 45 cm distance from the nozzle to wall; and ensure that:
     i. in upper position, the spray pump lance moves vertically upwards,
     ii. in the middle position the spray lance remains horizontal; and
     iii. in the lower position the spray lance moves downwards vertically through the middle position.

7. The first swath is from top to bottom. After the first swath, the spray operator should take a step sideways to get to the middle of the next swath and cover the second swath from bottom to top. The correct footwork should be maintained together with the hand spray speed to generate the correct rhythm.

Spraying doors and windows

Total coverage cannot be achieved without spraying the sides of all doors and windows of the targeted structures. In particular:

- when doors and windows open inwards, both sides need to be sprayed.
- when doors open outwards, only the interior surface needs to be sprayed.
- the doorframe must be sprayed, beginning from the left or right bottom corner.
- the portion of the wall covered by the door (behind the door) must be sprayed.
- once sprayed, the door should be opened to allow adequate lighting into the room for the rest of the spray operation.

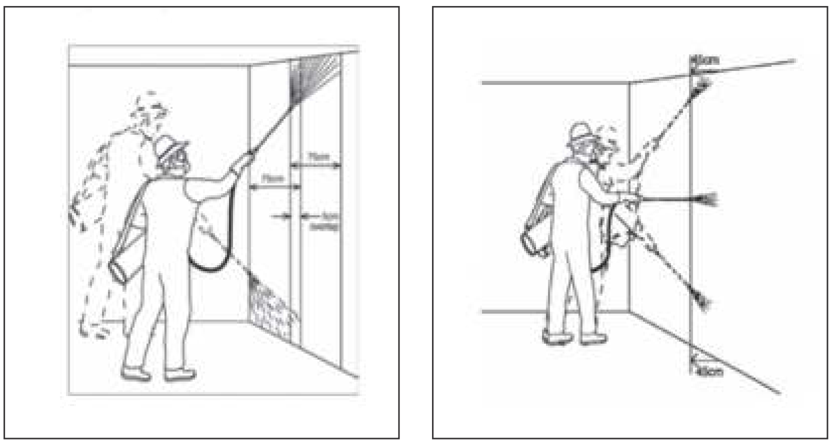


Figure-11: Techniques of IRS
(Source: Spraying, WHO 2015)

Spraying the wall (vertical spraying)

Starting from the edge of the doorframe, spray operators should spray the walls moving in a clockwise direction. Spray operators must:

- make sure the overall swath is 75 cm if the nozzle is 45 cm from the wall.
- maintain an overlap of 5 cm for successive swaths.
- ensure 5 seconds for every 2 meters vertical swath.
- agitate the sprayer at regular intervals while checking the pressure gauge.
- ensure that pressure does not drop below 25 psi (172kPa) for sprayers without a 1.5 bar CFV (re- pressurization will be required below this level). One pump stroke generally adds 1 psi to the tank pressure.

Spraying the ceiling

Spraying of inner roof and ceilings requires horizontal spraying. Spray operators should:

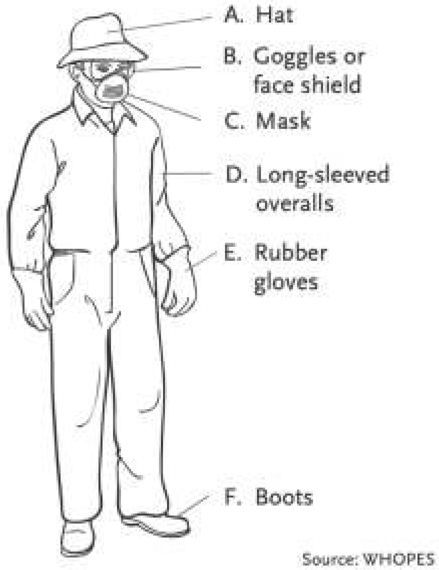


Figure-12: Personal Protective Equipment

- spray the ceiling or underside of the roof after the walls have been sprayed.
- the distance and spray timings will be same as is done for spraying of walls.
- if height of ceiling is more lance extension may be used.
- wear a hat when spraying the roof or ceiling.
- spray horizontally from the farthest point inside the room.
- avoid exposure to spray fall-out by directing the lance at an angle from the body.
- on completion, exit room and close the door; and spray door from outside if they open inside.

1. The correct timing for spraying a 2 m swath is 5 seconds (i.e., each linear metre covered should take2.2 seconds). Timing may be aided by mentally counting "one thousand and one, one thousand and two, one thousand and three", etc. Adjust the mental counting procedure according to the local language.

2. To maintain the proper distance between the nozzle and the sprayed surface while spraying vertically (i.e., a wall or the back surface of large furniture), it is necessary to slowly bend the elbow towards the waist as the nozzle approaches the midpoint. At this point, the elbow should be bent at a 90° angle. The arms must be extended as the spraying progresses. This process must be followed throughout the entire spraying process.

3. The spray should not drip on to the floor.

4. With conventional pumps, it takes about 5 minutes to cover a house with about 150 square metre area.

Comparison between Stirrup pump and Hand compression pumps with CFV is shown below:

In case of stirrup pump:

- The discharge rate should be 740 to 850 ml per minute. To obtain the above discharge rate, the pump person should give 20 to 26 strokes per minute with 10-15 cms plunger movement at a pressure of 10 PSI (0.7 kg/sq.cm) at the nozzle tip.
- Spraying into a bucket for one minute and measuring the quantity of the suspension in a graduated mug will check the correct discharge rate (740 to 850 ml/minute).
- The nozzle tip should be discarded if discharge rate exceeds 850 ml per minute.

In case of hand compression pump with CFV:

- The 8002E stainless steel or ceramic nozzles are the standards for flat fan nozzles recommended by WHO for IRS. The 8002 E nozzles emit 550 ml per minute at a standard 1.5 bar pressure through CFV.
- With the 8002E nozzle, a spraying speed of 2.2 seconds per vertical metre on a wall will produce the correct application of 30 ml/m^2.
- A CFV ensures uniform flow at the nozzle and with a 1.5 bar CFV (Red CFV).
- Applying this volume, the dose rate of product as a.i./m^2 remains the same and only the water volume is reduced by 25%. This means the dose will remain same and only water volume of 10 litres can be reduced to 7.5 litres.
- Also, the risk of inhalation of sprays is reduced by using a CFV set at a low pressure, typically 1.5 bar, in contrast to the pressure of 4 bar with spray tank with no CFV.

Points to be remembered during IRS

- A blockage in the nozzle is a frequent problem during Spray operation. The nozzle cap should be removed by unscrewing it and replaced by a new nozzle. The blocked nozzle should be kept immersed in water for a few hours and then cleaned off the blockage. Do not use fine wire to remove blockage as this will widen the hole size of nozzle and the discharge rate will be higher.
- The unused insecticide should be disposed safely as per the guidance of Environmental Code of Practices (ECoP) developed by NVBDCP.
- The buckets that were used should be cleaned properly ensuring safe disposal of the waste to ensure that it does not contaminate the environment.
- The deposits on the wall should be uniform and no areas should be skipped. This is an indication of good spray.
- The supervisor should check the quality of the spray. This is easy to do in the case of DDT or malathion since it leaves white deposits on the surface where it is sprayed.

- There are always some households that are not covered in the first round. These should be covered in the subsequent mopping up round on the same day or on a pre-decided different day. Waiting for second round is not advisable.

Routine maintenance of equipment

Spray equipment is subject to normal wear and tear since the insecticides are corrosive. To reduce the deterioration, the following actions should be undertaken at the end of each day:

- The discharge line should be disconnected at the delivery outlet at the end of spraying.
- The bucket and the discharge line should be emptied.
- The spray pump should be thoroughly rinsed with clean water.
- The filter assembly should be rinsed and cleaned. Filter should be removed from the valve by grasping it at its screen and slightly twisted on pulling it out.
- Reassemble all the clean parts except the nozzle. Put clean water in the tank, seal the tank and pump air into it. Open the control valve and let the water flow from the lance to flush the hose, filters, control valve and lance. Remove the tank cover and dry the inside of the tank.
- Clean the nozzle tip by washing thoroughly with water. Remove any dirt from the orifice with a fine bristle/ brush. Never use a wire or nails to clean the nozzle.

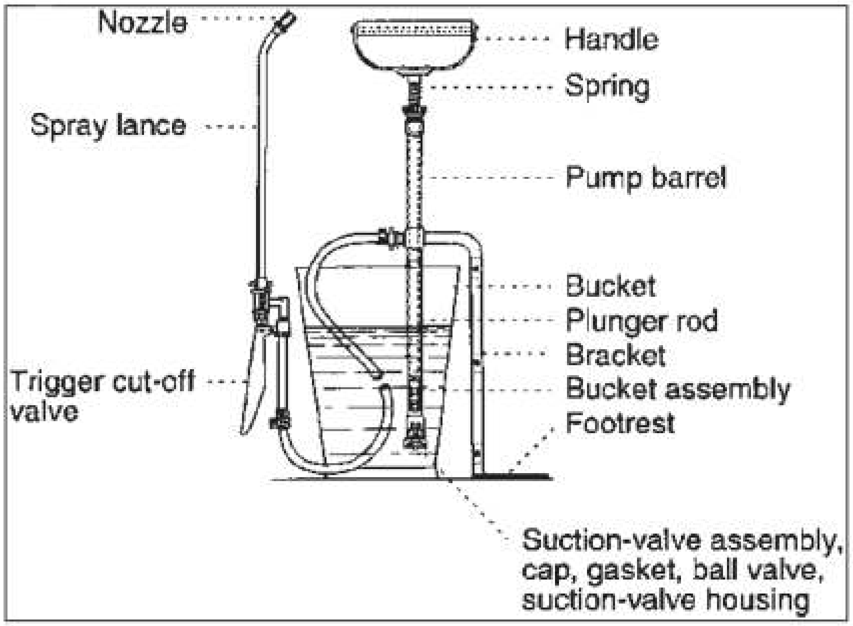
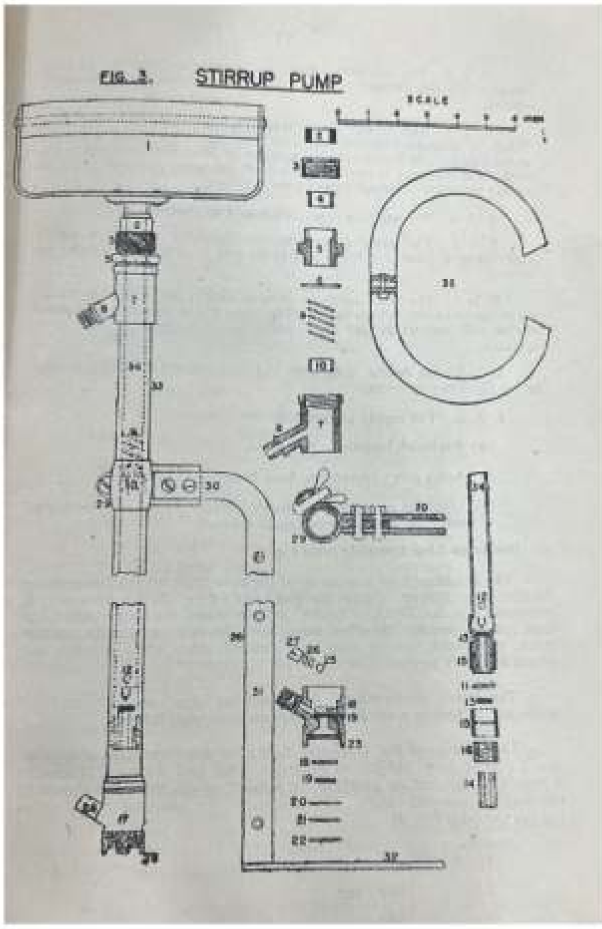


Figure-13: Stirrup Pump

Components of Stirrup Pump



1. 'D' Handle
2. Bumper (rubber or spring)
3. Plunger Shaft packing nut
4. Packing gland
5. Plunger guide
6. Leather ring washer
7. Plunger guide housing
8. Discharge outlet
9. Bumper spring (upstroke)
10. Travel limit ring
11. Valve pin
12. Plunger discharge orifice
13. Plunger volve
14. Volve assembly sleeve & seat
15. Cup (plastic or leather)
16. Cup retainer
17. Foot volve assembly
18. Foot volve pin
19. Foot volve
20. Strainer
21. Strainer reinforcement
22. Strainer retainer spring
23. Crow feet
24. Relief volve assembly
25. Relief volve
26. Relief volve spring
27. Relief volve adjustment nut
28. Stirrup
29. Clamp
30. Saddle
31. Vertical Shaft
32. Foot rest
33. Barrel
34. Plunger shhaft

Figure-14: Components of Stirrup Pump (Reference: NMEP Manual, 1958)

Minor repair of the spraying equipment

Minor repairs can be done in the field such as:

- Cleaning the nozzle
- Cleaning the discharge line
- Tightening the hose clamp
- Tightening the gasket
- Tightening the nut and compression of the cut off valve
- Replacement of the nozzle

Instructions for the spray squad members

A simple leaflet/booklet should be provided to each member of the spray squad. This should be in simple local language with appropriate illustrations:

- Wash your hands thoroughly with soap and water after preparing the insecticide spray. This is to be repeated every time the spray operation is stopped. Washing hands thoroughly with soap and water is advised when the team takes a lunch or tea break.
- The PPE comprising of apron, gloves, mask and goggles should be worn during insecticide spray.
- Avoid direct contact of the insecticides with eyes or skin. If this happens, wash the skin coming in contact and adjacent skin thoroughly with soap and water. Eyes

should be flushed repeatedly with clean water for a period of at least five minutes or ten times to protect against any harmful effects of the insecticides.

- If irritation persists even after thorough washing, seek medical advice.
- If any member of spray team suffers from any symptoms while spraying operations, medical attention should be sought without any delay.

Use of hand compression pump

The hand compression used earlier had Indian Standard specification which had pressure regulator. The main features are indicated below:

- A hand compression sprayer consists of a tank for holding the liquid insecticide formulation, which can be pressurized by means of a hand pump attached to it.
- The compressed air forces the liquid from the tank via a hose with a cut-off valve, a lance and a nozzle.
- The barrel of the sprayer should be capable of withstanding an internal pressure of 14 kg/cm^2, and for this purpose, the metal walls should not be less than 0.63 mm thick.
- The diameter of the plunger shaft should not be less than 12 mm. The plunger bucket of the pump should be made from nitrile rubber or chrome-tanned leather.
- The plunger assembly should be easily removable for cleaning and repair in the field.
- The handle may be shaped D or T. The handle grip should be about 30 mm in diameter. Further, the length of a T-type handle should not be less than 20 cm.

Actions to be ensured by the operators/supervisors

- The compression sprayer is pressurized before commencing spraying, and not continuously pumped. The pump is filled to levels usually at about three-fourth liquid to one-fourth air. A smaller air volume in relation to liquid volume would not retain sufficient pressure for long periods.
- When the tank is not in use, the spray lance is held in a bracket and nozzle cup, which protects the nozzle from damage.
- The nozzle tip is the most important part of the sprayer and therefore the discharge rate must be checked before spray operation.

Newer pumps with Control flow valve (CFV) are recommended by WHO to have uniform spray. These pumps have completely replaced Stirrup pumps used for IRS in Kala azar. It is displayed in Figure- 15.

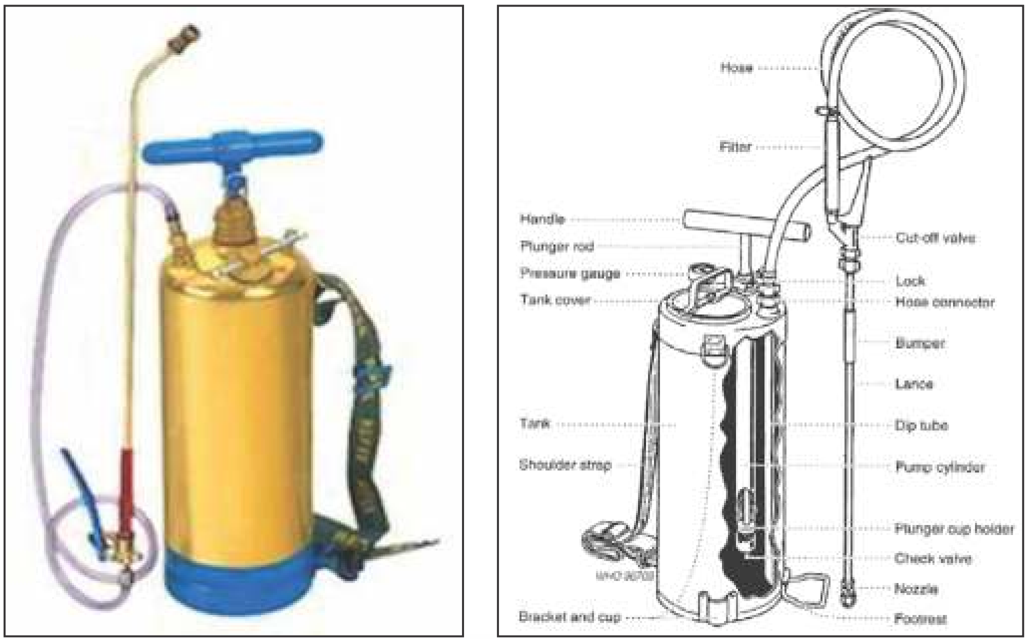
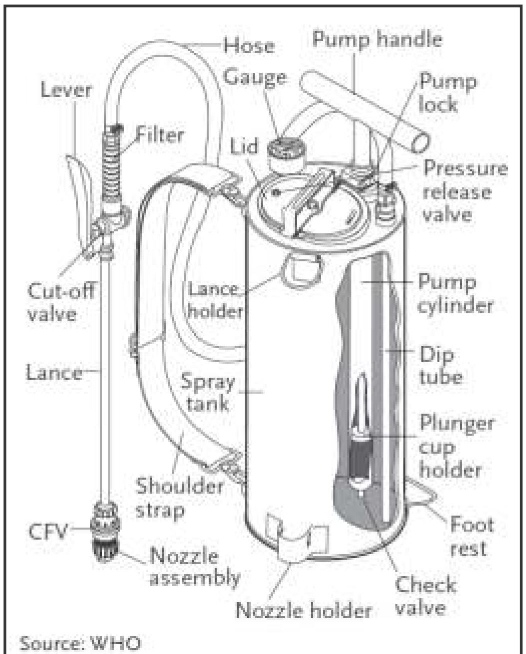


Figure-15: Hand Compression Sprayer



HC Pumps fitted with CFV

WHO recommended 8002E flat fan nozzle: 80° swath + liquid output of 0.2 US gallons (750 ml) per min at 3 bar pressures = 550 ml/min at 1.5 bar pressure + even spray

Figure-16: Cutaway Diagram of a Hand-compression sprayer & Sprayer & flat fan nozzle
(Source: Rozendaal, WHO 1997)

- Advantages of CFV: During IRS, the flow rate needs to be constant. If there is no CFV, the pressure decreases gradually, and it has to be pumped again.
- To avoid a decrease in flow rate, and to ensure an even discharge as tank pressure drops, it is recommended that flow regulators (i.e., 1.5 bar CFV) are fitted in the nozzle tip.
- By using a CFV, the operator (spray-person) gets constant pressure at the nozzle that ensures the output remains the same during the application and also ensures that the droplet spectrum does not change.
- When pressure in the tank falls below the amount set by the valve, the spray immediately shuts off.

Supervision of IRS

Supervision is an essential part of IRS to ensure its efficacy and safety. Concurrent and consecutive supervision should be carried out by SPO, DVBDCO/DMO, AMO, MI and MO-PHC to identify the problems and take necessary action to resolve them.

- An IRS operation should be carried out with clear terms of reference for each position.
- It must include a plan for supportive supervision and M&E system (for data collection and management).
- During the supervision, spraying is checked to see whether it is being done correctly as per norms.
- The condition of spray equipment, preparation of insecticide suspension, discharge rate, spray technique and speed should be checked.
- The consumption of insecticides should be verified by seeing the quantity issued and stock in hand.
- At the end of the visit, the supervisor should share the observations with the spray squads so that mistakes are not repeated in future.
- After the supervisory visits, the reports are sent to the districts for appropriate follow-up action.

3. Space sprays

- Space spraying involves applying small droplets of insecticide into the air in an attempt to kill adult mosquitoes. It has been the principal method for dengue control, used by most countries for many years. The current recommendations state that space spraying of insecticides (fogging) should be done to control outbreak and epidemic. However, operations should be carried out at the right time, at the right place and according to the prescribed instructions with maximum coverage, so that the fog penetration effect is complete enough to achieve the desired results.

- When space sprays are employed, it is important to follow the instructions on the equipment and also on the insecticide label. The maintenance of application equipment and its proper calibration is crucial.

- Droplets that are too small tend to drift beyond the target area, while large droplets fall out rapidly.

- Nozzles for ultra-low volume ground equipment should be capable of producing droplet size with Volume Median Diameter (VMD) between 5 to 50 µm.

- Desirable spray characteristics include sufficient period of suspension in the air with suitable drift and penetration into target areas with the eventual aim of impacting adult mosquitoes.

- Generally, there are two forms of space-spray that have been used for adult mosquito control namely "thermal fogs" and "cold fogs". Both can be dispensed by vehicle-mounted or hand-operated machines.

- Traditionally indoor space spray with pyrethrum extract 2% mixed in kerosene oil (1:19 Ratio) was carried out in and around 50 houses of malaria positive case immediately after detection. However, now it is used for *Aedes* control in order to contain dengue, chikungunya and Zika.

3.1 Indoor space spray

- For indoor space spray, hand operated atomizers (flit pump) or hand operated micro-discharge fogging machine are used.
- Usually in such cases, fog is not created if atomizers are used, however, the hand operated small thermal fogging machines are being used.

3.2 Thermal fogs

- Thermal fogs containing insecticides are normally produced when a suitable formulation condenses after being vaporized at a high temperature. Generally, a thermal fogging machine employs the resonant pulse principle to generate hot gas (over 200°C) at high velocity. These gases atomize the insecticide formulation instantly so that it is vaporized and condensed rapidly with only negligible formulation breakdown.

- Thermal fogging formulations can be oil-based or water-based. The oil (diesel)-based formulations produce dense clouds of white smoke, whereas water-based formulations produce a colorless fine mist. The droplet (particle) size of a thermal fog is usually less than 25 microns VMD. The exact droplet size depends on the type of machine and operational conditions. However, uniform droplet size is difficult to achieve in normal fogging operations.

3.3 Ultra-low volume (ULV), aerosols (cold fogs) and mists

- ULV involves the application of a small quantity of concentrated liquid insecticides. The use of less than 4.6 litres/ha of an insecticide concentrate is usually considered as ULV application.

- The droplet size is coarser than thermal fog. Usually, its range is 25-50 micron.
- Aerosols, mists and fogs may be applied by portable machines, vehicle-mounted generators or aircraft equipment.
- Portable spray units can be used when the area to be treated is not very large or in areas where vehicle-mounted equipment cannot be used effectively. This equipment is meant for restricted outdoor use and for enclosed spaces (buildings). Portable application can be made in congested low-income housing areas, multistoried buildings, godowns and warehouses, covered drains, sewer tanks and residential or commercial premises. Operators can treat an average of 80 houses per day, but the weight of the machine and the vibrations caused by the engine make it necessary to allow the operators to rest, so that two or three operators are required per machine.

Vehicle-mounted fogging

- Vehicle-mounted fogging machines (aerosol generators) can be used in urban or suburban areas with a good road system. One machine can cover up to or approximately 80 ha or 1500-2000 houses (more if multi storied housed in same area) per day. It is necessary to calibrate the equipment, vehicle speed and swath width (60-90 m) to determine the coverage obtained by a single pass.
- The speed of the vehicle and the timings of application are important factors to consider when insecticides are applied by ground vehicles. The speed of the vehicle should be 4-6 km/hour and the vehicle should be driven against the wind current. When the wind speed is higher or when the ambient air temperature is greater than 28°C, the insecticide should not be applied. The best time for application is at dawn (approximately 6.00-8.30 hours) or dusk (approximately 17.00-19.30 hours), however, local weather must be considered before start of fogging.
- A good map of area showing all roads helps in fogging.
- Prior information helps residents to cooperate during fogging by opening doors and windows.

Insecticide formulations for space sprays

- Under NVBDCP, Malathion (Technical), Cyphenothrin 5% and Pyrethrum Extract 2% formulations are recommended for fogging.
- Undiluted Malathion (technical) is used for ULV spraying, whereas one-part technical grade diluted with 19 parts of diesel are used for thermal fogging. The quantity of 0.5 litre of Malathion (technical) is required per hectare to conduct thermal fog operation using a vehicle mounted fog generator.
- Apart from the above-mentioned formulations, a number of formulations containing either permethrin, deltamethrin, lambdacyhalothrin or other

compounds are available for space spray applications, but these are not yet approved under the programme for want of request from producers for inclusion under programme.

It is important not to under-dose during operational conditions. Therefore, skill of the staff engaged in fogging must be strengthened and proper mixing procedure with speed of movement may be adhered.

Prerequisites of thermal fogging

- Thermal fogging with portable fogging is done in outdoor situations, where large number of cases are reported. Fogging machine/vehicle should move against the wind direction.
- During outdoor fogging, it is important to direct the fog to all possible adult mosquito resting sites like bushes, tree-shaded areas and other outdoor resting in peri-domestic habitats.
- The most effective type of thermal fog for mosquito control is medium/dry fog that should just moisten hand when the hand is passed quickly through the fog at a distance of about 2.5 to 3.0 metres in front of fog tube.
- The technical specification recommended for a fogging machine should be as per BIS Standard for vector control.
- Fogging is carried out under the right weather conditions (please refer to the table below).

Table-2: Fogging carried out under the right weather conditions

Climatic condition	Most favorable conditions	Average conditions	Unfavorable conditions
Time	Late evening between 17:00 to 19:00 hrs	Early evening	Mid-morning or afternoon
Wind	Steady, between 3-6 km/hr	0-3 km/hr	Medium to strong, over 13 km/hr
Rain	No rain	No rain	Heavy rain
Temperature	Mild	Mild	Hot

Frequency of fogging: In an outbreak, fogging applications have to be carried out at an interval of daily-weekly-fortnightly 7-10 days till a significant reduction in vector densities is achieved.

1. In case of malaria outbreak, indoor space spray with pyrethrum/cyphenothrin should be carried out for 7 to 10 consecutive days or till IRS is completed in all houses of the locality.
2. In case of dengue, chikungunya and Zika outbreak, only indoor fogging or space spray is recommended to cover all houses in 400-meter radius, weekly and fortnightly till the current transmission is contained.
3. In case of JE outbreak situations, fogging applications have to be carried out at 7-10 days interval till a significant reduction in vector densities is achieved.

Prerequisites of cold (ULV) fogging:

1. In the late evening hours, temperature is very cool when the vector mosquitoes are most active, hence, fogging is more effective.
2. Cool weather in the evening hours is more comfortable for worker wearing protective clothing.
3. In the afternoon when the temperature is high, convection currents from the ground will prevent concentration of the spray close to the resting places of adult mosquitoes flying or resting, thus, rendering the spray ineffective.
4. An optimum wind speed between 4-6 km/hr enables the spray to move slowly and steadily over the ground, allowing for maximum exposure of mosquitoes to the spray.
5. Air movements of less than 3 km/hr may result in vertical mixing, while winds greater than 13 km/hr disperse the spray too quickly.
6. In heavy rain, the spray generated loses its consistency and effectiveness. When the rain is heavy, spraying should stop and the spray head of the ULV machine should be turned down to prevent water from entering the blower.

- Fogging is not recommended as a routine vector control method.
- It should only be used during epidemics or outbreaks.

Outdoor transmission containment

The extra domiciliary transmission is becoming a major challenge because of:

- Human behaviour of sleeping outside and exposing themselves for mosquito bite
- Change in feeding behaviour of vector mosquitoes for outdoor feeding (exophilic) due to insecticide pressure either by IRS or LLIN and also mosquito proofing of houses.
- The main vector control tools are designed for vectors which are indoor feeder and indoor resters or to some extent for outdoor feeder and indoor resters.

The options under programme are personal protection and fogging operation to reduce the density of infective mosquito. But the main tool will remain as personal protection from mosquito bite. Use of repellents, covering arms and legs may be the choice.

Personal protection

- **Protective clothing:** Clothing reduces the risk of mosquito biting if the cloth is sufficiently thick or loosely fitted. Long sleeves and trousers with stockings may protect the arms and legs, the preferred sites for mosquito bites. School children should adhere to these practices whenever possible.
- **Repellents:** Repellents are a common means of personal protection against mosquitoes and other biting insects. These are broadly classified into two categories, natural repellents and chemical repellents.
  1. Essential oils from plant extracts are the main natural repellent ingredients, i.e., citronella oil, lemongrass oil and neem oil.

2. Chemical repellents such as DEET (N, N-Diethyl-m-Toluamide) can provide protection against *Ae. albopictus*, *Ae. aegypti* and anopheline species for several hours.
3. Mats, coils and aerosols: Household insecticidal products, namely mosquito coils, pyrethrum space spray and aerosols have been used extensively for personal protection against mosquitoes. Electric vaporizer mats and liquid vaporizers are common that are commercially available in open market. The role of such household insecticides and repellents need to be mentioned in IEC/BCC material for community.
4. Also, the role of individuals, housing societies/RWAs (urban) and Panchayats (rural) needs to be more cautious and take initiatives in order to avoid creating mosquitogenic conditions and protect themselves from mosquito bite.

Larval Source Management (LSM)

Larval source management is the targeted management of mosquito breeding sites, to reduce the number of mosquito larvae and pupae. Following four main types of LSM are advocated:

- habitat modification, which means a permanent alteration to the environment, e.g., land reclamation or surface water drainage.
- habitat manipulation, which refers to a recurrent activity e.g., water-level manipulation, flushing of streams, the shading or exposure of habitats.
- larviciding, which involves the regular application of a biological or chemical insecticide to water bodies; and
- biological control, which refers to the introduction of natural predators into water bodies, for example predatory fish or invertebrates.

LSM programmes generally need to be fully tailored to local environmental conditions and should be based on comprehensive feasibility and cost-effectiveness studies. Considering these facts, the anti-larval programme was instituted in towns and cities where IRS is not acceptable. In India, anti-larval operations are done using larvivorous fish, larvicides viz., MLO, Temephos, Diflubenzuron and Pyriproxyfen.

Larvicide

Larviciding to control immature stages of mosquitoes is usually limited to peri-domestic and or domestic-use containers that cannot be destroyed, eliminated or otherwise managed. It is also implemented in and around houses, drains, wells etc. Larviciding has to be done weekly/fortnightly to avoid emergence of adults. It is difficult and expensive to apply chemical larvicides on a long-term basis. Therefore, chemical larvicides are best used in situations where it is feasible and other core interventions like IRS are not acceptable. Establishing the precise timing and location are essential for maximum effectiveness. Anti-larval squad/personnel or Domestic Breeding Checkers (DBCs) implementing the anti-larval operations should always encourage house occupants to control larvae by environmental sanitation. The approved larvicides to be used under the programme MLO, Temephos 50% EC , Pyriproxyfen 0.5% GR and Diflubenzuron 25% WP.

Larvicidal Application

Mosquito Larvicidal Oil (MLO)

- This oil cause suffocation by producing a surface film which cuts off the oxygen supply to larvae and also by blocking of respiratory tubes by oil particles.
- This is used as such without any dilution. Usual dose is 175-225 litres (average 200 litres) per hectare or 1 litre per 50 linear meters at weekly interval.
- It can be applied using knapsack sprayers or mop and bucket method or using oil booms.

Temephos

Temephos is available as 50% Emulsifiable Concentrate (EC) and its ready to use solution is made by:

- Take 2.5 ml of 50% EC and put in 10 litres of water in pump. Close the pump and shake well. This will give a concentration of 0.0125% Temephos which must be used on same day.
- Its dose is 200 litres per hectare or one litre for 50 linear meters from ready-to-use spray. For treatment of containers, the ready to use spray (0.0125% Temephos) may be poured @20 ml per sq meter water surface. The quantity may be doubled for the breeding places having more than 20 cm of depth and tripled for those having depth of more than 50 cm.

Bio-larvicides

- *Bacillus thuringiensis* var. *israelensis* H14- is available as 5% wp: 5 kg of it mixed in 200 litres of water (250 gms in 10 litres of water).
- *Bacillus thuringiensis* var. *israelensis* 5% WP, Strain-ABIL, Serotype H-14: For clean water, its 7.5 kg is mixed in 200 litres of water (375 gms in 10 litres of water) and for polluted water, its 10 kg is mixed in 200 litres of water (500 gms in 10 litres of water)

Both these bio-larvicides are used on weekly intervals and the recommended dose under programme is 200 litres per ha. For smaller area, the ready to use suspension is to be sprayed @ 20 cc per m^2 and @ 1 litre per 50 linear meters.

- *Bacillus thuringiens* var. *israelensis* 12 Aqueous Suspension (12AS) formulation is also recommended and its 1 litre in 200 litres of water (50 cc in 10 litre) is mixed to be sprayed in clean water whereas 2 litres in 200 litres of water (100 cc in 10 litres) is mixed for spraying in polluted water.

The spray dose to cover the area remains same as in case of WP formulation.

Diflubenzuron

The recommended formulation under programme is 25% Wettable Powder and its 100 gms (25 gm a.i.) in 100 litres of water (10g in 10 litres) is mixed for clean water whereas 200 gms (50 gm a.i.) in 100 litres of water (20 g in 10 litres) is mixed for spray in polluted water. This is sprayed using knapsack sprayer @100 litres per hectare at weekly interval.

Pyriproxyfen

The recommended formulation under programme is 0.5% Granular formulation, so it is used as such. The granules are sprayed manually or using granule applicator @2kg/ha for clean water and 4 kg/ha for polluted water. The frequency of application in this case is three weekly.

- MLO can be sprayed only in organic polluted water against culicine control. Since there is no dilution, large quantities are procured, which may lead to logistics and storing problem.
- Temephos is mostly used in non-polluted/potable water with recommended dose under programme.
- Diflubenzuron and Pyreproxifen are insect growth regulators (IGRs) and need to be used as prescribed method.

Environmental management

Environmental management involves any change that prevents or minimizes vector breeding, hence, reducing human-vector contact. Environmental methods to control/prevent breeding of vectors and to reduce human-vector contact are source-reduction, solid waste management, modification of man-made breeding sites and improved house-design. The major environmental management methods used to control immature stages of vectors are:

- **Improved water supply:** Whenever piped water supply is inadequate and available only at restricted hours or at low pressure, the storage of water in varied types of containers is encouraged, thus, leading to increased *Aedes* and A*nopheles stephensi* breeding. The majority of such containers are large and heavy (e.g., storage jars) and can neither be easily disposed nor cleaned. In rural areas, disused wells become breeding grounds for vectors. It is important that potable water supplies be delivered in sufficient quantity consistently while maintaining quality of water to reduce unnecessary use of water storage containers that serve as the most productive larval habitats.
- **Mosquito-proofing of overhead tanks/cisterns or underground reservoirs:** Overhead tanks, cisterns, domestic wells and underground chambers need to be mosquito-proofed so that the female vector mosquitoes are not able to lay their eggs in the water.
- **Flowerpots/vases and ant traps:** Flowerpots, flower vases and ant-traps are common sources of mosquito breeding. These should be punctured to produce a drain hole. Alternatively, live flowers can be placed in a mixture of sand and water. Flowers should be removed/discarded weekly and vases should be scrubbed and cleaned before reuse. Ant traps to protect food storage cabinets can be treated with common salt or oil.

Breeding in incidental water collections

- Desert water coolers, condensation collection pans under refrigerators and air conditioners should be regularly inspected, drained and cleaned. Desert water coolers generally employed in arid/semi-arid regions of South-East Asia to cool houses during summer contain two following manufacturing defects:

1. The exit pipe at the bottom of the water-holding tray is generally fixed a few centimetres above the bottom. This exit pipe should be fitted at such a level that while emptying the tray, all the water should get drained without any retention at the bottom.

2. Desert coolers are normally fitted to windows with the exit pipe located on the exterior portion of the tray. These sites are usually difficult to access, therefore, there is a need to change the design so that the filling and emptying of the water-holding trays can be manipulated from the room, thus, eliminating the need to climb to reach the exit pipe at the exterior of the building. It is recommended that regulatory mechanism should be developed to ensure the design specifications as outlined above for manufacturing desert coolers.

Building exteriors

- **Construction sites:** The design of buildings during construction is important to prevent mosquito breeding. Drainage pipes of rooftops, sunshades, parapet, porticos, often get blocked and become breeding sites for mosquitoes. There is a need for periodic inspection of buildings during the rainy season to locate potential breeding sites.
- **Abandoned construction/ litigation:** Abandoned buildings/construction / land or those under litigations or locked houses should be periodically checked by authorities, and the officials should be given permission to access such buildings to check for vector breeding.
- **Mandatory water storage for fire fighting:** Fire prevention regulations may require mandatory water storage. Such storage tanks need to be kept mosquito proofed. In some municipalities in India, timber merchants are required to maintain two metal drums of about 200 litres full of water for fire-fighting. These drums should be kept covered with tight lids. The metal drums used for water storage at construction sites should be mosquito proofed.
- **Solid waste disposal:** Solid wastes, namely tins, bottles, buckets or any other waste material scattered around houses should be removed and buried in landfills. Scrap material in factories and warehouses should be stored appropriately until disposal. Household and garden utensils (buckets, bowls and watering devices) should be turned upside down to prevent the accumulation of rainwater. Similarly, water in canoes and small boats should be emptied and turned upside down when not in use. Plant waste (coconut shells, cocoa husks) should be disposed of properly without delay. Water collections in seized vehicles kept in dumping ground or near police stations become the source of mosquito breeding and potential threat for malaria or dengue so proper and quick disposal need to be considered.
- **Tyre management:** Used automobile tyres are of major importance as breeding sites for urban malaria vectors and dengue vectors. Tyre depots/vulcanizing centres/re-treading places should ensure that tyres are always to be kept under cover to prevent the collection of rainwater. Roadside tyres kept open should be either filled with sand or one or two holes should be made to drain out the water.

- **Filling of cavities of fences:** Fences and fence posts made from hollow trees such as bamboo should be cut down to the node, and concrete blocks should be filled with packed sand, crushed glass or concrete to eliminate potential *Aedes* larval habitats.

- **Industrial set up:** The owners/management of industries and industrial townships should ensure no mosquito breeding in and around their campus. They should get adequate training from concerned health departments for such measures.

Larvivorous Fish

- Use of larvivorous fish in public health has been recorded since 1903. The most successful and widely used fish is *Gambusia affinis* which is also known as mosquito fish. *Poecilia reticulata*, the common guppy is another fish which can survive in polluted water also. These fishes are self-perpetuating and therefore cost effective. Initial cost of introduction of larvivorous fish is relatively lower than that of chemical control. Larvivorous fishes prefer shallow water which is also a preferred site for mosquito larvae.

- These fishes are small in size to survive in shallow water. Larvivorous fish should be surface feeders and carnivorous. It should be able to survive in the absence of mosquito larvae and should be easy to rear. It should withstand a wide range of temperature and light intensity.

- The fish should be transported in small containers having capacity of water up to 40 litres viz., plastic buckets and jerry cans, or plastic bags, half filled with water. Fish should not be exposed to direct sunlight during transportation. The containers should have sufficient openings to allow flow of air. It can be taken polythene bag of 3 -5 litre capacity, half filled with water. After introducing fishes, the air can be bubbled from O_2 cylinder or from air pump and mouth can be closed. The bags can be put in thermocol box and can be transported for a period of 24 hours without further filling oxygen.

- The fishes can be released in new environment by floating the bag on water and opening its mouth. It is never poured from a distance. The number of fishes is usually 5-10 per linear meter but it can be more if larval density is high.

Gambusia affinis has been in use in India since 1928. It is an exotic species and has been distributed throughout the warmer and some temperate parts of the world. The optimum temperature for reproduction ranges from 24°C to 34°C. The suitable pH of water for its survival is between 6.5 to 9.9.

1. Male is smaller in size of about 4.5 cm. whereas female is about 5.2 cm to 6.8 cm. Its life span is approximately 4-5 years.
2. The female matures in about 3 to 6 months. Each ovary contains approximately 120 eggs. Young ones are released in broods of 25-30 at a time. The young females have two gestations per season while the older females may have up to six generations per season. A season lasts about 30 days. A single female may produce between 900 and 1200 offspring during its life span. It breeds throughout the year after maturity, especially in tropical conditions.
3. A single full-grown fish eats about 100 to 300 mosquito larvae per day.

Poecilia reticulata (Guppy) is also an exotic fish introduced in India in 1910. It reproduces quickly and prolifically. It is a very hardy fish and survives in all types of water bodies. It tolerates high degree of pollution with organic matter. The temperature range suitable for breeding is from 24°C to34° C. It can survive in water with pH ranging from 6.5 to 9.

- The male is 3 cm long, whereas the female is up to 6 cm in length. The Guppy lives for about 4-5 years. It takes about 90 days to mature. Each ovary contains 100 to 160 eggs. The female gives birth to young ones in broods of 5 to 7 at a time. About 50 to 200 young ones are released by the female every four weeks. It breeds throughout the year at about four weeks interval after maturity.
- A single fish eats about 80 to100 mosquito larvae in 24 hours. Therefore, it is comparatively less efficient than *Gambusia affinis*.

For implementation of IVM, the following points should be considered:

- Selection of intervention measures
- Area of the interventions to be undertaken
- Time period of the interventions to be implemented
- Implementing agency and supporting partners for the interventions
- Micro action plan of the interventions to be undertaken
- Training of implementers
- Community sensitization for improved acceptance
- Supervision and Monitoring for spot corrective measures

10 Safe Handling & Disposal

Each year thousands of public health insecticides containers are emptied and become waste items that require disposal. All these insecticides are registered under the Central Insecticide Board for public health use in the country with safety levels. The Insecticides Rules, 1971 has a provision (Rule 44) that sets clear cut guidelines for disposal of used packages, surplus materials and washings of insecticides. FAO/WHO recommends that the practice of disposal of insecticide packaging at the place of use by burying or burning be prohibited. For many years, the laws and regulations governing the safe use of insecticides also have placed some restrictions upon their disposal. Label instructions include warnings about container and rinse water disposal, and caution against the contamination of foods, feeds and water supplies. Disposal inconsistent with label instructions is a violation. Newer product labels show more extensive disposal instructions.

The NCVBDC aims to achieve effective vector control by the appropriate biological, chemical and environmental interventions of proven efficacy, separately or in combination, as appropriate, to the area through the optimal use of resources. IVM is done by using identical vector control methods to control malaria, kala-azar and other VBDs. Measures of vector control and protection include:

1. Measures to control adult mosquitoes in rural areas: IRS
2. Anti-larval measures in urban areas: chemical, biological and environmental
3. Personal protection: use of bed nets including ITNs and LLINs
4. IVM

NCVBDC is currently using IRS and LLINs as the primary method of vector control in rural settings, and anti-larval measures in the urban areas. Insecticides like DDT, malathion and synthetic pyrethroids are recommended in the programme for IRS. The state health departments are responsible for safe disposal of DDT and other insecticides. General safety precautions while handling insecticides and guidelines for proper storage, transportation, safe disposal of insecticides and insecticides containers are mentioned below

General safety precautions while handling insecticides

Exposure to insecticides may occur while handling and spraying in the following situations:

- When handling the insecticide while opening the package, mixing, and preparing the spray.
- When spraying the insecticide.
- When disposing the insecticide solution and containers.

General precautions:

- The operator should wear a protective hat and face shield or goggles.
- Do not eat, drink or smoke while working.
- Wash hands and face with soap & water after spraying and before eating or drinking.
- Shower or bath at the end of the workday and wear fresh and clean clothes.
- Wash overalls and other protective clothing at the end of every working day using soap and water and keep them separate from the rest of the family's clothes.
- If the insecticide touches the skin, wash immediately with soap and water.
- Change clothes immediately if they become contaminated with insecticides.
- Inform the supervisor immediately if anyone feels unwell.

Protective clothing and equipment

- Absorption of insecticide occurs mainly through the skin, lungs and mouth. Specific protective clothing and equipment given below must be worn in accordance with the safety instructions on the product label
- Broad-rimmed hat (protects head, face and neck from spray droplets)
- Face-shield or goggles (protects face and eyes against spray fall-out)
- Face mask (protects nose and mouth from airborne particles)
- Long-sleeved overalls (worn outside of boots)
- Rubber gloves
- Boots

Storage

- Insecticide storehouses should be located away from areas where people or animals are housed and away from water sources, wells and canals.
- They should be located on high ground and fenced, with access only for authorised persons. However, there should be easy access for insecticide delivery vehicles and, ideally, access on at least three sides of the building for fire-fighting vehicles and equipment in case of an emergency.
- Insecticides must NOT be kept where they may be exposed to sunlight, water or moisture as it can affect their stability.
- Storehouses should be secure and well ventilated.
- Containers, bags or boxes should be well stacked to avoid possibility of spillage. The principle of - first in, first out (FIFO)-should be followed.
- Stock and issue registers should be kept up to date. Access to the insecticides should be limited to authorized personnel only.
- The storeroom should have a prominently displayed mark of caution used for poisonous or hazardous substances. It should be kept locked.
- Containers should be arranged to minimize handling to avoid mechanical damage that could give rise to leaks. Containers and cartons should be stacked safely, with the height of stacks limited to ensure stability.

Transportation

1. Insecticides should be transported in well-sealed and labelled containers, boxes or bags.
2. Insecticides should be transported separately. These should NOT be transported in the same vehicle as items such as agricultural produce, food, clothing, drugs, toys and cosmetics that could become hazardous if contaminated.
3. Insecticide containers should be loaded in such a way that they will not be damaged during transport, their labels will not be rubbed off and they will not shift or fall off the vehicle onto rough surfaces.
4. Vehicles transporting insecticide should carry prominently displayed warning notices.
5. The insecticide load should be checked at intervals during transportation and any leaks, spills or other contamination should be cleaned up immediately using accepted standard procedures. In the event of leakage while the vehicle is moving, the vehicle should be brought to a halt immediately so that the leak can be stopped, and the leaked product cleaned up. Containers should be inspected upon arrival at the receiving station. There should be official reports to the national level and follow-up enquiries in the event of fires, spills, poisonings and other hazardous events.
6. In case of any accident, local police should be immediately requested to protect the goods and clean the leaked material.

Disposal of remains of insecticides and empty packaging

1. At the end of the day's work during IRS, the inside of the spray pump should be washed, and any residual insecticide should be flushed from the lance and nozzle.
2. The rinsing water should be collected and carefully contained in clearly marked drums with a tight lid. This should be used to dilute the next day's tank loads or disposed properly by the supervisor at disposal sites like pits or digs.
3. Never pour the remaining insecticide into rivers, pools or drinking-water sources.
4. Decontaminate containers wherever possible. For glass, plastic or metal containers, this can be achieved by triple rinsing, i.e., part-filling the empty container with water three times and emptying into a bucket or sprayer for the next application.
5. All empty packaging should be returned to the supervisor for safe disposal according to national guidelines.
6. Never re-use empty insecticide containers.
7. It shall be the duty of manufacturers, formulators of insecticides and operators to dispose packages or surplus materials and washing in a safe manner so as to prevent environmental or water pollution.
8. The used packages shall not be left outside to prevent their re-use.
9. The packages should be broken and buried away from habitation.

Disposal of expired insecticides

1. Adequate measures should be taken to avoid expiry of stocks in storehouses.
2. First expiry first out (FEFO) principle should be strictly followed during stock movements.
3. Information about near expiry stock should be provided to NCVBDC, Delhi well in time so that the stock can be re-allocated to other locations.
4. The expired stock should be returned to the manufacturer for disposal as per guidelines preferably using the incineration process.
5. The chemical efficacy should be tested before disposal of expired insecticide to find out possibility of usage. The efficacy and active ingredient of insecticide should be tested and certified by the authorized testing laboratory.

Design for soak pits

A soak pit is a specially designed hole in the ground for disposing insecticide remnant after the day's IRS activities. A properly sited and constructed soak pit protects the environment from getting contaminated with insecticides.

Location of the soak pit

The soak pit should be preferably located within the unused areas of the Sub-Centre/ Panchayat/ Government offices of a village. However, such pits should not be within 100 metres of any water body or drinking water source. The soak pit should be constructed only in areas where ground water table is at a depth of more than 5 metres below ground level.

Figure-17: Setting of Soak Pit, Soak pit located on away from water bodies and drinking water source (Source: ECoP, NVBDCP 2012)

Construction of the soak pit

A soak pit measuring 1m by1m X 1m X 1m is usually sufficient to absorb the effluent produced from one round of spraying operation. The bottom of the pit is lined with a layer of coarse gravel followed by a layer of stone aggregate. It is then filled with 1.5 to 2 bags of charcoal (where feasible) and 1.0 to 1.5 bags of sawdust/sand/ morrum/coarse soil. This shall create a filter that is 1 m deep. As the effluent percolates through the filter medium, the insecticides are filtered out.

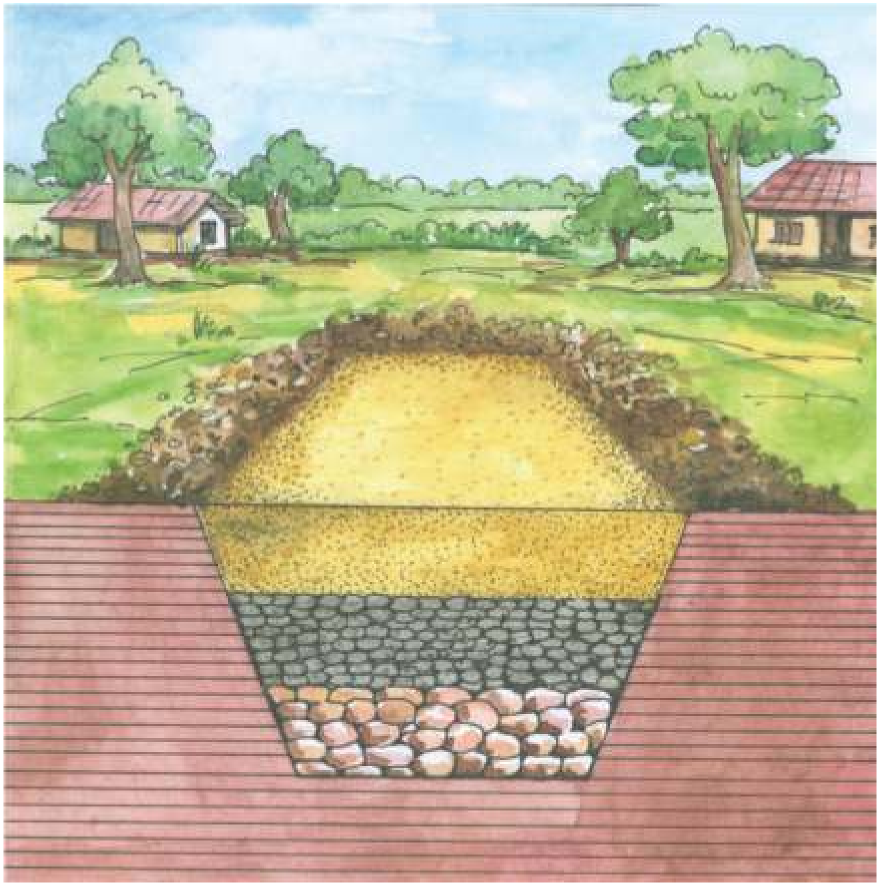


Figure-18: Construction of Soak Pits, Cross section of the soak pit with rural setting (Source: ECoP, NVBDCP 2012)

Disposal of the residue

At the end of a spraying round, the residue of chemicals left on the surface of the pit should be scrapped by the spraying squad and disposed of into the waste pit of the PHC.

Disposal of bags/containers

Empty bags or containers used for packing insecticides are contaminated and have to be disposed properly. These wastes are generated in the field during IRS spray, thus, need to be collected and decontaminated before they are disposed. However, type and size of containers vary depending on the insecticide used in a particular area and on the manufacturer of the insecticide.

The process of decontamination, collection and storage disposal is provided in figure-19:

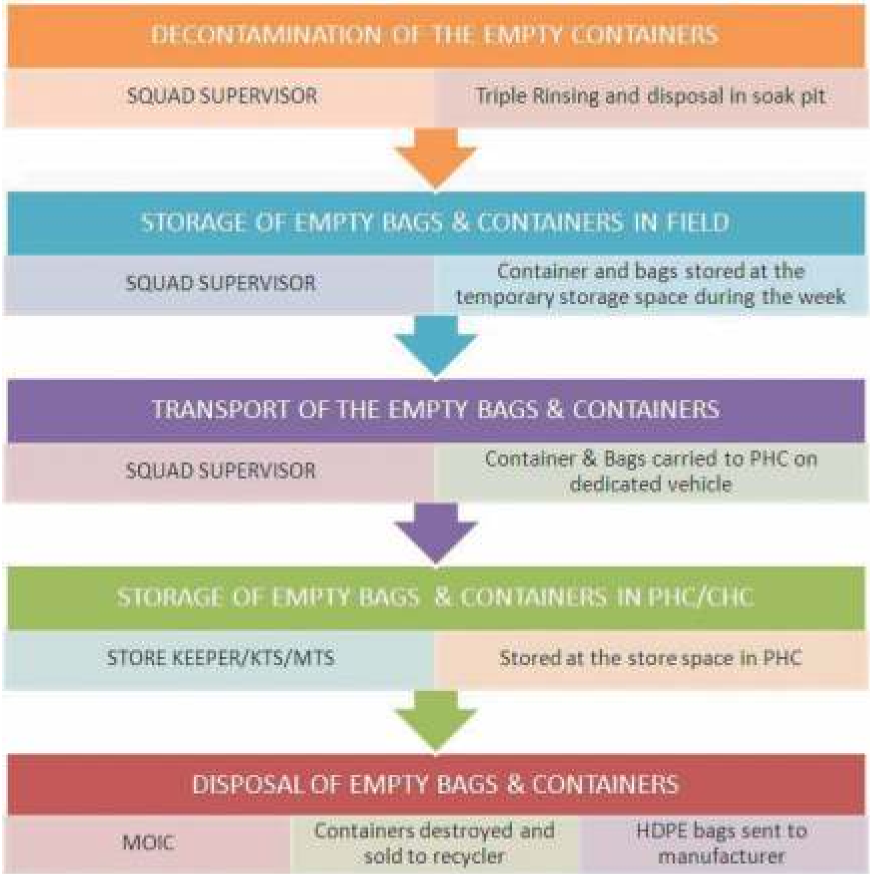


Figure-19: The process of decontamination, collection, and storage disposal

Collection and transportation to the PHCs

The Spray Supervisor is responsible for collecting the empty bags and containers generated from the week's operations and take it back to the PHC after triple rinsing. The water used for washing the containers should be disposed in the soak pit. A dedicated transport, e.g., cycle rickshaw, van rickshaw/auto rickshaw should be used for transporting the bags/containers containing insecticides. During transportation of the contaminated bags and containers, the load should be covered up with polythene sheets and tied up so that they are securely fixed. The vehicle should not be overloaded at the time of transportation.

The empty bags and containers have to be deposited with the storekeeper. The storekeeper should verify the quantity and maintain an account of the bags and containers returned. The empty bags and containers would be stored along with the insecticides before it is disposed. The following precautions should be taken while handling empty bags/containers:

- The personnel handling the empty bags and containers should wear their personal protective equipment (consisting of gloves, mask, apron, goggles and shoes).
- The empty containers and bags should be stacked properly and should not be strewn in the storage area.
- Any spill of the remaining insecticide should be contained and subsequently cleaned.

Disposal of the bags and containers at the PHCs

1. The following guidelines should be followed for proper disposal of bags and containers from the PHC. Since jute bags, High-density polyethylene (HDPE) bags, HDPE containers and MS containers are traditionally used to pack insecticides, the guidelines for disposal of each of these have been specified separately.

2. Gunny bags: Gunny bags used for the packing the insecticides are usually double ply jute cloth lined with an impermeable liner. There is an LDPE bag inside the double ply jute bag in which the insecticides are packed. The LDPE bag is extracted, and the jute bag can be allowed to decompose. The LDPE bags should be disposed in the deep burial pit at the PHC/store depot.

3. HDPE bags: The bags should be returned to the PHC by the Spray Supervisor after cutting it into two pieces. The store in-charge should maintain record of the bags that have been returned. The bags can then be disposed of in a hazardous waste recycler. Alternatively, the HDPE bag can either be sent back to the district during the cycle/year in the vehicle that supplies the insecticides to the PHC. These can be sent back to the manufacturer subsequently.

4. Containers: The containers, once rinsed, can be used as collection containers for hazardous wastes. Alternatively, PWD crushers (like JCB)/bulldozers) may be used at the PHC to crush these containers. The crushed containers can be disposed of in a hazardous waste recycler.

Health monitoring

In case of accidental exposures or appearances of symptoms of poisoning, medical advice must be sought immediately.

- In case of organophosphorus (malathion), regular monitoring of cholinesterase enzyme (CHE) level should be carried out and spray persons showing decline in CHE to 50% should be withdrawn and given rest, and if needed, medical aid be provided.

LLINs

The bags for individual nets and the packaging used to wrap bales of nets are made of various materials including low density polyethylene (LDPE), LDPE coated with polyethylene terephthalate (PET), polyester, linear low-density polyethylene (LLDPE), biaxially oriented polypropylene (BOPP), oxodegradable (OXO) plastic bags, paper bags and various strapping bands.

Having been in direct contact with the pesticides present in LLIN, an individual net bag is an "empty pesticide container" as defined by the FAO/WHO Guidelines on Management Options for Empty Pesticide Containers. Therefore, the bags should be handled in a manner consistent with that guidance. The Guidelines, which specify methods for the disposal of pesticide-contaminated packaging material, indicate that unless empty pesticide containers are managed correctly, they are hazardous to both mankind and the environment. In particular, burning plastics and pesticides in an uncontrolled fire will not destroy the hazardous components completely and may generate dangerous persistent toxins.

WHO Recommendations for the Management of LLIN Packaging Material

Options for the management of LLIN bags and baling material must be evaluated on a case-by-case basis. “Reuse” is currently not an option since no manufacturer produces reusable LLIN bags or baling material and it is unsafe to use them for any other purpose as such. The following recommendations apply only to the safe disposal and recycling of LLIN waste packaging (bags and baling material) and do not cover the LLINs themselves. Wherever possible, and with no reduction in the public health benefit, distribute LLINs without leaving any packaging with the intended LLIN user.

Recycle LLIN packaging

The recyclers who are processing used LLIN bags and baling material should apply proper controls of their materials and processes to ensure the bags are only recycled into appropriate products which have limited potential for human contact and are not likely to be recycled again.

- Ensure that proper personal protective equipment (PPE) are used and measures strictly followed by workers involved in all stages of operations for collection, sorting, recycling, disposal of LLIN bags and baling material.
- Incinerate LLIN bags and baling material ONLY if specified high temperature incineration conditions for pesticide-tainted plastic can be assured following Basel Convention Technical Guidelines and in accordance with national regulations and requirements.
- Store the used LLIN packaging awaiting future safe recycling, disposal or other processing in dry, well ventilated and secure facilities.
- If recycling or incineration is not possible, and if LLIN producers provide directions on methods for safe disposal, follow the manufacturer’s recommendations. Alternatively, landfilling of bags and baling material in a properly engineered landfill is an option, as detailed in the FAO/WHO Guidelines on Management Options for Empty Pesticide Containers.
- National pesticide registration authority to make mandatory that manufacturers provide recommendations on the safe disposal and/or recycling of LLIN packaging. This will include information on labels of LLIN bags regarding the material used in the production of such bags.
- Assure that disposal of LLIN packaging is included as a condition in the procurement of LLINs.
- Develop national LLIN packaging management protocols for these wastes and assure that all stakeholders are aware of proper packaging disposal procedures that is aligned with national regulations and requirements.
- Integrate good practice recommendations on the sound management of LLIN packaging into the existing national malaria strategy and related frameworks; and ensure that recommendations are aligned with national regulations concerning the safe handling and disposal of chemical waste (or pesticide-tainted waste).

11

Community Involvement & Social Mobilization

Community participation and social mobilization has always played an important role in preventing VBDs. The most important aspect of community participation is a change in the mindset of the community towards individual and social responsibility rather than the sole responsibility of concerned department. In order to achieve that, the community should be made aware through IEC and BCC activities. IEC and BCC are being used as a supportive strategy under NVBDCP. The goal of communication is to bring behavioural change through information and empowerment of people to facilitate community participation. The following steps are recommended with respect to community participation and social mobilisation:

- A national-level task force to sensitize different stakeholders, ministries and departments. A nodal official should be designated to organise meetings and ensure proper coordination.
- A state-level task force to identify local stakeholders and facilitate monthly coordination meetings to flag issues and suggest remedial measures.
- A district/block/village/urban area coordination committee should be set up, and nodal activists/champions should be identified to ensure smooth functioning and coordination.
- In addition to print and electronic media, inter-personal communication (IPC) is recommended between the health worker and/or health educator and the person whose behaviour is sought to be changed to adopt new skills and practices to ensure the welfare of their families and children. One-on-one contact facilitates comprehension of new concepts and demonstration of new practices. Over a period of time, if done consistently, this method can result in long-term and sustainable adoption of new practices.
- Digital media campaign through Social media (facebook, YouTube, Hotstar, Twitter), Mobile (SMS) for creating awareness among the community for prevention and control of VBDs.
- Tool kit for IPC should be developed to enable the communicator/health worker to demonstrate any concept using visual aids like such as role plays, flash cards, flip books, etc.
- Cross learning and sharing best practices of impactful activities should be shared.

12 Inter-sectoral Collaboration

Inter-sectoral coordination has been included as one of the guiding principle for Primary Health care. It involves collective action by other partner departments pertaining to their own departmental action to achieve common goal.

There are multiple factors that influence vector borne diseases in a community. Many of these factors are beyond the purview of Health Department. This can be achieved by multi-disciplinary approach and creating environment for holistic action by all stakeholders departments in a coordinated way.

There is no definitive list of stakeholder departments. It may vary from state to state depending on the state policies and infrastructure. Regular coordination and collaboration with other sectors are extremely important and need to be further strengthened. The efforts would need to progress beyond advocacy to commencement of 'dialogue' by exchanging information, determining priorities for 'collective planning and action' to make the programme effective and sustainable.

- A National Task Force under the Chairmanship of Secretary for Health & Family Welfare or DGHS may regularly meet with representatives from various Government Departments, and other stakeholders with clear Terms of Reference, which should meet periodically to identify specific areas of coordination, collaboration; to discuss concerns, best practices that could be replicated; to give directions for policy, planning, implementation and even to effective mobilization/ pooling of resources.
- The list of members and Terms of Reference should be clearly articulated. Engagement of ministries of education, tribal affairs, environment, industry, transport and tourism, finance, external affairs and home affairs for interventions in border areas, is especially important, due to their engagement with regulatory authorities and in policy formulation.
- A platform established may be helpful for information sharing especially on breeding potential, risk of mosquitogenic condition created due to construction or other various factors so that containment plan can be suggested to implementers or creators.
- The actions taken or addressed by stakeholder Ministry/ department to achieve the goal Intersectoral coordination need to be reviewed timely to ensure their impact. If action by any stakeholder is not attended timely, should be brought to the notice of senior state health officials.
- The various Ministries/departments identified with their roles and suggestive list of actions for prevention and control of Vector Borne Diseases are listed in Table-3:

Table-3: Suggestive list of actions for prevention and control of Vector Borne Diseases

Sl. No.	Agencies	Examples of Suggested Areas of Work
1.	Ministry of Health and Family Welfare	• Nodal Ministry to coordinate with all other ministries/ departments by sensitizing on VBDs for active participation and resource sharing • Vector surveillance at Point of entries (airports and seaports) and land crossings (International Health Regulation) • Maintaining all hospitals mosquito free zones • Take stock of the activities carried out
	Department of Health Research	• Carrying out implementation research to assess the efficacy of existing strategies to make them more effective and robust • Insecticide and drug resistance monitoring • Research on novel vector control tools and technologies
2.	Ministry of Jal Shakti	• Linking mosquito control with Swachh Bharat Abhiyan activities in rural areas • Improved water supply to avoid storage • Proper disposal of solid waste • Maintenance of pipelines to avoid leakage and stagnation • Repair of sluice valves Diversion of wastewater to natural or artificial ponds/pits • Encourage mosquito-proofing of water harvesting devices
3.	Ministry of Housing and Urban Affairs	• Linking mosquito control with Swachh Bharat Abhiyan activities in urban localities • Improved design to avoid undue water logging and access to overhead tanks, roof tops etc • Mosquito proofing of houses by fixing wire mesh on windows and doors • Health impact assessment of all construction activities before issuing clearance certificate to avoid mosquitogenic conditions especially in smart cities • Building bye-laws to be enacted and implemented in all urban areas • Introducing civic bye-laws by local bodies of cities and towns for proper disposal of refuse, junk materials and solid waste to prevent mosquitogenic conditions • Screening of migrant workers for malaria, filaria and kala-azar • Orientation training of Public Health Engineers to prevent mosquitogenic conditions in construction areas and buildings maintained by Central Public Works Department (CPWD)/Public Works Department (PWD) • Safe rainwater harvesting e.g., covered tanks etc • Provisioning sufficient budget for elimination of mosquito breeding and implementation of vector control activities by the urban local bodies

4.	Ministry of Rural Development	• Maintenance of rural water supply, sanitation campaign • Closing of dysfunctional wells, filling of unwanted ponds & ditches • Construction of pucca houses in kala-azar endemic areas
5.	Ministry of Panchayati Raj	• Monitoring of surveillance & interventions • Advocacy on vector control • Community education and awareness • Motivating community for acceptance of indoor residual spraying (IRS) and sleeping under LLIN • Promotion of larvivorous fishes in permanent waterbodies • IEC and source reduction activities through Village Health, Sanitation and Nutrition Committee • Improved drainage and sanitation programme in rural areas
6.	Ministry of Human Resource Development (Department of School Education and Literacy)	• Vector borne diseases and their prevention are included in the curricula • Students need to be encouraged to motivate the community for safe water storage practice and adoption of personal protection measures to avoid mosquito bites • Vector control teaching in educational curriculum, eg. CBSE mandatory 15 days SEWA (Social Empowerment through Work Education and Action) activity for community service for Class-IX to XII, which may be adopted by other education boards to encourage students to respond as a socially empowered change maker. • Maintaining mosquito free school premises • Ensuring full sleeved uniform particularly during dengue transmission period • Use of LLINs and screening of dwellings for boarding students
7.	Ministry of Environment, Forest & Climate Change	• Pesticide and environment management policy • Reclamation of swampy areas • Vector control measures in areas under social forestry (plantation areas), management & protection of forests and aforestation on barren lands • Coordination for vector control in inter-state and inter-country boarder areas • Undertake studies on climate change and correlation with VBDs with provision for timely sharing of findings with NCVBDC for policy decision
8.	Ministry of Railways	• Prevent mosquito breeding in railway yards/tracks and residential colonies • Prevention of water stagnation in railway construction areas • Proper excavations, maintenance of yards and dumps. • Conduct HIA of all projects during construction

9.	Ministry of Road Transport and Highways	• Policy for reuse of old tyres • Vector control measures for mosquito free tyre storehouses/ godowns • Timely disposal/proper storage of the junk material including unused vehicles • Timely filling of the ditches, merging pits/breaking bunds along roads and highways to avoid mosquito breeding • Excavations in line with natural slope/gradient, making way for water to flow into natural depression/pond/river • Conduct HIA of all projects during construction
10.	Ministry of Tribal Affairs	• IEC for enhancing acceptance of vector control measures (IRS & LLIN) and personal protection measures to avoid mosquito bite • Mosquito breeding free villages • Use of LLINs and screening of dwellings for boarding students
11.	Ministry of Information and Broadcasting (Bureau of Outreach and Communication)	• Dissemination of messages on VBDs to increase community participation • Organizing programmes on VBDs focusing on preventive measures and services provided by the government • Appropriate and transparent risk communication during outbreaks
12.	Ministry of Defence (Indian Armed forces)	• Control of VBDs in defence establishments • Prevent mosquito breeding in office buildings and residential colonies • IEC for personal protection during night duty and in forest & forest fringe areas • Use of LLIN, mosquito repellant • Coordination with local health department
13.	Ministry of Home Affairs (Police and Paramilitary forces)	• Prevent mosquito breeding in office buildings and residential colonies • IEC for personal protection during night duty • Use of LLIN, mosquito repellant • Coordination with local health department • Timely disposal/proper storage of broken and tow away vehicles kept at police station 'Malkhanas'

14.	Ministry of Commerce and Industry	• Set up of Public Health Unit in industries to ensure mosquito free industries and development projects • Timely disposal of solid waste, industrial junk and used containers to avoid mosquito breeding • Health impact assessment for new mining project for prevention and control of VBDs measures to prevent accumulation of water • Screening of labourers at the time of recruitment and thereafter at repeated intervals for sign and symptoms of VBDs • Education campaigns on prevention and control of VBDs for the employees and their families • Safe water storage/disposal and improvement of drainage • Mosquito proofing of dwellings and buildings • Use of LLINs by labourers, especially migrants
15.	Ministry of Agriculture and Farmers Welfare	• Encourage use of dry-wet irrigation system • To minimize the vector breeding sites in irrigation channels • Information sharing on insecticide policy and appropriate pesticide management • Providing facilities for larvivorous fish hatcheries • Promote proper drainage of irrigation channels by farmers to avoid water stagnation • Encouraging intermittent irrigation to avoid mosquito breeding particularly JE vectors • IEC of farmers for integrated pest and vector management through farmer field schools
16.	Ministry of Fisheries, Animal Husbandry and Dairying	• Institutional help/training in mass production of larvivorous fishes • Promotion of composite fish farming schemes at community level
17.	Ministry of Science and Technology	• Development of newer technology and novel vector control tools • Studies on mosquito behaviour, genetic variation, etc.
18.	Ministry of Women & Child Development	• Incorporation of vector control activities in the training curriculum of Anganwadi workers and their involvement in vector control activities • Inclusion of messages on VBDs focusing on preventive measures and services provided by the government during the community sensitization sessions

Note : In addition, NGO or other stakeholders may be identified and involved at local level.

13 Capacity Building

Trainings on various techniques and procedures for entomological surveillance and vector control are of utmost importance for capacity building of entomologists on IVM for prevention, control and elimination of VBDs. The newly engaged entomologists need to be trained on entomological parameters, vector bionomics, entomological surveillance and vector control etc. for smooth implementation of the strategies.

Training is designed to impart necessary knowledge and develop the required skills while on the job to make real-time positive changes. Training should not only strengthen technical skills but also help motivate field staff to undertake their job with discipline, diligence and dedication. Trainers can become role models for the personnel engaged in the work. Training efforts should be ongoing and have an inbuilt provision to update knowledge and skills in the light of scientific and technical advances. Training programmes should not be conducted in a routine and mundane way. They should create a positive learning climate. The participants should be treated with respect and should be allowed to provide input on schedules, activities and other events. Discussions should be encouraged. Hands-on work, group and individual projects, and classroom activities should be planned. Audio-visual aids, role plays, and case studies should be used.

Induction training

Induction training is meant to enable newly recruited staff to become productive as quickly as possible. Under the programme, the newly recruited staff such as Entomologists, District VBD Consultants and MTS need induction training soon after their joining. The following components may be included in induction training:

- On-the-job training occurs when workers learn skills while on the job alongside experienced workers at their place of work. New workers may shadow or observe fellow employees to begin with, and further receive training by using instruction manuals or through interactive training programmes. On-the-job training should be provided by supervisory staff during supportive supervision visits. Visual job aids, manuals and instructions should be used during the training so that the trainee has reference material in the absence of the supervisor/trainer.
- Off-the-job training is conducted away from the place of work over a short period. It may be conducted at a training institute, at a PHC, if classroom facilities are available or at school premises during weekends. In-service training should always be task-oriented, interactive and participatory. The one-way, lecture format is outdated and has proven to be extremely inefficient. Training should be conducted through modules.

Medical and paramedical personnel (regular/ contractual) involved in IVM activities in a district

Control and elimination activities in the district are the responsibility of the Chief Medical & Health Officer (CMHO)/District Health Officer/Chief Medical Officer (CMO). The DMO/DVBDCO is the district-level nodal person in-charge of these activities and reports to the CMHO. In high-endemic areas, additional human resource support is provided by the programme in the form of district level consultants and sub-district-level MTSs.

Refresher trainings

Refresher trainings at periodic interval for programme personnels, in updating their knowledge on recent development in vector control strategies are important. It also helps in reviving their skills and knowledge which may fade over time.

Similarly, the entomologists already working in the field also need to be updated on recent changes in the field from time to time on the newer guidelines and procedures through refresher training.

14 Legislative measures & IHR

For management domiciliary and extra-domiciliary mosquito breeding places, adoption and enforcement of bye-laws for use under Urban Malaria Scheme were framed as under:

Control of Malaria and other Mosquito Borne Diseases

Draft provisions suggested for adoption under appropriate section/rule prevailing in the State.

Application of this Provision

1. The State Govt./local authority constituted under any act may enforce the following provisions to the whole or any part of the State/local authority area.

2.1 If the provisions have been extended, no person or local authority shall, after such extension:

2.1.1 have, keep, or maintain within such area any collection of standing or flowing water in which mosquitoes breed or are likely to breed, or

2.1.2 cause, permit, or suffer any water within such area to form a collection in which mosquitoes breed or are likely to breed, unless such collection has been so treated as effectively to prevent such breeding.

2.2 The natural presence of mosquito larvae, in any standing or flowing water shall be evidence that mosquitoes are breeding in such water.

3. Treatment of Mosquito Breeding Places

3.1 The Health Officer may, by notice in writing, require the owner or the occupier of any place containing any collection of standing or flowing water in which mosquitoes breed or likely to breed. Within such time as may be specified in the notice, not being less than 24 hours, to take such measures with respect to the same, or to treat the same by such physical, chemical or biological method, being measures or a method, as the Health Officer may consider suitable in the circumstances.

3.2 If a notice under sub-section (1) is served on the occupier, he/she shall in the absence of a contract expressed or implied, to the contrary, be entitled to recover from the owner the reasonable expenses incurred by him in taking the measures or adopting the method of treatment, specified in the notice and may deduct the amount of such expenses from the rent which is then or which may thereafter be, due from him to the owner.

4. Power of Health Officer in Case of Default

If the person on whom a notice is served under provision3 fails or refuses to take the measures, or adopt the method of treatment, specified in such notice within the time specified therein, the Health Officer may himself take such measures or adopt such treatment, specified in such notice within the time specified therein, and recover the cost of doing so from the owner or occupier of the property, as the case may be, in the same manner as if it were a property tax.

5. Protection of Anti-mosquito Works

Whereas, with the object of preventing breeding of mosquitoes in any land or building, the Govt. or any local authority or the occupier at the instance of the Govt. or local authority, (have constituted any works) in such land or building, the owner for the time being as well as the occupier for the time such land or building shall prevent its being used in any manner which causes or is likely to cause the deterioration of such works, or which impairs, or is likely to impair the efficiency.

6. Prohibition of Interference with such works

6.1 No person shall, without the consent of the Health Officer, interfere with, injure, destroy, or render useless any work executed or any material or thing placed in under or upon any land or building, by the orders of the Health Officer with the object of preventing the breeding of mosquitoes therein.

6.2 If the provisions of sub-section (1) are contravened by any person, the Health Officer may re-execute the work or replace the materials or things, as the case may be, and the cost of doing so shall be recovered from such person in the same manner as if it were a property tax.

Section in Respect of Household Cans and other Containers

7. The owner or occupier of any house, building, or shed or land shall not therein keep any bottle, vessel, can or any other container, broken or unbroken, in such manner that it is likely to collect and retain water which may breed mosquitoes.
8. All borrow pits required to be dug in the course of construction and repair of roads, railways, embankments, etc. shall be so cut as to ensure that water does not remain stagnant in them. Where possible and practicable the borrow pits shall be left clean and sharp edged and extra expenditure not exceeding 1 per cent of the cost of the earth work in any project may be incurred to achieve this. The bed level of borrow pits shall be so graded and profiled that water will drain off by drainage channels connecting one pit with the other till the nearest natural drainage nullah is met with. No person shall create any isolated borrow pit which is likely to cause accumulation of water which may breed mosquitoes.
9. In case of any dispute or difference of opinion in the execution of any anti-mosquito scheme or in its operation or any work under these provisions in which the jurisdiction of the Govt. of India, or Govt. of any other State is involved, the mater shall be referred to the Govt. of India for final say in the matter.
10. Power of Health Staff to enter and inspect the premises in case of default: For the purpose of enforcing the provisions, the Health Officer or any of his subordinate not below the rank of Health or Sanitary Inspector may, at all reasonable times, after giving such notice in writing as may appear to him reasonable, enter and inspect any land or building within his jurisdiction and the occupier or the owner as the case may be, of such land or building, shall give all facilities necessary for such entry and inspection, and supply all such information as may be required of him for the purpose aforesaid.

- Though these provisions were made for Urban Malaria Scheme, in present context it can be adopted for dengue, chikungunya and Zika control.

- Few Municipal corporations have well-structured bye-laws for preventing mosquitogenic conditions with provisions of penalty for the defaulters.

Notifiable Diseases

Among the VBDs malaria, dengue and kala-azar are made notifiable diseases to make mandatory report from all health facilities at public and private sector. Few states have made Chikungunya and JE also notifiable diseases.

During elimination phase of malaria and kala-azar, tracking of each case is very important for case-based surveillance and to trace the source of infection for taking foci-based vector control actions. Similarly, once elimination is achieved, it is important to closely monitored, timely reporting of malaria cases and vector control measures to prevent re-introduction and re-emergence of any case. For *Aedes* borne diseases, timely reporting of each case is important for taking public health measures in the affected area/s to prevent further spread of the disease.

International Health Regulations (IHR)

In today's connected world, health security is a global issue. The International Health Regulations (IHR) are legally binding regulations aiming to a) assist countries to work together to save lives and livelihoods endangered by the spread of diseases and other health risks, and b) avoid unnecessary interference with international trade and travel.

The Twenty-Second World Health Assembly (1969) adopted, revised and consolidated the International Sanitary Regulations, which were renamed the International Health Regulations (1969). During the Forty-Eighth World Health Assembly in 1995, WHO and Member States agreed on the need to revise the IHR (1969) against the backdrop of the increased travel and trade characteristic of the 20th century. The IHR (2005) entered into force on 15 June 2007 and are currently binding on 194 countries (States Parties) across the globe, including all 193 Member States of WHO. The purpose and scope of IHR (2005) are to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade. (Art. 2, IHR 2005). WHO plays the coordinating role, through the IHR, WHO keeps countries informed about public health risks, and works with partners to help countries to build capacity to detect, report and respond to public health supervisor.

Core Obligations for Member Countries

- Designate a National IHR Focal Point as the operational link for urgent communications concerning the implementation of the Regulations.
- Develop, strengthen, and maintain the surveillance and response capacity to detect, assess, notify, report and respond to public health events, in accordance with the core capacity requirements under the IHR (2005).
- Notify WHO for all events that may lead to a Public Health Emergency of International

Concern (PHEIC) within 24 hours of assessment by using the decision instrument [an algorithm]

- Respond to requests for verification of information regarding public health risks.
- Provide WHO with all relevant public health information, if a State Party has evidence of an unexpected or unusual public health event within it territory, which may constitute a PHEIC.
- Control urgent national public health risks that may threat to transmit diseases to other Member Countries.
- Provide routine inspection and control activities at international airports, ports and some ground crossings to prevent international disease transmission.
- Make every effort to fully implement WHO-recommended temporary and standing measures and provide scientific justification for any additional measures.
- Collaborate with other Countries, Parties and with WHO in implementing the IHR (2005), particularly in the area of assessment, provision of technical and logistical support, and mobilization of financial resources.

Core Obligations for WHO

- Designate WHO IHR contact points as operational links for urgent communications concerning the implementation of the IHR (2005).
- Support Member Countries' efforts to develop strengthen and maintain the core capacities for surveillance and response in accordance with the IHR (2005).
- Verify information and reports from sources other than official notifications or consultations, such as media reports and rumours, when necessary.
- Assess events notified by Member Countries (including on-site assessment, when necessary) and determine if they constitute a PHEIC (Public Health Emergency of International Concern).
- Provide technical assistance to Countries in their response to Public Health Emergencies of International Concern.
- Provide guidance to Countries to strengthen existing surveillance and response capacities to contain and control public health risks and emergencies.
- Provide all Member Countries with public health information to enable them to respond to a public health risk.
- Issue temporary and standing recommendations on control measures in accordance with the criteria and the procedures set out under the Regulations.
- Respond to the needs of Member Countries regarding the interpretation and implementation of the IHR (2005).
- Collaborate and coordinate its activities with other competent intergovernmental organizations or international bodies in the implementation of the IHR (2005).
- Update the Regulations and supporting guidelines as necessary to maintain scientific and regulatory validity.

Role of WHO in Global System for Alert and Response

When a significant public health event takes place, WHO's comprehensive global alert and response system ensures that information is available and response operations are coordinated effectively.

Country Capacity Building

To help countries review and, if necessary, strengthen their ability to detect, assess and respond to public health events, WHO develops guidelines, technical materials, and training, and fosters networks for sharing expertise and best practice.

International Health Regulations in Ports, Airports and Ground Crossings

In case of arboviral/Vector Borne Diseases, all international air/seaports and ground crossings with a perimeter of 500 meters should be kept free from vector of yellow fever/dengue/ plague, if present, their density should be less than one to limit the spread of health risks to neighbouring countries, and to prevent unwarranted travel and trade restrictions so that traffic and trade disruption is kept to a minimum.

International transport, travel and trade contribute to economic development and welfare of populations, pose great public health risks. Today's high traffic at airports, ports, and ground crossings-points of entry, can play a key role in the international spread of diseases through persons, conveyances and goods. The International Health Regulations (2005) provide a public health framework in the form of obligations and recommendations that enable countries to better prevent, prepare for and respond to public health events and emergencies.

Under the IHR, Member Countries are requested to maintain effective sustainable public health measures and response capacity at designated ports, airports and ground crossings, in order to protect the health of travellers and populations; keep ports, airports and ground crossings running as well as ships, aircrafts and ground transportation travelling in a sanitary condition; contain risks at source, respond to emergencies and implement public health recommendations, limiting unnecessary health-based restrictions on international traffic and trade.

In India, an International Health Division under Directorate General of Health Services (Dte. GHS) monitors the IHR related activities in the country.

Activities undertaken for Vector Control in Air/Seaport and Ground Crossing

1. Strengthen regular epidemiological/entomological surveillance at international air/Sea ports and ground crossings. The National Center for Vector Borne Diseases Control (NCVBDC) and National Center for Disease Control (NCDC) have to regularly monitor the *Aedes* breeding at international airports and seaports to maintain *Aedes* breeding free status. If any breeding is detected actions need to be taken to immediately through port health authority to eliminate the source and prevention for future. The observations/actions taken have to be shared with the International Health division of Dte. GHS with suggestions, if any.
2. Support the Ministry of Health and Family Welfare in the development of regular feedback reports and early warning systems for the diseases.
3. Co-ordinate activities to review the legislative framework of the IHR implementation.
4. NCVBDC and NCDC to organize and facilitate training for port health office staff on core capacity for entomological surveillance as identified in the field of VBDs.

5. Support implementation of the IHR (2005) action plan.

Government of India (GoI) Policy for Yellow Fever

Yellow Fever (YF) does not occur in India. The conditions for transmission of YF are very conducive in India (presence of *Aedes* vector and susceptible population). GoI has been following a strict YF vaccination programme to prevent its entry to India. Strategy of GoI for prevention of entry of YF disease into India has been screening of all international passengers for vaccination against YF at all points of entry in compliance of the IHR 1969 & 2005 and Aircraft (Public Health) Rules 1954 and Port Health Rules 1955. All passengers coming to India or passengers going from India to countries endemic for YF should have a valid International Vaccination Card for YF or they are quarantined for a period of 6days or till the YF vaccination becomes valid (whichever is earlier).

YF disease will be treated as disease of public health significance and all health measures being applied presently like disinfection of conveyance by spraying Aerosol (Aircrafts and Ships), vaccination requirements and quarantine of passengers and crew (as may be required) (as per Article 7, P.2(b), 42 and relevant annexure) will be continued as has been stipulated under Annex-II of IHR-1969.

Source: http://www.who.int/ihr/ent

For details of India's perspective on IHR refer:http://www.mohfw.nic.in/index1

15

Health Impact Assessment (HIA)

WHO defines Health Impact Assessment (HIA) as a "combination of procedures, methods, and tools by which a policy, programme, or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population." https://www.euro.who.int/en/health-topics/environment-and-health/health-impact-assessment/definition-of-health-impact-assessment-hia.

The purpose of HIA is to produce a set of evidence-based recommendations to inform decision-making. HIA seeks to maximise the positive health impacts and minimise the negative health impacts of proposed policies, programmes or projects.

HIA is a practical approach used to judge the potential health effects of a policy, programme, or project on a population, particularly on vulnerable or disadvantaged groups. Recommendations are produced for decision-makers and stakeholders, with the aim of maximising the proposal's positive health effects and minimising its negative health effects. Environmental factors such as terrain features (plain, desert, hilly and forests), ecology, climatic features, rainfall, humidity influence the presence of vector mosquitoes thereby helping in the transmission of a particular disease. Developmental projects such as irrigation, dam, hydro-electrical projects, jhoom cultivation, deforestation lead to direct health impact on the population in that area in terms of VBDs.

The process to implement HIA is similar to other forms of impact assessment such as environmental impact assessment or social impact assessment. Conducting an HIA often involves the following steps:

- Screening - determining if an HIA is warranted/required.
- Scoping - determining the impacts that will be considered and the plan for the HIA.
- Identification and assessment of impacts - determining the magnitude, nature, extent and likelihood of potential health impacts, using a variety of different methods and types of information.
- Decision-making and recommendations - clearly highlighting the trade-offs to be made in decision-making and formulating evidence-informed recommendations.
- Evaluation, monitoring, and follow-up-process and impact evaluation of the HIA and the monitoring and management of health impact.

Practitioners may label these steps differently or break them into sub-steps.

The main objective of HIA is to (1) apply existing knowledge and evidence on health impacts to specific social and community contexts and (2) develop evidence-based recommendations that inform decision-making in order to protect and improve community health and wellbeing. Because of financial and time constraints, HIAs do not involve new research or the generation of original scientific knowledge. However, the findings of HIAs, especially where these have been monitored and evaluated over time, can be used to inform other HIAs in similar settings. Recommendations that emerge from the HIA may focus on the design and operational aspects of a proposal.

HIA has also been identified as a mechanism by which potential health inequalities can be identified and redressed prior to the implementation of the proposed policy, programme or project.

Department of Health

The proposition that policies, programmes and projects have the potential to change the determinants of health underpins the use of HIA. Changes to health determinants are expected to lead to changes in health outcomes or the health status of individuals and communities. The determinants of health are largely environmental and social, hence, there are overlaps with environmental impact assessment and social impact assessment.

Under the NVBDCP, insecticides and larvicides are being used which are registered with Central Insecticide Board based on the toxicity data to ensure human safety. However, ECoP envisaged under the orbit of the programme implementation, need to be followed. But there is need for health monitoring of the spray personnel handling insecticides during IRS or fogging operations. Such monitoring is a part of HIA.

Level of HIA- There are three forms of HIA:

- Desk-based HIA: It takes 2-6 weeks for one assessor to complete and provides an overview of potential health impacts.
- Rapid HIA: It takes approximately 12 weeks for one assessor to complete and provides more in-depth information on potential health impacts.
- Comprehensive HIA: It takes approximately 6 months for one assessor and provides in-depth assessment of potential health impacts.

It is suggested that HIAs can be prospective (done before a proposal is implemented), concurrent (done while the proposal is being implemented) or retrospective (done after a proposal has been implemented). This remains controversial, however, with a number of HIA practitioners suggesting that concurrent HIA is better regarded as a monitoring activity and that retrospective HIA is should be carried out as structured evaluation with a health focus, rather than simple assessment. Prospective HIA is preferred as it allows maximum practical opportunity to influence decision-making and subsequent health impacts.

HIA practitioners can be found in the private and public sectors but remain few in number. There are no universally accepted competency frameworks or certification processes. It is suggested that a lead practitioner should have extensive education and training in a health-related field, experience of participating in HIAs and should have attended an HIA training course. It has been suggested and widely accepted that a mere medical or health degree should not be regarded as an indication of competency.

HIA is based on four values that link HIA to the policy environment in which it is undertaken:

- **Democracy:** Allowing people to participate in the development and implementation of policies, programmes or projects that may impact their lives.

- **Equity:** HIA assesses the distribution of impact from a proposal on the whole population, with particular reference to how the proposal will affect vulnerable people (in terms of age, gender, ethnic background and socio-economic status).
- **Sustainable development:** Both short- and long-term impact are considered, along with the obvious and less obvious impacts.
- **Ethical use of evidence:** The best available quantitative and qualitative evidence must be identified and used in the assessment. A wide variety of evidence should be collected using the best possible methods.

HIA and policy making

This section investigates how HIA contributes to policy making.

HIA can be a valuable tool in developing policies and assisting decision-makers. The usefulness and need of HIA within policy and decision-making is clear, wherein, HIA:

- is used in projects, programmes and policies
- assists policy development
- brings policies and people together
- involves the public
- provides information for decision makers
- addresses policies for making requirements
- recognizes that other factors influence policy apart from HIA
- is a proactive process that improves positive outcomes and decreases negative outcomes
- can provide what policy makers need

Suggestions on how an HIA practitioner might interact with the policy process and policy makers, a description of the different stages in policy making and some key steps for HIA practitioners are also provided.

Tools and methods

This section will draw on a number of case studies to briefly describe the theory and practice of carrying out an HIA. Many HIA guidance documents have been developed globally and it is recommended to use them. While there is no single agreed method to undertake HIA, a general pattern has emerged among the various methods and there is overlap between them. Guidance documents often break HIA into four, five or six stages. Despite the differing number of stages, it is important to note that there are no significant differences between the methods. Additionally, the theoretical stages often overlap and intermingle, and a clean separation is not often obvious in practice. The stages are shown in Figure-20.

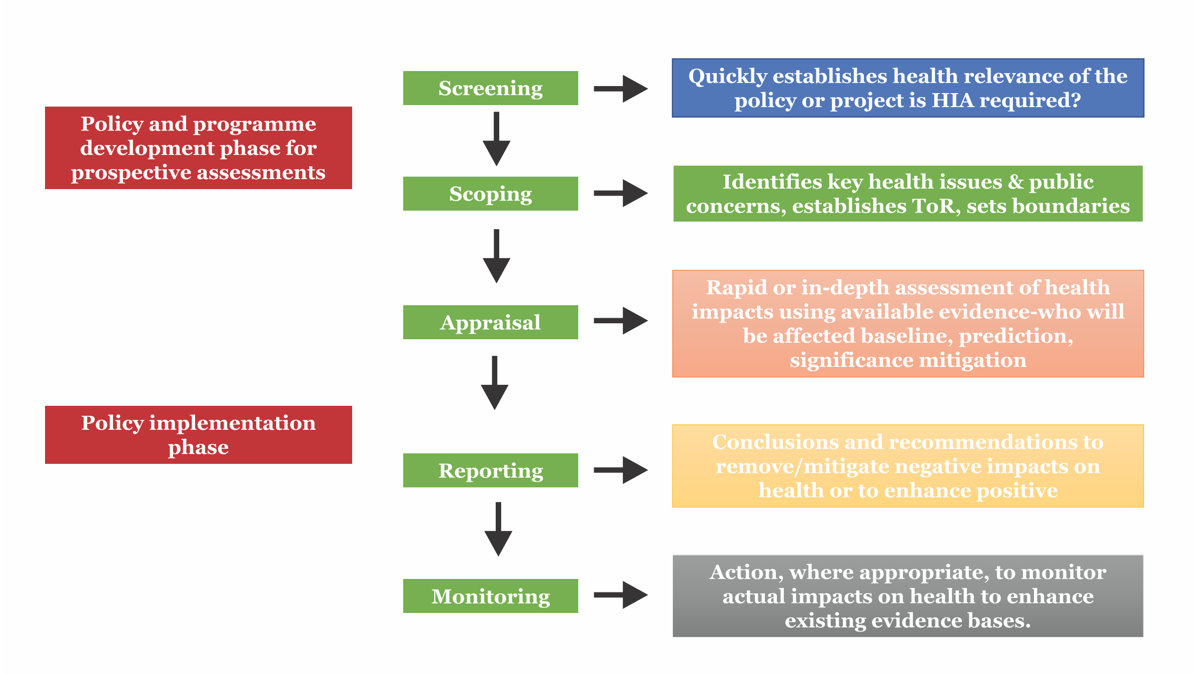


Figure-20: HIA Procedure

Using evidence in HIA

One of the key values of HIA is the ethical use of evidence. A wide variety of evidence should be collected and assessed, using appropriate and effective methods. This will provide the basis for evidence-based recommendations that can be provided to decision-makers, who can then make decisions about accepting, rejecting, or amending the proposal in the knowledge that they have the best available evidence before them. HIA considers several types of evidence. It goes beyond published reviews and grey literature to include the knowledge of stakeholders who are involved in or affected by the proposal under study. Where evidence of the quality and quantity demanded by decision-makers is not available, a note of this is made within the HIA.

16

Statistical Applications in Vector Borne Diseases

Entomological Parameters

An understanding of entomological parameters is important in the study of dynamics of VBDs in a given terrain, both in the presence or absence of anti-vector measures. These parameters are useful in assessing the intensity of transmission in an area as well as assessing the anti-vector measures. However, its proper understanding depends on the integration of values obtained under individual parameter. Therefore, while interpreting the results, more than one parameters need to be looked into. The important entomological parameters used in vector control programmes may be arbitrarily grouped into two important aspects:

A. Vector control: Data on following important parameters is collected:

- Mosquito density-per man hour density (PMD/PMHD) per room density (PRD), etc.
- Outdoor mosquito population sampling
- Larval density in breeding places
- 24 hours survival of vectors collected from sprayed houses
- Bio-assay: Cone and Aerial bio-assay
- Susceptibility Test: Adults and Larvae
- Abdominal condition of female mosquitoes
- Parity rate and age determination

B. Disease transmission: Data on the following parameters is collected:

- Man-biting rate-man mosquito contact
- Trap collections -light/bait
- Seasonal infectivity of vector and incrimination of vectors
- Anthropophilic index
- Duration of gonotrophic cycle

Important entomological parameters used in various vector control programmes are:

1. Adult Mosquito Density:

1.1. Per Man Hour Density (PMD/PMHD): (By suction tube/ aspirator)

Method

This index is calculated for each vector species as well as for total anophelines and is calculated using the hand collection made by the Insect Collectors at dawn and dusk. Aspirators tube and flashlight technique is commonly used for collecting the resting mosquitoes from inside (rooms/cattle sheds etc.) and outside (bushes/wells etc.).

$$\text{PMD/PMHD} = \frac{\text{Number of mosquitoes (male \& female) collected}}{\text{Number of Insect Collector X time spent in search in hour}}$$

Significance

This parameter is useful to know:

a) Mosquito fauna of the area

b) Seasonal prevalence of mosquitoes and vectors

c) Resting habits, both indoors and outdoors

d) Impact of vector control measures

1.2 Mean Per Room/Hut Density (PRD): (By Pyrethrum Space Spray Catch/ Pyrethrum Total Catch/Spread Sheet Catch)

Method

Pyrethrum solution is prepared by mixing one part of 2% pyrethrum extract with19 parts of kerosene oil and sprayed in suitable rooms whose openings (windows and doors) can be temporarily closed. Before spraying, white cotton sheets are stretched on the floor covering wall to wall and after spray, the room is closed for 15-20 minutes. The knocked down mosquitoes are collected, identified and recorded. After collections from 3-4 rooms, the indoor resting mosquito per room on an average may be calculated.

Significance

a) Determination of mosquito/vector prevalence in an area of low indoor resting densities

b) It is useful in places where indoor hiding mosquitoes are not easily detected through hand collection method

c) When large numbers of mosquitoes are required for dissection.

1.3 Outdoor collection (through trapping devices)

Method-Hand collections of mosquito's outdoors is done through trapping devices such as pit-shelters, shelters, etc. placed at different distance.

Significance-This parameter indicates dispersal of mosquito population in space and time.

1.4 Mosquito collection on animals

Method-Hand collection with the help of aspirator tube and flashlight, from the animals in the proximity of human dwelling is done during the usual biting hours.

Significance

a) This parameter indicates preference of mosquitoes for animals or human for blood meals.

b) If mosquito has predilection for animals, the latter may be used as zooprophylactic.

2. Larval density

Method

Larval collection is done with the help of standard ladle, dipper, well net, etc. The common approach is to work out per dip density of larvae (for anopheline or culicine). Commonly, a minimum of four dips are applied in each breeding place at different points and number of larvae an average per dip is determined.

Significance

a) An auxiliary method of detection of vector prevalence in time and space.
b) This parameter is used in understanding mosquito breeding habits.
c) This indicator is used in assessing the anti-larval measures in urban areas.

3. Human mosquito contact

3.1 Human biting rate

Method

Mosquitoes are collected from human baits in the night during usual sleeping hours. Index is determined either indoors or outdoors usually from 6.00 P.M. to 6.00 A.M. Hourly collections are recorded. No. of mosquitoes collected per night on each bait becomes the parameter. It is also estimated as per hour per bait to see peak biting time.

Significance

a) This parameter helps in understanding the vectorial potency and quantum of human mosquito contact in space and time.
b) This indicates differential human feeding propensity.
c) Helps in understanding the site of vector-human contact.
d) Helps in deciding whether indoor residual insecticidal spraying is advisable.
e) Helps in understanding Endophagy or Exophagy.

3.2 Human /Animal bait traps

Method

Animal or human may be put as bait in traps like bait night trap, magoon trap, steer bait trap, etc. The mosquitoes are collected by hand in the early morning and density per trap per night may be calculated.

Significance

a) This indicator helps in understanding differential feeding on human or animals.
b) This gives an idea about site of human-mosquito contact.
c) Helps in understanding human biting rate and vectorial potency in space and time.

3.3 Adult biting / Landing rate:

Method

Collecting mosquitoes directly while landing or during the process of biting a human / animal host throughout night (18:00-6:00 hrs) for night biting species. It is estimated as number of mosquitoes collected at bait per unit of time.

Significance

a) Vector prevalence/potential in time & space

b) Impact of control measures

c) Variations in their relative abundance

- Only use male human bait for landing collection. Remove the shirt or vest from the bait and make it sit in one corner of the house facing the wall. Ask the bait to breathe deeply for about 5 to 10 minutes.
- Without much disturbance, start collecting the adult mosquitoes as they land on the bait.
- It is expressed in no. of adults collected /bait/hour.
- Average no. of mosquitoes / bait / night.
- No. of adults captured /no. of baits used.
- Frequency of collection monthly
- All female mosquitoes to be processed for age, infection, and infectivity.
- Human bait or landing collection for *Aedes* mosquitoes is not suggested to avoid any infective bite

4. Twenty-four (24) hours survival rate

Method

Exit window traps are fixed in the houses and adult females caught in them are put in the holding chambers and observed for 24 hours for survival/mortality. The mosquitoes caught in the trap are placed individually in small vials.

Significance

a) This indicator gives an understanding about impact of residual insecticide spray.

b) It gives an indication of inherent population characteristic of daily mortality.

5. Seasonal infectivity of vectors / Sporozoite rate

Method

Mosquitoes collected from known positive houses and nearby houses are dissected in 0.65% saline (https://apps.who.int/iris/bitstream/handle/10665/42481/WHO OFFSET_13_%28part2%29.pdf?sequence=2&isAllowed=y Page 90) for salivary glands dissection. The glands so obtained are to be examined under a compound microscope with 100x magnification and proper staining. The sporozoite rate (infectivity rate) may be calculated as follows:

$$\text{Sporozoite rate} = \frac{\text{Number of mosquitoes found with sporozoites}}{\text{Number of mosquitoes dissected}} \times 100$$

Significance

a) To incriminate the suspected vector/re-incriminate known vectors
b) To evaluate the impact of control measures
c) To estimate transmission season
d) To understand the vectorial potency of vectors

6. Oocyst rate

Method

Mosquitoes are dissected for gut, which may be examined under low power for presence of Oocyst on the gut wall. The rate may be calculated as follows:

$$\text{Oocyst rate} = \frac{\text{Number of mosquitoes found with Oocyst}}{\text{Number of mosquitoes dissected}} \times 100$$

Significance

a) Helps in determining the transmission season
b) Helps in evaluating the impact of vector control measures

7. Vector infection (Filaria vector)

7.1 Percentage of mf in vector

Understanding the presence of human mf carriers in the vicinity of collection

$$\text{mf \%} = \frac{\text{Positive for mf stages in adult vector mosquitoes}}{\text{Total number of vector females dissected}} \times 100$$

7.2. Vector infection rate (VIR)

Proportion of vector females containing larval stages I (L1) & II (L2) and developed III (L3) forms of filarial parasite.

$$\text{VIR} = \frac{\text{Number of vector females with L1, L2 \& L3 stages of parasite}}{\text{Total number of vector females dissected}} \times 100$$

Significance

Crude index to understand the extent of sources of human infection

7.3 Vector infectivity rate

Proportion of vector females with developed stage (L3) only

$$\text{Vector infectivity rate} = \frac{\text{Number of vector females with L3 stage alone}}{\text{Total number of vector females dissected}} \times 100$$

Significance

Indicates transmission potential in community.

7.4 Average number of infective larvae per infective mosquito

$$\text{Mean no. of L3/ infective mosquitoes} = \frac{\text{No. of infective larvae (L3) found}}{\text{No. of infective mosquitoes}}$$

8. Parity rate

Parity in mosquitoes is defined as the number of times a female mosquito has laid eggs. This gives some idea of the age of a mosquito. Determining the age structure of a population is important because older mosquitoes are more likely to transmit diseases since they have had the opportunity to blood feed on potentially infectious hosts and transmit them to a susceptible host.

If the mosquito has not laid eggs (nulliparous), she is likely to be young; if she has laid eggs before (parous), she must have had the opportunity to mate and take a blood meal, therefore, is likely to be older.

8.1 Parity assessment can be performed by a technique called **Detinova Ovarian Tracheation** (1962). Tracheoles are tube-like structures that are a part of the respiratory system in insects. In mosquitoes, the tracheoles looks like a coiled knot around the forming ovarioles. Due to its resemblance to a ball of yarn, this knot is referred to as a 'skein'. Once the eggs fully develop and the female oviposits them into the environment, these skeins become loosened or straightened and never become coiled into tight knots again. The presence or absence of tracheole skeins (coiled ends of tracheoles) can be used to classify mosquitoes either as nulliparous or parous. The method is rapid and simple, and a well-developed framework has been established for applying nulliparous/parous classification. However, the inability of this method to distinguish older age classes of mosquitoes and population age structure in natural settings has prompted the development of additional age grading methods.

8.1.1 Detinova technique

Mosquitoes are dissected for ovary. After water on slide around the ovary in nearly half dry, ovary is covered with glycerin and examined under bionocular to observe whether tracheolar endings were coiled (skeins) or straightened. The parous females i.e., those who have taken blood meals once and digested it, will not show skeins. For this dissection, the females caught during the human bait collections are preferred.

8.2 Polovodova (1949) described a method of counting bead-like structures occurring in the ends of ovarioles, subsequently referred to as "dilatations", to determine the number of previous egg-laying cycles completed. This method, along with the estimation of gonotrophic cycle gave the calendar age of the mosquitoes in days.

8.3 The gonotrophic cycle of a mosquito is the time taken to complete the following three parts which, under normal circumstances, needs certain favourable conditions like temperature, full blood meal and fertilization:

i. Time required to find and feed on a hosts to get a full blood meal

ii. Time required for the digestion of blood and the development of the ovary

iii. Time until oviposition

The gonotrophic cycle duration may then be defined as the time interval between two consecutive blood-meals (or the time interval between two consecutive acts of egg-laying/ oviposition).

8.4 Duration of gonotrophic cycle

Method

a) Direct observations on known fed mosquitoes in cage
b) Estimate ratio of blood fed and gravid and semi gravid in morning pyrethrum space spray collection

Significance

This parameter helps in estimating the vectorial capacity of the mosquitoes.

8.5 Determining the proportion of parous females

$$\text{The proportion of parous females} = \frac{\text{Number of parous females}}{\text{Total number of females examined}}$$

$$\text{Parous rate} = \frac{\text{Number of parous females}}{\text{Number of females examined}} \times 100$$

9. Anthropophilic index

Method

Blood meal samples from freshly fed females are collected on filter papers and the human blood index (HBI) is determined either by precipitin test or gel-diffusion test or ELISA or any other method. The index is calculated as:

$$\text{HBI} = \frac{\text{Number of mosquitoes showing source of human blood}}{\text{Total number of mosquitoes whose blood meals have been identified}} \times 100$$

Significance

a) Helps understanding the feeding preference and biting frequency of mosquito on men.
b) Helps in assessing change in feeding behaviour of mosquitoes.

10. Abdominal conditions of female mosquito

Method

The mosquitoes collected in the early morning hours are examined for abdominal conditions such as fullfed (FF), unfed (UF), semi-gravid (SG) and gravid (G) are recorded. The percentage of each type may be worked out as below:

$$FF\% = \frac{\text{Number of mosquitoes with FF abdomen}}{\text{Total number of mosquitoes examined}} \times 100$$

Significance

a) To determine the composition of mosquito population.

b) To assess the impact of spraying/ LLIN use.

11. For container breeders (*Aedes*)

11.1 House index (HI): Percentage of Houses and their premises positive for immature stages of *Aedes* mosquitoes (HI >10 % high risk; 5-10% moderate risk and <1% low risk). It is calculated as

$$\text{House Index (HI)} = \frac{\text{Nos of houses positive for } Aedes}{\text{Nos of houses inspected}} \times 100$$

Significance: Extent of *Aedes* larval breeding in a locality

11.2 Container index (CI): Percentage of water holding containers (Wet containers) positive for immature stages of *Aedes* mosquitoes (CI >10 % high risk; 5-10% moderate risk and <1% low risk)

$$\text{Container index (CI)} = \frac{\text{Nos of containers positive for } Aedes}{\text{Nos of containers inspected}} \times 100$$

Significance: Intensity of *Aedes* larval breeding in a locality

11.3 Pupal index: No. of pupae per 100 houses

Significance: Helps in assessing vector control especially the presence of pupae. It reflects operational failure in terms of time and space.

11.4 Breteau Index: No. of positive containers per 100 houses (100 houses ideal; BI > 50% high risk; 5-50% moderate risk and <5% low risk).

Significance: Helps in assessing vector control.

Note: BI is only valid when minimum 100 houses are inspected. If 100 houses are not checked, then BI is irrelevant and should not be used for interpreting the impact of vector control intervention.

12. Bio-assay tests

12.1 Contact bio-assay

Method

On sprayed wall-The cones are fixed to a sprayed wall surface and mosquitoes are exposed for a standard period of time (usual 30 minutes) as per standard WHO method and mortality is recorded at the end of 24 hours holding period.

On LLIN - The cones are fixed to LLIN and mosquitoes are exposed for a standard period of time (usual 3 minutes) as per standard WHO method and mortality is recorded at the end of 24 hours holding period.

Significance

a) Helps in determining the residual efficacy of insecticide on different surface and in different duration of time.

b) Assists in evaluating the equality of insecticidal spraying.

c) Helps in assessing the effectiveness of LLIN.

12.2 Aerial bio-assay

Method

a) Mosquitoes from unsprayed areas/lab bred are kept in a small mosquito cage which is suspended in the middle of a sprayed room. The mortality in the mosquito is observed after 24 hours and the cage is taken out of the room.

b) The caged mosquitoes may be placed outside the house at suitable places for assessing the efficacy of fogging.

Significance

a) Helps in understanding the vapour or air-borne effect of insecticide on mosquitoes.

b) Helps in assessing efficacy of thermal/cold fog at varying distances and heights.

13. Mosquito/ vector susceptibility to insecticides

13.1 Determining susceptibility status of adult mosquitoes

Method

Blood fed female adult mosquitoes are exposed to diagnostic doses of insecticides for standard time, i.e., DDT 4% X 1 hr; Dieldrin 0.4 x1 Hr. Malathion 5% X 1 Hr. Fenitrothion 1% X 2 Hrs.; and propoxure 0.1 X 1 Hr. Mosquito mortality is recorded at the end of 24 hours holding period.

The mortality of the test sample is calculated by summing the number of dead mosquitoes across all exposure replicates and then expressing this as a percentage of the total number of exposed mosquitoes:

$$\text{Observed mortality} = \frac{\text{Total number of dead mosquitoes}}{\text{Total sample size}} \times 100$$

If the control mortality is 5% to 20%, the test mortality may be corrected by following Abbot's formula:

$$\text{Corrected mortality} = \frac{\text{\% Test mortality - \% control mortality}}{\text{100-\% control mortality}} \times 100$$

- If the control mortality is <5% no correction of mortality is required.
- If control mortality is more than 20%, test should be discarded.
- A mortality in the range of 98–100% indicates susceptibility of the mosquitoes
- A mortality in the range of 90–97% indicates Possible resistance
- Mortality< 90% indicates Confirmed resistance

Significance

a) Helps in establishing the susceptibility level of vectors to different insecticides and subsequently in different time intervals.

b) Helps in suggesting change in current control methods or suggesting alternative control measures.

Note :

- The impregnated papers should be used upto 6 times, equalling to about 150 mosquitoes.
- Between tests, papers should be kept in their original plastic box, sealed with tape and stored in a container or refrigerator at 4°C or, if this is not possible, in a darkened cupboard at room temperature.
- If papers are stored at 4°C, they should be brought to room temperature before being used in an exposure test.
- Test papers should never be exposed to direct sunlight.
- Date of expiry of each batch is given on the box and should be strictly adhered to.

WHO susceptibility tests with intensity concentrations (5xand10x of Diagnostic concentrations)-

Significance

- If the mortality is in the range 98–100% at the 5x dose , then it is not necessary to assay at the 10x dose-it indicates a low resistance intensity
- If the mortality is less than 98% at the 5x dose, then it indicates a moderate resistance intensity. It is necessary to assay further at the 10x dose
- If the mortality is in the range of 98–100% at the 10x dose, it confirms a moderate resistance intensity
- If the mortality is less than 98% at the10x dose, it indicates high resistance intensity

13.2 Susceptibility test of mosquito larvae

Method

The third or early fourth instar larvae are exposed to diagnostic concentration of larvicide in water and mortality is recorded after 24 hours. Tests are carried out using the WHO Test Kit, and mortality, if need be, is corrected applying Abbot's formula as in the case of Adults.

Significance

a) To find susceptibility status of larvae to the applied larvicide

b) To establish a baseline susceptibility level of vectors to different insecticides before these insecticides are put to usage and subsequently monitor any change in susceptibility level in course of time

c) To change the existing control measures or to suggest alternative control methods

14. *Phlebotomous argentipes* (Sand fly)

14.1 Age determination: Usual method of age determination of sand flies is the examination of ovariole relics. The ovaries are dissected in sterile saline and the ovarian follicles are examined for dilatations. Each relic represents one gonotrophic cycle. The examination of accessory glands for secretary granules also provides criteria for determination of age (parity).

14.2 Host preference: The blood meal of a freshly fed sand fly is sampled on a filter paper that may be subjected to a precipitin test, gel-diffusion technique or ELISA to determine the source of blood meal.

14.3 Vector incrimination: After dissecting a sand fly in sterile saline, midgut is examined for presence of flagellates. If found positive, head should also be dissected for examination of cibarium, pharynx and proboscis. The promastigotes must be spread on a slide, fixed with methanol and stained with Giemsa or Leishman stain. The presence and promastigote, however, does not confirm the species of the parasite as all promastigotes are morphologically indistinguishable. For confirmation, samples should either be subjected to xenodiagnoses or to biochemical characterization of parasite.

14.4 Determination of susceptibility to insecticide: The conventional WHO susceptibility test kit should be used. Freshly fed *Ph. argentipes* can be subjected to preliminary screening on the basis of silvery white legs. However, after recording the data, all sandflies subjected to the test must be examined under microscope after mounting and due corrections should be made in the observations before interpreting the results.

17 Monitoring & Evaluation

Monitoring is a very crucial component of IVM. In addition to its role in disease situation, monitoring the entomological parameters as well as output indicators is important to derive the desired impact out of various vector control activities.

With respect to malaria elimination, two core vector control interventions are IRS and LLIN/ITN. Indicators to be monitored in reference to the aforesaid two core interventions are described below:

- **Percentage of targeted households/rooms sprayed:** Impact of IRS on malaria morbidity in a particular area will depend on the coverage achieved during spray operation. Therefore, maximum sprayable surfaces need to be covered. This can be monitored by assessing the proportion of fully sprayed houses against the targeted. Ideally, this coverage should in the range of 85% to 90% to achieve maximum epidemiological as well as entomological impact. This is a key indicator under IRS to be monitored.

- **Percentage of population in high-risk areas protected with effective IRS:** The criteria for inclusion under IRS is API. Previously, all sub centres/villages reporting >2 API were shortlisted for IRS. Since 2017, this criterion has been revised and now all sub centres/villages with >1 are to be covered under IRS. This is to achieve the ambitious target of malaria elimination by2030. Hundred percent coverage of the targeted sub centres/villages under IRS to reduce the disease burden in such high-risk areas. This will reduce the number of areas that are high risk. This indicator has high significance for malaria elimination.

- **Percentage of population in high-risk project areas protected with either effective IRS or LLIN:** Areas that is highly vulnerable to malaria transmission (construction or project areas) as receptivity is quite high due to influx of population/ migrant labourers, availability of potential mosquito breeding habitats and favourable environmental conditions. Such areas should become the top priority for vector control. The proportion of high-risk population in such areas (because of high receptivity and vulnerability) covered under any of the core interventions is an important indicator to be monitored and corrective actions to be taken whenever necessary.

- **Percentage of population in high-risk areas provided with effective LLINs/ITNs:** The second core intervention under vector control/IVM for malaria elimination is distribution of LLIN in high-risk areas. When LLINs are distributed, great care has to be taken to ensure that all the sub centres/village that qualify for such intervention is covered fully, so that the entire population is protected. This requires survey of the population to assess the requirement of LLINs of different sizes for each household. Considering this, percentage of high-risk population covered under LLINs is an important indicator.

- **Percentage of households with LLIN:** Mere distribution of LLIN will not have any impact on the malaria situation of the area unless all the households in that area are provided with LLINs of appropriate size, the community is motivated to use it while sleeping and to monitor the availability of LLINs with the household and to replace the LLINs that are damaged/lost. The proportion of households that have LLINs out of the total households needs to be monitored by the concerned PHC staff periodically.

- **Percentage of individuals who slept under LLIN/ITN the previous night:** The purpose of distributing LLINs is to prevent human-mosquito contact and reduce transmission. This will become a reality when the people who have been provided with LLINs sleep under it during night. Monitoring this usage is very crucial so that the epidemiological impact can be correlated. Moreover, appropriate corrective measures, particularly for awareness generation can be taken.

- **Number of LLINs distributed:** Planning distribution of LLINs is done after assessing the requirement for each sub centre/village. Therefore, it is logical to monitor the number of LLINs distributed against the projected target. Any shortfall needs to be highlighted and corrective actions should be taken.

- **Number of ITNs retreated:** In certain areas, the local community uses simple mosquito nets to protect themselves from mosquito bites. Under the programme, there is provision to enumerate the mosquito nets available with the community and to treat them with insecticides every six months. This will require the household survey to find out the total mosquito nets available and percentage of ITNs retreated.

- **Number of LLINs replenished:** Damaged LLINs need to be replenished in the community. This will require a survey at least once in a year or through MPHWs during their house visit. Percentage of LLINs replenished against the total numbers damaged/lost needs to be monitored.

Monitoring of biological control activities/larval source management

In addition to the core interventions of IRS and LLIN, several other vector control tools can also be implemented to supplement these activities. Biological control is one such activity that can be implemented particularly in areas where IRS or LLIN is not implemented. This activity is cost-effective and environment friendly, however, require planning and proper implementation. Success depends on the coverage of potential mosquito breeding habitats with larvae eating fishes. Survival of fishes is another aspect that needs to be monitored. Adequate quantity of larvae eating fishes should be available in each health facility/PHC/Urban Health Centre (UHC).

1. **Number of hatcheries established:** Larvae eating fishes need to be reared in hatcheries constructed for the same. Each health facility (PHC/UHC) should have at least one functional hatchery. Therefore, the number of hatcheries established against the required hatcheries is an important indicator.
2. **Number of hatcheries with fishes:** Once the hatcheries are established, larvae eating fishes should be available throughout the year so that it can be transferred and introduced in permanent breeding habitats. Hence, the percentage of hatcheries with fishes (functional hatcheries) should be monitored. These hatcheries in case of any laxity can become a source of mosquito breeding.
3. **Percentage of permanent water bodies seeded with fishes:** For biological control to be effective, meticulous planning is required. The first step is to map the permanent water bodies for seeding the fishes. Once mapped and listed, a plan for seeding of fishes has to be developed. Hence, percentage of such permanent water bodies seeded with fishes is important. Periodic monitoring regarding survival of the fishes also needs to be done.
4. **Percentage of larval sources managed:**In addition to biological control methods, several tools such as chemical control/use of IGR and source reduction can also be implemented depending on available resources and technical feasibility. In such areas, mapping of breeding habitats (intra-domestic and peri-domestic) is essential. The percentage of larval sources managed (by different methods) out of the total numbers identified/available should be monitored. Periodicity of the activity is significant considering the life cycle of mosquito. Hence, these activities have to be recurrent depending upon the type of larvicide/IGR being used.
5. **Monitoring larval indices:** Unlike malaria, *Aedes*-borne diseases such as dengue, chikungunya and zika do not have any specific treatment, therefore, control strategy depends primarily on vector control with priority to larval source management. In this regard, vector surveillance is a critical component of the programme. Monitoring larval indices is important to delineate high-risk areas as well as to assess the impact of the larval source management activities. The following parameters/indicators should be regularly monitored:

   i. Number of houses checked: Ideally, not less than 100 houses need to be checked for monitoring the larval indices in a particular locality. It is monitored as the Percentage of houses with *Aedes* larvae (House index). (HI >10 % high risk; 5-10% moderate risk and <1% low risk).

   ii. Number of containers checked: Number of water-holding containers in the houses visited needs to be checked. It is monitored as Percentage of containers with *Aedes* larvae (Container index). (CI >10 % high risk; 5-10% moderate risk and <1% low risk).

   iii. Breteau Index: Number of mosquito positive containers per 100 houses should be inspected. This is generally considered to be the best among the commonly used indices, but valid only when 100 houses are checked. (BI >50% high risk; 5-50% moderate risk and <5% low risk).

iv. Pupal Index: Number of pupae per 100 houses inspected.

v. Number of breeding sites checked: In addition to intra domestic containers, peri-domestic breeding sites need to be checked during such visits to ascertain the gravity of the situation.

Checking of vacant land and abandoned/locked houses is important for prevention of *Aedes* borne diseases.

Supervision of vector control activities

All vector control activities require concurrent and consecutive supervision to ensure that it is implemented as per programme guidelines as described in previous chapters. Key aspects to note are:

- Detailed plan for vector control
- Availability of logistics (insecticide & equipment) and other resources
- Application procedure and adherence to the standard guidelines
- Maintain proper dosage of insecticide
- Achieving desired coverage
- Preventing adverse effects
- Maintain reports and registers

Out of all the vector control activities, IRS is the most significant, therefore, supervision of IRS is described elaborately.

Supervision of IRS

Supervision is an essential component of IRS to ensure its efficacy and safety. Supervision should be done thoroughly to have the desired impact and ensure that there are no adverse effects. To be effective, supervision should be carried out at all levels. There should be a written plan for supervision and supervisory checklists are to be developed and used. Supervision will be effective if problems are identified, and they are solved by the supervisors as soon as they are detected. Any unsolved problems should be brought to the notice of district authorities for resolution. All supervisory reports should be sent to the district to facilitate follow-up action. The supervisory reports should be kept safely in the district and available for reference whenever needed. Points to note for supervision are:

1. Availability of spraying plan with the spray squad.
2. Review of the plan to be done periodically to ensure that it is being followed.
3. Ensure that all members of the spray squad are present and undertaking their responsibilities.
4. Checking that the spraying is being done according to the guidelines.
5. Examination of the spray equipment to be done to ensure that it is in working condition and is being properly maintained as per the guidelines.
6. Going with the squad to the households where there is refusal or reluctance for spraying.
7. Checking the records of the spray squads.
8. Discussions on plans for mopping to cover the refused or locked houses to be held.
9. Assessing the consumption of insecticides to arrange additional supplies, if required.
10. Review of time schedule for the following week.
11. Visit selected households randomly and enquire whether the house was sprayed or not.
12. If the house was sprayed, then check for grey or white deposits as evidence for spray. (In case of synthetic pyrethroids, it is difficult to see the deposits on the walls during concurrent supervision. The droplets may be seen on the wooden structures in the rooms/cattle sheds where insecticide has been sprayed).
13. Check that the deposits are uniform. Uniform deposits indicate that the spraying was satisfactory.
14. Check to see if any portions of the dwelling or the cattle shed were missed.
15. Check whether the walls have been plastered with mud. If the walls have been plastered, then determine the time interval between the IRS and the plastering.
16. Visit the households that were not covered and find out the reasons for non-coverage. Try to convince them to get their houses sprayed as a part of a special mop up drive.
17. Prepare a written report along with recommendations and share with the spray squads to ensure that the mistakes are corrected as soon as possible.

Informing and involving the community

The supervisors should inform the community leaders and influencers in the villages about the plans for the spraying at least one week before spraying. The spray team members should remind them at least one day before the operation.

During the first visit, discuss the following issues with the community leaders and influencers in the community:

- Distribution of a simple leaflet/handbill/booklet explaining the purpose of the spraying and including the common do's and don'ts developed in the local language. Simple illustrations should be included to facilitate easy understanding. This should be a part of BCC. The leaflet/handbill/booklet should be handed over to several key persons in the village for distribution and briefing in the community they represent or influence.

- The key persons should share the contents of the leaflet/handbill/booklet with others in the community.
- Explain to the community that if all surfaces are not sprayed, sand fly would fly to the uncovered areas and the desired effect of spraying will not be obtained.
- Insecticide is harmful for food items. Food and water should not be exposed to insecticides.
- Mud plastering should not be done on sprayed walls for at least three months after spray.
- One day prior to the spraying, villagers should be informed using audio announcement or other local means.

Analysis and reporting

Daily summary and reporting of information

At the end of each day, the spray squad should prepare the summary of the day's work. This includes information on the households targeted, households sprayed, insecticide used, insecticide left and the problems encountered. A daily summary of spray operations and daily consumption record of insecticide should be maintained in the prescribed proforma.

The daily report should be sent to the supervisor by all the spray squads for review and feedback by the supervisor in order to take corrective actions, if required. The supervisors should send the consolidated report to the focal point in the district once a week.

Monthly reporting

Reporting the compiled data as per formats provided by NCVBDC needs to be ensured. The vector control forms (VC1 to VC6) and the entomological surveillance forms (EF1 to EF 10) are available on the websites and the same have been provided in the Annexures of this document for reference. In addition, the reporting formats (D1 & D2) for dengue are also annexed, which are common for chikungunya and Zika. These may be referred by the state and zonal entomological teams. IDSP and district-level entomologists should use this format for reporting and analysis.

Annual reporting

Compiled monthly data on vector control and entomological surveillance should be analysed and compared with the previous year for submission to NCVBDC.

18 Suggested Reading

- World Health Organization. Handbook for Integrated Vector Management, 2012, WHO: Geneva.
- World Health Organization. Global Strategic Framework for Integrated Vector, anagement, 2004, World Health Organization: Geneva.
- Directorate of National Vector Borne Disease Control Programme. Strategic Plan for Malaria Control in India- 2012-2017, a Five-year Strategic Plan, 2012, NVBDCP: Delhi.
- Achee NL, et al. A critical assessment of vector control for dengue prevention PLoS Negl Trop Dis, 2015. 9: p. e0003655.
- Esu E, et al. Effectiveness of peridomestic space spraying with insecticide on dengue transmission; systematic review. Trop Med Int Health, 2010. 15: p. 619-31.
- Bonds JAS. Ultra-low-volume space sprays in mosquito control: a critical review. Medical and Veterinary Entomology 2012. 26: p. 121-130.
- Reiter P and Gubler DJ. Surveillance and control of urban dengue vectors, in Dengue and Dengue Haemorrhagic Fever, DJ Gubler & G Kuno, Editor 1997, CABI: New York. p.425-462.
- Perich MJ, et al. Behavior of resting *Aedes aegypti* (Culicidae: Diptera) and its relation to ultra-low volume adulticide efficacy in Panama City, Panama. Journal of Medical Entomology, 2000. 37: p. 541-546.
- Renganathan E, Parks W, Lloyd L. Towards sustaining behavioural impact in dengue prevention and control. Dengue Bulletin 2003. 27: p. 6-12.
- World Health Organization. Core Structure for Training Curricula on Integrated Vector Management, 2012, WHO,: Geneva.
- National Vector Borne Disease Control Programme. Interim Standard Operating Procedure (SOP) for introduction of public health pesticides including biolarvicides in the national vector control programme, 2020, NVBDCP: Delhi.
- National Vector Borne Disease Control Progamme. Revised common protocol for uniform evaluation of public health pesticides including bio-larvicides for use in vector control, 2014, NVBDCP: Delhi.
- World Health Organization. Test procedures for insecticide resistance monitoring in malaria vector mosquitoes, 2013, WHO: Geneva.

- Toé KH, et al. Increased pyrethroid resistance in malaria vectors and decreased bed net effectiveness in Burkina Faso. Emerg Infect Dis [Internet], 2014.
- Bagi J, et al. When a discriminating dose assay is not enough: measuring the intensity of insecticide resistance in malaria vectors. Malaria Journal, 2015.14 : p. e210.
- World Health Organization. Lymphatic filariasis: a handbook of practical entomology for national lymphatic filariasis elimination programmes., 2013, WHO,: Geneva.
- World Health Organization. Dengue - Guidelines for diagnosis, treatment, prevention and control, 2009, WHO: Geneva.
- World Health Organization. Instructions for determining the susceptibility or resistance of adult black flies, sand flies and biting midges to insecticides, 1981, WHO: Geneva. p. 1-6.
- World Health Organization. Insecticide-treated mosquito nets: a WHO position statement, 2007, WHO: Geneva.
- World Health Organization. WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control (September 2013 - revised March 2014), 2014, WHO,: Geneva.
- World Health Organization. Indoor residual spraying: An operational manual for IRS for malaria transmission, control and elimination, 2013, WHO: Geneva.
- World Health Organization. Larval Source Management: a supplementary measure for malaria vector control. An Operational Manual, 2013, WHO,: Geneva.
- Directorate of National Vector Borne Disease Control Programme. Strategic Plan for Malaria Control in India - 2012-2017 - a Five-year Strategic Plan, 2012, NVBDCP: Delhi.
- World Health Organization. Monitoring & Evaluation indicators for Integrated Vector Management, 2012, WHO,: Geneva.
- Directorate of National Vector Borne Disease Control programme (NVBDCP), Dte. GHS, Ministry of Health & FW, Government of India. Operational Manual for Integrated Vector Management in India (2016).
- Directorate of National Vector Borne Disease Control programme (NVBDCP), Dte. GHS, Ministry of Health & FW, Government of India. Compendium on Entomological Surveillance and Vector Control in India-2016.
- Directorate of National Vector Borne Disease Control programme (NVBDCP), Dte. GHS, Ministry of Health & FW, Government of India (2020). Mosquito and other Vector Control Response (MVCR).

19 Annexures

Treatment of Insecticide-Treated Mosquito Nets

Why use Insecticide - Treated Mosquito Nets?

- Malaria and certain other diseases are transmitted by the bite of mosquitoes. Pregnant women, babies and young children are at the greatest risk of dying of malaria.
- Ordinary untreated mosquito nets provide limited physical barrier between mosquito and human; limited protection as they may still bite through the net or get inside the net following improper use.
- Mosquito nets treated with insecticides provide better and effective protection by keeping away mosquitoes as well as killing them. An insecticide-treated mosquito net also kills or keeps away other nuisance insects-cockroaches, bedbugs, houseflies, fleas, etc.

How to treat the net-10 easy steps for mass treatment

- Mass treatment is done at fixed/designated sites.
- Insecticide treatment is recommended for synthetic nets (nylon, polyester), as treatment of cotton nets is not cost-effective, and effect of insecticide is not long lasting.

Step 1: Collect the necessary equipment

- Necessary equipment: mosquito nets, insecticide, basin, measuring container, rubber gloves, soap and plastic rope.
- Make sure the net is washed/cleaned before treatment.
- Nets should be treated outdoors in the shade. If treatment is to be carried out indoors, a room with open windows should be used.
- Use basin

Step 2: Put on protective gloves before treating nets

Step 3: Measure the correct amount of water

The amount of water needed depends on the net material. Regardless of the size and shape of net, the amount of water required for:

- One synthetic net (nylon, polyester)-½ litre (if the net is very large, more water may be needed).
- If measuring container comes with insecticide, use it to measure water. Otherwise, use any measuring container, that is not used for food, drinks and medicines.

The surface of the net is determined by using the following formula:

Surface Area = 2 (a+b) +c

Where

a = length X height

b = width X height

c = length X width

The amount of technical grade of insecticide required for effective does is calculated thus:

Weight (gm) required = Surface area X treatment dose

The volume of solution required is determined by:

$$\text{Volume (ml) required} = \frac{\text{Weight (gms) X 100}}{\text{Strength of solution (\%) of insecticide}}$$

Water quantity: Just sufficient for completely soaking the bed net without causing any dripping

Step 4: Measure the correct amount of insecticide

- The amount of insecticide or "dose" needed to treat a net depends on type of insecticide used. Follow instructions on the container, sachet, packet. Generally, 10-15 ml of insecticide is required to treat one net. [BIS Number of Liquid Synthetic Pyrethroid used for treatment of Bed Nets - i) Deltamethrin-IS14411: 1996; ii) Cyfluthrin-IS14156: 1994].
- Store leftover insecticide in its original container, in the dark and away from children.

Step 5: Mix the water and insecticide thoroughly by gloved hands in basin

Step 6: Treatment of nets

- Always treat one net at a time.
- Put the net in the basin containing water and insecticide.
- Soak the net long enough to ensure that all parts of the nets are impregnated.
- Take out the nets and allow excess liquid to drip back.
- Do not wring the treated net.

Step 7: Drying the nets

- Let the net dry flat in the shade on plastic sheets.
- Later, the net can be hung up to finish drying in the shade.

Step 8: Disposal of leftover mixture of water and insecticide and insecticide containers

- Following treatment of all available nets, leftover mixture of water and insecticide, if any, may be used to treat curtains.
- Otherwise, dispose the liquid in the toilet or a hole away from habitation, animal shelters, drinking water sources, ponds, rivers, streams.
- Destroy empty insecticide containers, sachets, packets and/or bury in a hole away from habitation, animal shelters, drinking water sources, ponds, rivers, streams.

Step 9: Washing and cleaning of hands, equipment

- Wash equipment (basin, measuring container) with lots of water while wearing protective gloves.
- Wash gloves (if non-disposable ones are used) with soap and lots of water, or dispose with insecticide containers.
- Wash hands with soap and lots of water.

Step 10: Washing and re-treatment of nets

- Washing removes insecticide from the net. So, wash the nets as seldom as possible and gently with soap and cold water and dry flat on plastic sheet in shade.
- Do not wash/rinse treated net in or near drinking water sources, ponds, lakes, rivers, streams. Dispose of water for washing/rinsing in the toilet or in a hole away from habitation, animal shelters, drinking water sources, ponds, rivers, streams.
- Nets must be re-treated again after it has been washed three times. Or, at least once a year even if it is not washed, preferably just before the rainy season. Nets may be treated twice a year in areas that have a lot of mosquitoes all year long.

Remember

- Use the insecticide-treated net every night, all year round, even if mosquitoes are not seen/heard.
- Preferably, everyone should sleep under a treated mosquito net. Or, at least pregnant women and children under five years must sleep under treated net.
- Insecticides used for mosquito nets are not harmful to people, if used correctly.
- Direct skin contact with the insecticide on a still wet net may cause a tingling sensation on the skin.
- After treatment, the net may smell of insecticide. This will go away in a few days and is not harmful to people who sleep under the net.

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Reporting formats

- Entomological reporting Forms (EF) 1 to 10
- Vector Control reporting Forms (VC) 1 to 7
- Aedes borne diseases report (DF) 1 and 2

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Species and surfaces code			
List of the code no. of different vectors and insecticides for different proformae for entomological data computerization			
CODE NO.	**MALARIA VECTORS**	**CODE NO.**	**TYPE OF SURFACE**
01	*Anopheles culicifacies*		Mud plastered surface
02	*Anopheles stephensi*		Cemented surface
03	*Anopheles fluviatilis*		Wooden surface
04	*Anopheles philippinensis*		Bamboo surface
05	*Anopheles sundaicus (epiroticus)*		Thatched surface
06	*Anopheles dirus (baimaii)*		Others
07	*Anopheles minimus*		
08	*Anopheles varuna*		
09	*Anopheles annularis*		
	FILARIA VECTORS	**CODE**	**INSECTICIDE**
10	*Culex quinquefasciatus*	DDT	DDT
11	*Mansonioides annulifera*	MLN	Malathion
12	*Mansonioides uniformis*	PIP	Pirimiphos-methyl
	JE VECTORS	DEL	Deltamethrin
01	*Culex vishnui*	CYF	Cyfluthrin
02	*Culex pseudovishnui*	LCO	Lambdacyhalothrin
03	*Culex tritaeniorhynchus*	TEM	Temephos
04	*Culex gelidus*	PRO	Propoxure
05	*Culex fuscocephala*	FTO	Fenitrothion
06	*Culex whitmorei*	ACM	Alphacypermethrin
07	*Culex epidesmus*		
08	*Culex bitaeniorhynchus*		
09	*Anopheles barbirostris group*		
10	*Anopheles hyrcanus group*		
11	*Anopheles subpictus*		
12	*Mansonioides annulifera*		
13	Other species (specify)		
	KALA-AZAR VECTORS		
01	*Phlebotomus argentipes*		
02	*Phlebotomus papatasi*		
03	*Phlebotomus sergenti* (Vector of cutaneous leishmaniasis)		
	VECTORS OF DENGUE, CHIKUNGUNYA & ZIKA		
01	*Aedes aegypti*		
02	*Aedes albopictus*		
03	*Aedes vittatus (non-vector)*		

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Malaria, Filaria and other vector mosquito (adult) density

State: ____________________

1. District Code: | | | | | | |

2. P.H.C. Name and population under spray: __________________

3. Locality: ______________________

4. Date of collection: | D | D | M | M | Y | Y | Y | Y |

5. Time of collection: | H | H | | M | M |

6. Insecticide sprayed: (Code of insecticide*) | | | | |

7. Spray coverage %:

Population	Houses	Rooms	CS

8. Date of spray: | D | D | M | M | Y | Y | Y | Y |

9. Time spent in:

Indoor		Outdoor	

Hours

10. Vectors of malaria

Code	Male	Female	MHD

11. Vector of Filaria

Code	Male	Female	MHD

12. Vectors of malaria

Code	Male	Female	MHD

*N.B.- When in a P.H.C. more than one insecticide is used, Code of other insecticide(s) also to be written with a plus mark

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Density of vectors (adult) of JE and Kala-azar

State:____________________________

1. District Code:

2. P.H.C. Name and population under spray: __________________

3. Locality: ______________________

4. Date of collection:

D	D	M	M	Y	Y	Y	Y

5. Time of collection:

H	H		M	M

6. Insecticide sprayed: (Code of insecticide*)

7. Spray coverage %:

Population	Houses	Rooms	CS

8. Date of spray:

D	D	M	M	Y	Y	Y	Y

9. Time spent in: Hours

Indoor		Outdoor	
H	H	H	H

10. Vectors of JE

Code	Male	Female	MHD

11. Vector of Kala-azar

Code	Male	Female	MHD

EF-4

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Susceptibility test adult mosquito form

State: ____________________

District code: | | | | | | |

P.H.C. Name or Name of locality: ____________________ Date of test: | D | D | M | M | Y | Y | Y | Y |

Exposure period: | | | | | | |

	Species code			Species code			Species code			Species code		
	TT	D	% MORT	TT	D	% MORT	TT	D	% MORT	TT	D	% MORT
O.C. – Control												
D.D.T. 4%												
O.P. – Control												
M.L.N. 5%												
Fenitro 1%												
CB – Control												
Propoxur												
S.P. – Control												
Deltamethrin												
Cyfluthrin												
Lambdacyhalothrin												

Temperature: Maximum: [ ] Minimum: [ ] Relative humidity: [ ]

TT = Total taken, D - Dead, MORT = Mortality

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Susceptibility test (Larval) form

State: ____________________

District code: | | | | | | | | |

P.H.C. Name or Name of locality: ______________________ Date of test: Day | | Month | | Year | | | |

Exposure period: | | | | |

	Species code			Species code			Species code			Species code		
	TT	D	% MORT	TT	D	% MORT	TT	D	% MORT	TT	D	% MORT
OP Control												
Temephos 1.25 mg/L												
Temephos 6.25 mg/L												
Temephos 31.25 mg/L												
Temephos 156.25 mg/L												
Other larvicides												
Deltamethrin												
Cyfluthrin												
Lambdacyhalothrin												

Temperature: Maximum: Minimum: Relative humidity:

TT = Total taken, D - Dead, MORT = Mortality

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Dissection form

State: ____________________

District code: | | | | | | |

P.H.C. Name or Name of locality: ____________________ **Date:** D D M M Y Y Y Y

Abdominal condition: (Give number of mosquitoes) U.F. ____ F ____ S.G. ____ G ____

1. Malaria

Particulars	Number of Dissected			Number of Positive				
Gut								
Gland								
Ovarian Dissection	Number of Dissected			Nulliparous	Parous (P)			
					I	II	III	IV

2. Filariasis

Particulars	Number of Dissected			Number of MF Positive
Number of Positive				
Number of +ve for infection with larval stage	I	II	III	III Only

U.F. Unfed F Full Fed S.G. Semi gravid G Gravid

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Whole night vector biting/ landing collection

State: ____________________

District Code | | | | | | |

PHC Name: ______________________

Date: | D | D | M | M | Y | Y | Y | Y |

Time of Collection: | H | H | M | M |

Number of Human Baits: | | |

Number of Animal Baits: | | |

Weather conditions (Tick mark): Windy [ ] Rain [ ] No Wind [ ] Fog [ ] Cloudy [ ]

Night hours of Collection	Vectors collected per human bait			Vectors collected per human bait			Vectors collected per human bait		
	Vectors Code	Indoor	Outdoor	Vectors Code	Indoor	Outdoor	Vectors Code	Indoor	Outdoor
18-19 Hours									
19-20 Hours									
20-21 Hours									
22-23 Hours									
23-00 Hours									
00-01 Hours									
01-02 Hours									
02-03 Hours									
03-04 Hours									
04-05 Hours									
05-06 Hours									

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Space spray total catch (Pyrethrum spray)

State: ______________________

District Code | | | | | | |　　PHC Name: ________________________

Date | D | D | M | M | Y | Y | Y | Y |　　Time of Collection | H | H | M | M |

Date of last spray | D | D | M | M | Y | Y | Y | Y |　　Code of Insecticide | | | |

1. Place of Collection (Tick Mark)　Human Dwelling ☐　Mixed Dwelling ☐　Cattle Shed ☐

2. Total number of Mosquitoes collected Species wise

Malaria Vectors		Other Anophelines		Culicine		Kala-azar vectors	
Vectors Code	No. Collected	Vectors Code	No. Collected	Vectors Code	No. Collected	Vectors Code	No. Collected

Weather conditions　Windy ☐　Rain ☐　Dry ☐　Cold ☐　Hot ☐

EF-9

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME
(Contact Bio-assay)

State: ____________________

District Code: | | | | | | |

PHC Name: ______________________

Date: D D M M Y Y Y Y

Species code: H H M M

Insecticide sprayed (write code) | | |

Date Sprayed D D M M Y Y Y Y

Exposure period | | | |

Abdominal condition (Female):	Full fed:		Gravid:		Unfed:	
Control:	No. Exposed:		No. Dead:		% Mortality:	
On contact Surface:	No. Exposed:		No. Dead:		% Mortality:	
Temperature:			Relative Humidity:			

EF - 10

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Mosquito larval collection form

State: ___________________________

1. District Code:
2. P.H.C. Name and population under spray: ____________________
3. Locality: ________________________
4. Date of collection:
5. Time of collection:
6. Distance from nearest: house (in metres).
7. No. Checked:

Sl. No.	Breeding Place	Vector Code	No. of +ve
1	Sullage water drains		
2	Cess pits		
3	Cess pools		
4	Septic tanks		
5	O.H.T.		
6	Cisterns (Fresh water)		
7	Barrels		
8	Earthen pitchers/		
9	Containers		
10	Rejected Tyres/Utensils		
11	Ornamental tanks		
12	Wells-unused Fresh water channels		
13	Wells-used		
14	Irrigation canals		
15	Seepage water		
16	Rice fields		
17	Lakes		
18	Pit/low lying water collections		
19	Rainwater collection		

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Primary record of IRS form

(Superior / Field Worker's diary)

Village: ____________ Village Code ____________ Subcenter: ____________ PHC: ____________

Planned Date | D | D | M | M | Y | Y | Date of spray | D | D | M | M | Y | Y | Insecticide: ____________

Code of squad ____________ Name of SFW - Name of FWs: FW -1: ____________ FW2: ____________

FW3: ____________ FW4: ____________ FW5 ____________ FW6 ____________

Summary

	Total number	Partially covered	Completely covered	% Covered
Houses				
Rooms				
Population				

Sprayed houses only

Sl. No.	Head of family	No. of inhabitants	Total rooms	Rooms completely sprayed	Rooms partially sprayed	Rooms refused	Rooms locked	Remarks
1								
2								
3								
4								
5								
6								
7								
Total								

Pumps issued: [ ] Pumps functional: [ ]

Insecticide received: [ ] Insecticide used: [ ] Insecticide balance: [ ]

Name & Signature of SFW: .... Name & Signature of MPHW: ....

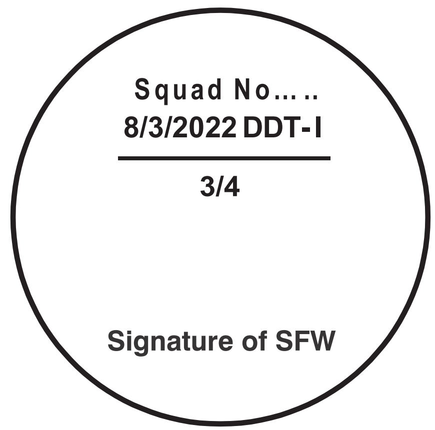
VC -2

NATIONAL VECTOR BORNE DISEASES CONTROL PROGRAMME

Wall stencil form

Squad number : ....
Date : ....
Insecticide : ....
Spray round : ....
Sprayed rooms : ....
Signature of SFW : ....

Example



Date of spray: 8 March 2022
Insecticide: DDT
Round No: 1st round
Number of rooms sprayed in the house: 3
Total number of rooms in the house: 4

VC-3

NATIONAL VECTOR BORNE DISEASES CONTROL PROGRAMME

IRS output report form

ound Number: .... Name of insecticide ....

Name of village/Subcenter/ PHC	Village code	Total population	Planned date for spray	Date(s) of spray done	Squad code	Quantity of insecticide received	Quantity of insecticide used	Balance quantity of insecticide	Total number of houses	Number of houses sprayed	Percentage of houses sprayed	Total number of houses	Rooms completely sprayed	Rooms partially sprayed	Percentage of rooms completely sprayed	Population in sprayed houses	Percentage of population protected
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Subcenter 1																	
Village 1																	
Subcenter 2																	
Village 2																	
Village (N)																	
PHC total																	

Signature of MO - PHC

Date of dispatch/approval: ....

District report only

Spray squads required: ☐ Spray squads present: ☐

Spray pumps required: ☐ Spray pumps available: ☐ Spray pumps certified functional by DVBDCO/CMHO/CDMO: ☐

VC-4

NATIONAL VECTOR BORNE DISEASES CONTROL PROGRAMME

Primary record of bednet delivery and impregnation form

Village:__________ Village Code__________ Subcenter:__________ PHC:__________

Planned Dates of:

Survey | D | D | M | M | Y | Y | Impregnation | D | D | M | M | Y | Y |

Actual Dates of:

Survey | D | D | M | M | Y | Y | Impregnation | D | D | M | M | Y | Y |

Name of Volunteers/ASHA/ AWW 1:__________ 2:__________

Total Number of Houses [ ] Number of Houses having at least two effective bednets [ ]

Sl. No	Name of head of household	Number of persons living in household	Number of LLINs required for total coverage				Number of LLINs within their life span available				Number of Lines distributed				No. of ITNs available	Number of ITNs	Number of ITNs treated (out of column of 16 & 17)	Total number of bed nets within their life span (Columns 11 +15 + 18)
			Size-I	Size-II	Size–III	Total	Size-I	Size-II	Size-III	Total	Size-I	Size-II	Size-III	Total				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Size-I [ ] Size-II [ ] Size-III [ ] Note: LLINs within their lifespan only should

Quantity of synthetic pyrethroids available before impregnation- [ ] Quantity utilized for impregnation [ ]

Volunteers name and signature:__________ Health workers name and signature:__________

VC- 5

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Bednet output report form

Name of PHC/subcentre/village targeted for bed net impregnation	Village code	Total population	Total number of houses	Number of bed nets required for total coverage	Planned date of survey	Actual date of survey	Planned date of distribution	Actual date of distribution	Planned date of impregnation	Actual date of impregnation	Number of ITNs noted in survey	Number of ITNs distributed	Number of ITNs available for use	Number of Size I LLINs in survey	Number of Size II LLINs in survey	Number of Size III LLINs in survey	Number of Size I LLINs distributed	Number of Size II LLINs distributed	Number of Size III LLINs distributed	Number of Size I LLINs available for use	Number of Size II LLINs available for use	Number of Size III LLINs available for use	Number of ITNs + LLINs available for use	Number of households with at least two effective bed nets	% Of Population coverage (% of households with at least 2 effective bed nets)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
PHC																									
SC																									
SC																									

Note: LLINs within their life span should only be counted

VC- 6

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

District annual stock report on insecticides form

Nameofdistrict ....Year ....

Name of PHC	Insecticide	Opening balance as on 1st Jan	Date of expiry of stock in Col 3	Quantity received during the year	Date of expiry of item in Col 5	Total available (Columns 3 + 5)	Quantity used in 1st round	Quantity used in 2nd round	Quantity used in 3rd of Malathion	Total quantity used in all rounds	Quantity life expired	Closing balance as on 31st Dec	Disposal of expired insecticide	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
District total	DDT													
	Pyrethroids													
	Malathion													
District store	DDT													
	Pyrethroids													
	Malathion													
PHC-n	DDT													
	Pyrethroids													
	Malathion													
PHC-2	DDT													
	Pyrethroids													
	Malathion													
PHC-1	DDT													
	Pyrethroids													
	Malathion													

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

District LLIN log form

Name of subcenter/ village	Number of LLINs distributed by year (with sizes)															
	2018				2019				2020				2021			
	I	II	III	Total	I	II	III	Total	I	II	III	Total	I	II	III	Total
Subcenter 1																
Village 1																
Village 2																
Village (N)																
Subcenter 1 total																
Subcenter (N)																
Village 1																
Village (N)																
Subcenter (N) total																
PHC total																

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Proforma for *Aedes* Larval Survey

State:______________Town/Village:____________Locality:______________Week Ending: ----- Month .../ year......

Sl. No.	House No. Name of the owner (No. of occupants)	Water Tanks (All types)		Containers (all types & materials)		Used Tyres (Cycle/ Motor etc.)		Desert Coolers		Rainwater collection sites		Leaking water supply		Garden ponds/ pools/tree holes/ irrigation stagnant water		Discarded Materials (coconut shells /scrapes/ plastics)		Misc. Any others	
		S	FP	S	FP	S	FP	S	FP	S	FP	S	FP	S	FP	S	FP	S	FP

S= Searched, FP = Found Positive

$$\text{House Index} = \frac{\text{No. of Houses +ve for Aedes Larva}}{\text{No. of Houses Searched}} \times 100$$

$$\text{Container Index} = \frac{\text{No. of containers +ve for Aedes Larva}}{\text{No. of Containers Searched}} \times 100$$

$$\text{Pupal Index} = \frac{\text{Number of pupae}}{\text{Number of houses inspected}} \text{X}100$$

$$\text{Breteau Index} = \frac{\text{No. of containers +ve for Aedes Larva}}{\text{No. of Houses Searched}} \times 100$$

Note:

- *Aedes aegypti* eggs cannot easily be detected by the untrained eye. Eggs require a drying period to produce the next generation of larvae. It is, therefore, essential to kill the Aedes eggs by scrubbing to dislodge and destroy eggs while cleaning the water storage facilities/desert coolers etc.
- For BI minimum of 100 houses must be surveyed; if 100 houses are not surveyed, then BI is irrelevant.
- Area specific breeding habitat to be searched/ included.

DF-2

NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME

Proforma for Weekly Action Taken Report of Dengue, Chikungunya and Zika Affected Districts

Name of the State............................ District................. Week Ending----- Month.........../Year...........

Sl. No	Date	Vector Control strategies	Norms of interventions	Baseline information of affected PHCs/Wards	Coverage achieved	Remarks
1		Fogging	Malathion & Cyphenothrin 5% EC (technical grade), thermal fogging on weekly basis	Number of affected wards (with total number of houses)	% Coverage of house dwellings	
2		Indoor space spray	Pyrethrum extract 2% & Cyphenothrin 5% EC space spray in around a positive case at weekly interval	Number of affected houses reporting dengue cases	% Houses covered with space spraying	
3		Source reduction	Destruction/ emptying of containers & scrubbing	House index in affected wards	House index after interventions	
4		Larviciding	Temephos 50% EC, Bio-larvicide and IGR approved under programme	Number of affected wards (with total number of houses)	% Houses covered with larvicide	

21 Glossary

Amastigotes
The morphological form of *Leishmania* and *Trypanosoma* species with a rounded body and without a flagellum occurs predominantly in macrophages (*Leishmania* species) or muscle cells (*T. cruzi*) of a vertebrate host.

Amplifying host
An organism in which a harmful infectious agent (such as a virus or bacterium) may multiply fast and in large quantities e.g. Pig is amplifying the host for JE.

API
The Annual Parasite Incidence (API) is a malariometric index to express malaria cases per thousand population. API refers to high and moderate malaria transmission risk areas.

Anthropogenic factors
Refers to blood-sucking arthropods that prefer to feed on humans rather than other hosts. The degree of anthropophagy can vary geographically within species and between species.

Arbovirus
Arbovirus is an arthropod-borne virus. A virus that multiplies in a blood-sucking arthropod and is principally transmitted by the bite of arthropods to vertebrate hosts e.g. dengue, chikungunya and Zika virus.

Arthropod
Arthropod is an animal with segmented body, an exoskeleton, jointed limbs, a dorsal blood vessel, a haemocoel, and a ventral nerve cord e.g., mosquito, fly etc.

Bacillus thuringiensis
Bacillus thuringiensis (*Bt*) is a rod-shaped, spore-forming, gram-positive bacterium widely distributed in nature. Also known as bio-larvicide or bacterial larvicide, and used to control mosquito larvae.

Definitive host
Host in which parasites reach maturity. This rarely occurs in arthropod vectors, but the noted exception is the development of parasites involving sexual reproduction in a host, e.g. mosquito is a definitive host of malaria transmission.

Ecology
Ecology is an interaction between living organisms, including humans, and their physical environment.

Ecosystem
The ecosystem is made up of the living community of plants and animals in a given area and the non-living components of the environment such as soil, air, and water.

Emulsifiable Concentrate
Emulsifiable concentrates are typically optically transparent oily liquid formulations prepared by dissolving a certain amount of insecticide in organic solvents.

Entomology
Entomology deals with the scientific study of various aspects of insects including their structure, physiology, behaviour etc.

Entomological inoculation rate
Number of infective bites received per person in a given unit of time, in a human population.

Epidemic
Occurrence of diseases cases in excess of the number expected in a given place and time.

Endemic
Applied in VBDs, there is an ongoing, measurable incidence of infection and mosquito-borne transmission over a succession of years.

Epidemiology
The study of the occurrence and distribution of health-related events, states, and processes in specified populations, including the study of the determinants influencing such processes, and the application of this knowledge to control relevant health problems.

Epizootic
Disease events in an animal population are analogous to an epidemic in humans. An epizootic may be restricted to a specific locale (an "outbreak"), general (an "epizootic"), or widespread ("panzootic").

Extrinsic incubation period
The time it takes for an organism to develop in an intermediate host is the extrinsic incubation period. Malaria parasites, e.g., must mature within the mosquito before they can infect humans after being consumed by it.

Gametocytes
The sexual stage of malaria parasite present in the host's red blood cells.

Granules
Granules are agglomerates of powdered materials prepared into larger, free-flowing particles. They typically fall within the range of 850 µm to 4.75 mm size. The shape of granules is generally irregular.

Host
An organism infected with or is fed upon by a parasitic or pathogenic organism (e.g., nematodes, fungi, viruses etc.). It is also described as an animal or plant that nourishes or supports a parasite.

Incubation period
The time interval between invasion by an infectious agent and appearance of the first signs or symptoms of the disease.

Insecticides
Insecticides are toxic substances used to kill insects.

Intermediate host
Ordinarily, a necessary host and one in which only the immature stages occur in the host, e.g., the human body is an intermediate host for the *Plasmodium* parasite.

Indoor Residual Spraying (IRS)
IRS involves coating the walls and other surfaces of a house with a residual insecticide. For several months, the insecticide will kill mosquitoes and other insects that contact these surfaces.

Lymph node
The lymph nodes are organized lymphoid organs that contain lymphocytes within a delicate reticular stroma.

Lymphatic system
The lymphatic system is part of the vascular system and an essential part of the immune system, comprising an extensive network of lymphatic vessels that carry a clear fluid called lymph directionally towards the heart.

Merozoite
Daughter cell resulting from schizogony (merogony).

Metamorphosis
A profound change in form from one stage to the next in the life history of an organism. The mosquito life cycle is an example of complete metamorphosis.

Microfilaria
Microfilaria is a name used to describe the larvae of a parasitic nematode, i.e. filariae when they are still in the larval stage. Adult parasites discharge these parasites into the bloodstream of the host. As a result, these embryonic larvae are commonly discovered in the blood of infected individuals.

Monocytes
Monocytes are a type of white blood cells that fight against pathogens. Monocytes are the most significant type of white blood cells in the immune system. Firstly, they are formed in the bone marrow and released into blood and tissues. When certain germs enter the body, they quickly rush to the site for attack.

Neglected tropical disease
The diverse group of infectious diseases prevail in tropical and subtropical countries, e.g., malaria, chikungunya, dengue, and lymphatic filariasis.

Nocturnal
Some organisms which remain active at night are called nocturnal. e.g., microfilariae of *Wuchereria bancrofti* nocturnally periodic.

Outbreak
Occurrence of more disease cases than expected or sudden upsurge in a given area among a specific group of people over a particular period of time.

Parasite
A parasite is a microorganism that lives on a living host and derives nutrition from the host without any benefit to the host.

Parasitemia
The presence of parasites in the blood.

Passive Surveillance
Regular reporting of disease data by all institutions where patient approached the health facility for diagnosis.

Pathogen
A microorganism capable of producing disease in the host is called a pathogen.

Promastigotes
In the life cycle of some protozoans (family Trypanosomatidae, especially genus *Leishmania*), the motile, elongated, extracellular form is characterized by a single anterior flagellum and no undulating membrane. The amastigotes in the sandfly stomach exit the host cell, change into promastigotes and reproduce extracellularly.

Schizonts
Mature malaria parasite in host liver cells (hepatic schizont) or red blood cells (erythrocytic schizont) undergoing nuclear division by schizogony.

Slide *falciparum* Rate (S*f*R)
Percentage of slides found positive for *P. falciparum* parasite from examined slides.

Slide Positivity Rate (SPR)
The proportion of microscopy slides found positive among the slides examined. The slide positivity rate (SPR) is defined as the number of laboratory-confirmed malaria cases per 100 suspected cases examined. It provides an alternative method for estimating temporal changes in malaria incidence.

Surveillance (in control programmes)
Ongoing, systematic collection, analysis, and interpretation of disease-specific data for use in planning, implementing and evaluating public health practice. Surveillance can be carried out at different levels of the health care system (e.g., health facility-based, community-based), and using different detection systems (e.g., case-based, active, passive), and sampling strategies (e.g., sentinel sites, surveys).

Surveillance (in elimination programmes)
That part of the programme designed for the identification, investigation and elimination of continuing transmission, prevention and cure of infections and final substantiation of claimed elimination.

Sporogony
The sexual stage of a sporozoan parasite's life cycle, during which the zygote develops into one or more haploid spores, each containing a different number of sporozoites.

Sporozoites
Minute, motile, an infective form of certain protozoa which infects the host cells. e.g, *Plasmodium* sporozoites are infective protozoans injected by mosquito.

Temephos
Temephos is a non-systemic organoph-osphorus insecticide, mainly used as a larvicide to control mosquitoes.

Transmission intensity
The frequency with which people living in an area are bitten by anopheline mosquitoes carrying human malaria sporozoites

Transovarial transmission
A vital transmission mechanism among viruses, the transmission of an infectious agent from parent to offspring by infection of the developing egg, which culminates in infectious adult arthropods.

Trophozoites
It is the general term for most protozoa's active, feeding, multiplying stage. In parasitic species, this is the stage usually associated with pathogenesis.

Urbanization
Transition from traditional rural economies to modern industrial ones. It is the gradual concentration of people in urban areas.

Vaccine
Vaccines are biological agents that elicit an immune response to a specific antigen derived from an infectious disease-causing pathogen that enhances immunity against disease and either prevents (prophylactic vaccines) or, in some cases, treats disease (therapeutic vaccines).

Vector
Vector is an arthropod or any living carrier that transports an infectious agent to a susceptible individual e.g., mosquitoes, bed bugs, fleas etc.

Vectorial capacity
It is a measurement of the efficiency of vector(s) of vector-borne disease transmission.

Wettable Powder
A technical grade insecticide that has been diluted with an inert carrier (dust) and to which a wetting agent or surfactant has been added is water dispersible powder. The wettable powder that results is then combined with water and sprayed onto the surface.

Zoonotic disease
A disease that can be transmitted from animals to people or, more specifically, a disease that normally exists in animals but that can infect humans. There are multitudes of zoonotic diseases.

NOTES

NOTES

NOTES

Manual on Integrated Vector Management in India 2022 http://nvbdcp.gov.in

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