



GLOBAL VECTOR CONTROL RESPONSE 2017–2030



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GLOBAL VECTOR CONTROL RESPONSE 2017-2030

Global vector control response 2017–2030

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Contents

Acknowledgements	iv
Foreword	v
Global vector control response 2017–2030	vi
1. Background	1
2. Need for a global vector control response	7
2.1 Beyond integrated vector management	9
2.2 Opportunities	10
2.3 Challenges	11
3. Response development process	14
4. Vision, aim and goals	15
5. Priority activities	17
6. Response framework	19
6.1 Foundation	19
6.2 Pillars of action	24
6.3 Enabling factors	32
7. Cost of implementing the response	35
8. Role of the WHO secretariat	36
9. Proposed progress indicators	38
Annex 1. Global burden of major vector-borne diseases, as of March 2017	42
Annex 2. Examples of major successes achieved through vector control	44
Annex 3. List of relevant global and regional strategies, plans, frameworks and resolutions, as of March 2017	46
Annex 5. Examples of collaboration for implementing vector control beyond the health sector	48
Annex 6. Method for estimating costs for workforce, coordination, vector surveillance and intervention monitoring and evaluation as set out in the response	50

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Foreword



Dr Tedros Adhanom Ghebreyesus
Director-General
World Health Organization

Technology and innovation have provided us with many advances which have improved the health of societies around the world. Yet daunting challenges remain, one of which is the growing burden and threat of vector-borne diseases to human health.

This risk is tied to the changing world we live in. On top of age-old problems, vectors that include mosquitoes, flies and bugs now have new opportunities to transmit infectious diseases. Rapid unplanned urbanization, climate and environmental change, and increased global travel and trade have stimulated the emergence or re-emergence of these diseases. Lack of reliable piped water and poor solid waste management create sites for mosquitoes to breed, which can facilitate explosive outbreaks as occurred with Zika virus disease in 2016 and urban yellow fever in 2015. The vectors are also developing resistance to insecticides and evolving new strains of pathogens.

Diseases such as malaria, dengue, leishmaniasis and lymphatic filariasis thrive in conditions of poverty and often exact their heaviest toll on the poorest. The economic and social burdens of these diseases on individuals, households and economies are tremendous.

One of the leadership priorities for WHO is to improve people's health outcomes and increase healthy life expectancy through prevention addressing social, economic and environmental factors. To do this, we need to elevate and strengthen vector control as a key public health service and integrate across other sectors such as water, sanitation and education. This requires careful evaluation and re-alignment of national programmes along with increased global financing, technical capacity, strengthened monitoring and surveillance systems and better use of interventions. We need new approaches that are sustainable. That means working together through effective partnerships with increased participation of communities and others such as private industry, to develop and apply solutions for vector control.

The Global vector control response utilizes science and innovation to bring positive change that we can measure and, most importantly, see and feel. It sets out the guidance needed to make vector control programmes effective, as well as acceptable and sustainable.

This new strategy was strongly supported by the World Health Assembly that elected me in May 2017. I am committed to supporting this ambitious global effort to save lives and avert suffering.

In the next two years, WHO will support the development and roll out of regional implementation plans as needed, and will support countries in updating and harmonizing their national vector-borne disease strategic plans. This response will require strong political leadership and expanded financing. This is a problem shared by all, so the solutions and support must come from all.

By working together, we can create a world in which no one is afflicted by deadly or debilitating vector-borne diseases. And this can only happen if we act with urgency and determination.





A STRATEGIC APPROACH TO TACKLE VECTOR-BORNE DISEASES

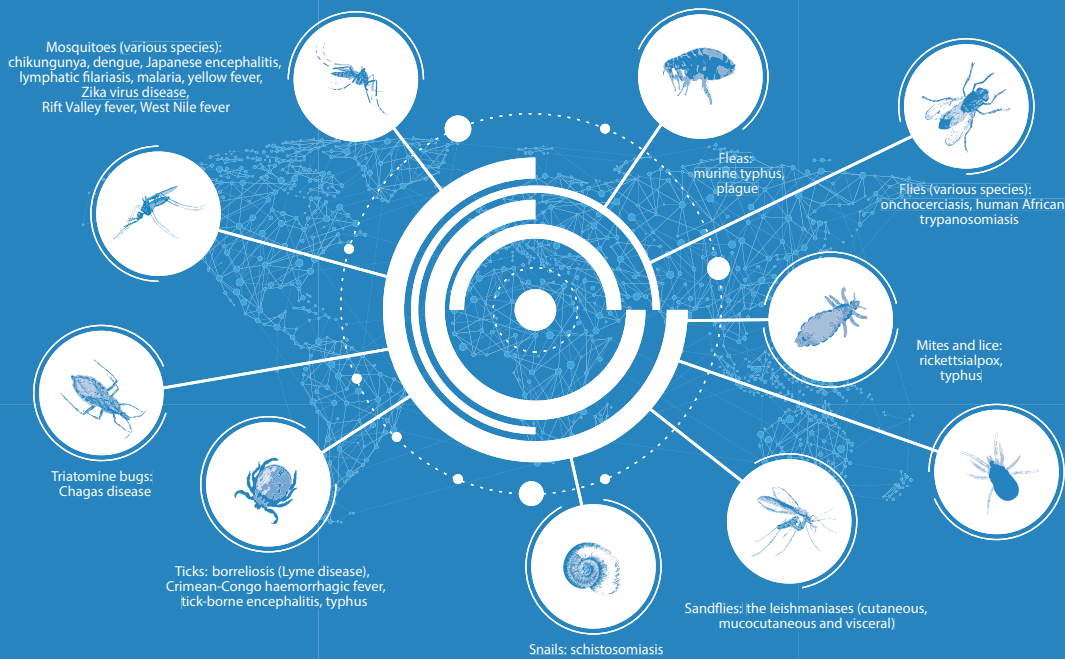
Mosquitoes, flies, bugs and other vectors transmit viruses, parasites and bacteria that infect millions of people globally. They cause many diseases, including malaria, dengue, leishmaniasis, Chagas disease and Zika virus disease.

The World Health Organization (WHO) has developed a new strategy to strengthen vector control worldwide. Member States welcomed this integrated approach at the 2017 World Health Assembly and adopted a resolution to support the strategy.

VECTORS CAN CAUSE NUMEROUS DISEASES IN HUMANS

Rapid unplanned urbanization, changing land use patterns and increased international travel and trade bring humans into more frequent contact with vectors, while climate and other environmental changes fuel their spread worldwide.

In recent years, vector-borne diseases have moved into new territory: many diseases once limited to tropical and subtropical zones are now increasingly seen in temperate areas. Vector-borne diseases cause ongoing disease or outbreaks across all WHO regions.



RISK

80% of the world's population is at risk of one or more vector-borne disease

BURDEN

17% of the global burden of communicable diseases is due to vector-borne diseases

MORTALITY

Over 700 000 deaths are caused by vector-borne diseases annually



GLOBAL VECTOR CONTROL RESPONSE

2017-2030

AT A GLANCE

VISION

A world free of human suffering from vector-borne diseases.

AIM

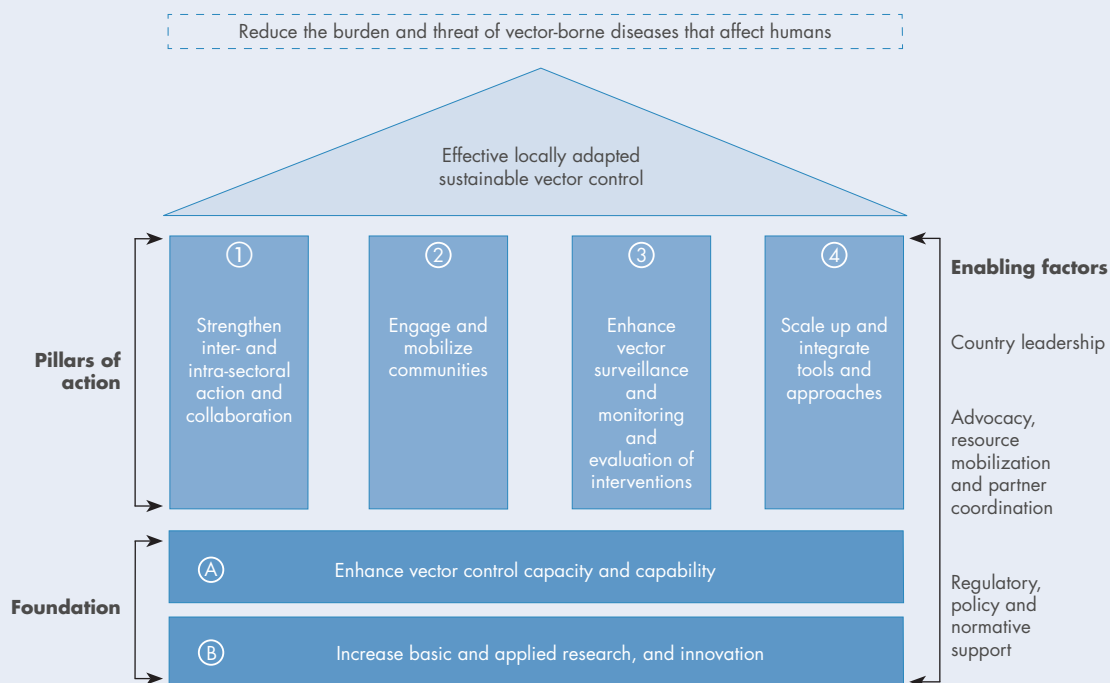
Reduce the burden and threat of vector-borne diseases through effective locally adapted sustainable vector control.

RATIONALE

- Major vector-borne diseases of humans include malaria, dengue, lymphatic filariasis, Chagas disease, onchocerciasis, leishmaniasis, chikungunya, Zika virus disease, yellow fever, Japanese encephalitis and schistosomiasis. Other vector-borne diseases are of local importance in specific areas or populations, such as tick-borne diseases.
- These diseases account for around 17% of the estimated global burden of communicable diseases and disproportionately affect poorer populations. They impede economic development through direct medical costs and indirect costs such as loss of productivity and tourism.
- Social, demographic and environmental factors strongly influence transmission patterns of vector-borne pathogens, with major outbreaks of dengue, malaria, chikungunya, yellow fever and Zika virus disease since 2014.
- Most vector-borne diseases can be prevented by vector control, if it is implemented well. Major reductions in the incidence of malaria, onchocerciasis and Chagas disease have been largely due to strong political and financial commitment.
- For other vector-borne diseases, vector control has not yet been used to its full potential or had maximal impact. This situation can be reversed by realigning programmes to optimize the delivery of interventions that are tailored to the local context.
- This response calls for improved public health entomology (and malacology) capacity and capability, a well-defined national research agenda, better coordination within and between sectors, community involvement in vector control, strengthened monitoring systems and novel interventions with proven effectiveness.

GOALS	MILESTONES		TARGETS
	2020	2025	2030
Reduce mortality due to vector-borne diseases globally relative to 2016	By at least 30%	By at least 50%	By at least 75%
Reduce case incidence due to vector-borne diseases globally relative to 2016	By at least 25%	By at least 40%	By at least 60%
Prevent epidemics of vector-borne diseases*		In all countries without transmission in 2016	In all countries

* Rapid detection and curtailment of outbreaks to prevent spread beyond the country.



PRIORITY ACTIVITIES FOR 2017–2022¹

National and regional vector control strategic plans developed or adapted to align with the global vector control response.

1. National vector control needs assessment conducted or updated and resource mobilization plan developed, including for outbreak response.
2. National entomology and cross-sectoral workforce appraised and enhanced to meet identified requirements for vector control.
3. Relevant staff from health ministries or supporting institutions trained in public health entomology.
4. National and regional institutional networks to support training and/or education in public health entomology and technical support established and functioning.
5. National agenda for basic and applied research on entomology and vector control established and/or progress reviewed.
6. National inter-ministerial task force for multisectoral engagement in vector control established and functioning.
7. National plan for effective community engagement and mobilization in vector control developed.
8. National vector surveillance systems strengthened and integrated with health information systems to guide vector control.
9. National targets for protection of at-risk population with appropriate vector control aligned across vector-borne diseases.

¹ To be revised and updated for the subsequent period of 2023–2030.



1. Background

Vector-borne diseases pose a major threat to the health of societies around the world. They are caused by parasites, viruses and bacteria transmitted to humans by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails and lice.¹ The major global vector-borne diseases of humans include malaria, dengue, lymphatic filariasis, schistosomiasis, chikungunya, onchocerciasis, Chagas disease, leishmaniasis, Zika virus disease, yellow fever and Japanese encephalitis (**Annex 1**). Other vector-borne diseases, such as human African trypanosomiasis, Lyme disease, tick-borne encephalitis and West Nile fever, are of local importance in specific areas or populations.

The major vector-borne diseases together account for around 17% of the estimated global burden of communicable diseases and claim more than 700 000 lives every year. The burden is highest in tropical and subtropical areas. More than 80% of the global population live in areas at risk from at least one major vector-borne disease, with more than half at risk from two or more. The risk of infection for certain viral pathogens is particularly high in towns and cities where *Aedes* and *Culex* mosquitoes proliferate because of favourable habitats and close contact with human beings. Morbidity and mortality rates are often disproportionately high in poorer populations.^{2,3} People who survive these diseases can be left permanently disabled or disfigured, compounding their disadvantage. Vector-borne diseases exact an immense toll on economies and restrict both rural and urban development (**Box 1**).

1. These vectors and other arthropods can also transmit pathogens to animals or to intermediate hosts which may directly or indirectly impact human health (such as by compromising food security).

2. World malaria report 2016. Geneva: World Health Organization; 2016 (<http://www.who.int/malaria/publications/world-malaria-report-2016/>, accessed March 2017).

3. Working to overcome the global impact of neglected tropical diseases: first WHO report on neglected tropical diseases. Geneva: World Health Organization; 2010 (http://www.who.int/neglected_diseases/Third_report_2015/, accessed March 2017).

Box 1. Economic cost of vector-borne diseases

The economic burden of vector-borne diseases to society is significant. For governments in endemic countries, this includes the costs of vector control activities and of case management. For households, this relates to expenditures towards personal protective measures and/or treatment as well as foregone income due to reduced productivity or time off work due to illness or caregiving to sick household members. From a macroeconomic perspective, vector-borne diseases have been associated with lower economic development. Available evidence indicates that:

- Malaria has been found to be associated with slower economic development. From 1965 to 1990, the economies of countries with malaria grew 0.25–1.3% less per capita per year than countries without malaria (1).
- Over a period of 25 years, gross domestic product per capita growth in countries not affected by malaria was more than five times higher than in countries affected by a heavy malaria burden (2).
- In 2015, a total of US\$ 2.9 billion was invested in malaria control and elimination activities. Malaria has also been shown to cost on average nearly US\$ 3 per case to households in direct treatment-seeking expenses (3), far exceeding the international minimum level of income of US\$ 1.90 that is the benchmark for extreme poverty met by 750 million people worldwide (4).
- The global cost of Chagas disease was estimated to be about US\$ 7 billion per year in 2013, including lost productivity (5). Cost of treatment ranges from less than US\$ 200 to more than US\$ 30 000 per person per year in endemic countries, and exceeds US\$ 40 000 in the United States of America (6).
- Human African trypanosomiasis in the Democratic Republic of the Congo costs affected households in a typical rural community more than 40% of their annual household income (6).
- In Bangladesh, India, Nepal and Sudan, 25–75% of households affected by visceral leishmaniasis experience some type of financial catastrophe in obtaining diagnosis and treatment, even when tests and medicines are provided free of charge (7–11).
- The estimated aggregated global cost of dengue illness was US\$ 8.9 billion in 2013 (12).
- The total economic benefit from productivity loss averted is estimated for the period 2011–2020 and 2021–2030 to be respectively in billion US\$, for lymphatic filariasis 10.5 and 13.8, for schistosomiasis 5.5 and 11.9 and for onchocerciasis 1.19 and 2.11 (13).

- (1) Gallup JL, Sachs JD. The economic burden of malaria. The intolerable burden of malaria: a new look at the numbers. *Am J Trop Med Hyg.* 2001; 64(1) Suppl.
- (2) McCarthy FD, Wolf H, Wu Y. Malaria and growth. Washington (DC): World Bank Policy Research Working Group; 2000.
- (3) World malaria report 2016. Geneva: World Health Organization; 2016.
- (4) The World Bank annual report 2016. New York (NY): World Bank; 2016.
- (5) Lee BY, Bacon KM, Bottazzi ME, Hotez PJ. Global economic burden of Chagas disease: a computational simulation model. *Lancet Infect Dis.* 2013; 13:342–8.
- (6) Investing to overcome the global impact of neglected tropical diseases: third report. Geneva: World Health Organization; 2015.
- (7) Anoop SD, Bern C, Varghese B, Chowdhury R, Haque R, Ali M et al. The economic impact of visceral leishmaniasis on households in Bangladesh. *Trop Med Int Health.* 2006; 11:757–64.
- (8) Meheus F, Abuzaid AA, Baltussen R, Younis BM, Balasegaram M, Khalil EA et al. The economic burden of visceral leishmaniasis in Sudan: an assessment of provider and household costs. *Am J Trop Med Hyg.* 2013; 89:1146–53.
- (9) Ozaki M, Islam S, Rahman KM, Rahman A, Luby SP, Bern C. Economic consequences of post-kala-azar dermal leishmaniasis in a rural Bangladeshi community. *Am J Trop Med Hyg.* 2011; 85: 528–34.
- (10) Sundar S. Household cost-of-illness of visceral leishmaniasis in Bihar, India. *Trop Med Intl Health.* 2010; 15(Suppl2):50–4.
- (11) Uranw S, Meheus F, Baltussen R, Rijal Su, Boelaert M. The household costs of visceral leishmaniasis care in south-eastern Nepal. *PLoS Negl Trop Dis.* 2013; 7: e2062.
- (12) Shepard DS, Undurraga EA, Halasa YA, Stanaway JD. The global economic burden of dengue: a systematic analysis. *Lancet Infect Dis.* 2016; 16:935–41.
- (13) Redekop WK, Lenk EJ, Luyendijk M, Fitzpatrick C, Niessen L, Stolk WA et al. The socioeconomic benefit to individuals of achieving the 2020 targets for five preventive chemotherapy neglected tropical diseases. *PLoS Negl Trop Dis.* 2017; 11(1): e0005289.



Impressive gains have been made against malaria, onchocerciasis, lymphatic filariasis and Chagas disease, but the burden of many other vector-borne diseases has increased in recent years.^{1,2} Since 2014, major outbreaks of dengue, malaria, chikungunya and yellow fever have afflicted populations, claimed lives and overwhelmed health systems in many countries. Zika virus infections and their associated complications rapidly spread across the WHO Region of the Americas and beyond in 2016, affecting individuals and families and causing social and economic disruption.³

Social, demographic and environmental factors have altered pathogen transmission patterns, resulting in intensification, geographical spread, re-emergence or extension of transmission seasons. In particular, unplanned urbanization, lack of reliable piped water supply and inadequate solid waste or excreta management can render large populations in towns and cities at risk of viral diseases spread by mosquitoes. Increased global travel and trade, combined with environmental factors such as altered land use patterns (e.g. deforestation) and climate change, may also have an effect. Together, such factors influence the reach of vector populations and the transmission patterns of disease-causing pathogens.

The dynamic and complex nature of vector-borne pathogens complicates predictions of the impact of existing, re-emerging or new diseases on human health. Despite this unpredictability, it is reasonable to expect emergence of some new vector-borne diseases and further intensification of others, particularly those viral diseases transmitted by *Aedes* mosquitoes that are closely associated with urbanization. Also of concern are pathogens that may be transmitted by *Culex* mosquito species and other arthropods. This complexity and unpredictability underscores the critical need for adaptive and sustained approaches to prevent and reduce pathogen transmission to reduce disease burden.

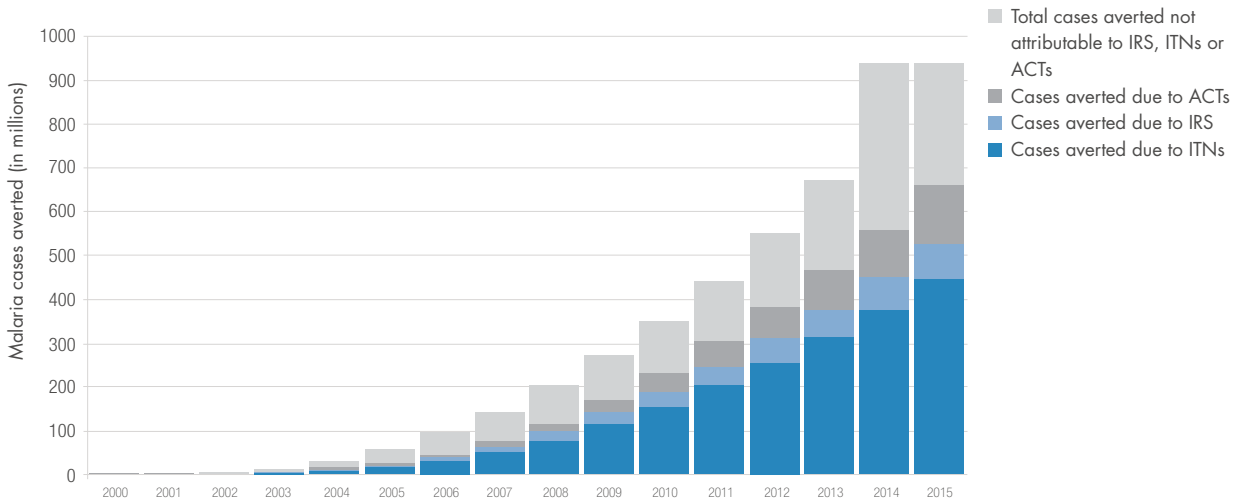
1. World malaria report 2016. Geneva: World Health Organization; 2016 (<http://www.who.int/malaria/publications/world-malaria-report-2016/>, accessed March 2017).

2. A global brief on vector-borne diseases. Geneva: World Health Organization; 2014 (<http://www.who.int/campaigns/world-health-day/2014/global-brief/>, accessed March 2017).

3. Zika virus outbreak global response. Interim report May 2016. Geneva: World Health Organization; 2016 (<http://www.who.int/emergencies/zika-virus/response/>, accessed March 2017).

Targeting the vectors that transmit disease-causing pathogens is an effective preventive approach against most important vector-borne diseases. Interventions that reduce human–vector contact and vector survival can suppress and even halt transmission. History provides clear examples of when rigorous vector control has led to significant reductions in disease burden (Annex 2). Major declines in malaria, onchocerciasis and Chagas disease have been largely due to strong political commitment and substantial investment in vector control. Malaria reduction and elimination was achieved in some areas through intensive spraying with DDT in the 1950s and 1960s and, more recently, through the widespread scaling up of insecticide-treated mosquito nets and indoor residual spraying (Figure 1). Large-scale use of larvicides aimed at reducing vector populations of human onchocerciasis along with community-directed treatment with ivermectin have contributed to substantial reductions in disease. For Chagas disease, elimination of domestic vectors by indoor residual spraying and housing improvements together with enhanced blood screening of donors and supportive treatment for those infected have been impactful in southern countries of South America. Vector control was applied effectively against dengue and yellow fever in the Americas (1950s–1960s), and was effective against dengue for decades in Singapore (during the 1970s and 1980s) and Cuba (during the 1980s and 1990s).

Figure 1. Predicted cumulative number of malaria cases averted by interventions in sub-Saharan Africa, 2000–2015¹



ACT, artemisinin-based combination therapy; IRS, indoor residual spraying; ITN, insecticide-treated mosquito net

1. Adapted from: Cibulskis RE, Alonso P, Aponte J, Aregawi M, Barrette A, Bergeron L et al. Malaria: global progress 2000–2015 and future challenges. *Infect Dis Poverty*. 2016; 5:61. doi:10.1186/s40249-016-0151-8.



Vector control interventions have one of the highest returns on investment in public health.¹ Effective vector control programmes that reduce disease can advance human and economic development. Aside from direct health benefits, reductions in vector-borne diseases will enable greater productivity and growth, reduce household poverty, increase equity and women's empowerment, and strengthen health systems (**Box 2**). Optimal impact from strengthened vector control is predicated on high-quality implementation, requiring appropriate deployment, coverage, uptake and use. The impact of vector control on the environment and on biodiversity is an important consideration because many vector-borne diseases are part of complex ecological systems and unintended impacts on non-target organisms should be avoided.

Many countries continue to experience an ongoing high burden or risk of vector-borne diseases because of inadequate delivery of vector control interventions, resulting from limited investments. There are numerous examples of where upsurges have resulted from weakening of control programmes, particularly for malaria and dengue. The lack of sustainable and targeted financing has been underpinned by many factors, such as poor coordination within and between sectors, weak or non-existent monitoring and evaluation systems, and limited sustainable and proven interventions for certain vectors and situations. In addition, most countries suffer from a dire lack of public health entomology and malacology capacity.^{2,3,4} The result is that the full impact of vector control has not yet been achieved, even though this is often the best-proven or the only available preventive measure against most vector-borne diseases.

1. Investing to overcome the global impact of neglected tropical diseases. Geneva: World Health Organization; 2015 (http://www.who.int/neglected_diseases/9789241564861/, accessed March 2017).

2. A public health entomologist or malacologist is a professional with at least basic vector and ecological knowledge and skills, who is also a public health practitioner skilled in epidemiology and programme management. For the purpose of this document only, the term 'entomologist' will be extended to include those professionals engaged in malacology. Similarly, the term 'entomology' will be extended to include the field of 'malacology'.

3. Mnzava AP, Macdonald MB, Knox TB, Temu EA, Shiff CJ. Malaria vector control at a crossroads: public health entomology and the drive to elimination. *Trans R Soc Trop Med Hyg.* 2014; 108:550–4. doi:10.1093/trstmh/tru101.

4. Rollinson D, Knopp S, Levitz S, Stothard JR, Tchuem Tchuenté IA, Garba A et al. Time to set the agenda for schistosomiasis elimination. *Acta Trop.* 2013;128(2):423-40. doi: 10.1016/j.actatropica.2012.04.013.

Box 2. Economic benefits of vector control

Increased coverage of insecticide-treated nets in Africa has been reported as the most important driver of the decline in malaria prevalence between 2000 and 2015, accounting for an estimated 68% of the 663 million clinical cases averted since 2000 (1). The overall reduction in malaria case incidence was estimated to have saved a total of US\$ 900 million in malaria case management costs to governments sub-Saharan Africa; nets alone were estimated to have contributed to a total gross saving of US\$ 610 million (2). The decline in malaria mortality risk between 2000 and 2015 contributed to increase life expectancy at birth by 1.2 years, or 12% of the total gain of 9.4 years over that same period (3). The economic value of reduced mortality risk between 2000 and 2015 is estimated at US\$ 1810 billion in sub-Saharan Africa and at US\$ 2040 billion globally. It is anticipated that achieving the goals in WHO's Global Technical Strategy for Malaria 2016–2030, which relies heavily on effective vector control, would save 10 million lives and generate more than US\$ 4 trillion of additional economic output with a global return on investment of 40:1 and for sub-Saharan Africa of 60:1 (4). Insecticide-treated nets and indoor residual spraying against malaria are affordable and highly cost-effective, with estimates of US\$ 2.20 and US\$ 6.70 per person protected per year, respectively (5). In Zambia, vector control via environmental management, screening of housing and DDT spraying accompanied by weekly entomological and epidemiological surveillance led to a 89% reduction in mortality, with a cost per death averted of US\$ 858 and a cost per symptomatic case averted of US\$ 22.10 (6). The cost-effectiveness of vector control against Chagas disease in the Argentinean Chaco region was estimated to range between US\$ 45 and US\$ 132 per human case averted depending on the strategy chosen (7). For dengue, initial estimates put the cost per DALY averted by vector control at US\$ 1992–US\$ 3139 (8). Results from new studies indicate lower cost-effectiveness ratios, ranging from a 2012 cost equivalent of US\$ 334 per DALY averted by larval control in Cambodia to US\$ 779–US\$ 1604 per DALY averted by adult mosquito control in Brazil (9–10). Environmental change, including urbanization and climate change, strengthen the investment case for sustained vector control. It is cost-effective and should be part of a sustainable strategy to address challenges listed above.

- (1) Bhatt S, Weiss DJ, Cameron E, Bisanzio D, Mappin B, Dalrymple U et al. The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. *Nature*. 2015; 526:207–11.
- (2) World malaria report 2015. Geneva: World Health Organization; 2015.
- (3) World malaria report 2016. Geneva: World Health Organization; 2016.
- (4) Roll Back Malaria Partnership. Action and investment to defeat malaria 2016–2030. Geneva: World Health Organization; 2015.
- (5) White MT, Conteh L, Cibulskis R, Ghani AC. Costs and cost-effectiveness of malaria control interventions – a systematic review. *Mal J*. 2011; 10:337.
- (6) Utzinger J, Tozan Y, Singer BH. Efficacy and cost-effectiveness of environmental management for malaria control. *Trop Med Int Health*. 2002; 6:677–87.
- (7) Vazquez-Prokopec GM, Spillmann C, Zaidenberg M, Kitron U, Gürtler RE. Cost-effectiveness of Chagas disease vector control strategies in northwestern Argentina. *PLoS Negl Trop Dis*. 2009; 3: e363.
- (8) Cattand P, Desjeux M, Guzmán MG, Jannin J, Kroeger A, Medici A et al. Tropical diseases lacking adequate control measures: dengue, leishmaniasis, and African trypanosomiasis. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB et al (editors). *Disease control priorities in developing countries*, 2nd edition. Washington (DC): World Bank and Oxford University Press; 2006.
- (9) Suaya JA, Shepard DS, Chang MS, Caram M, Hoyer S, Socheat D et al. Cost-effectiveness of annual targeted larviciding campaigns in Cambodia against the dengue vector *Aedes aegypti*. *Trop Med Int Health*. 2007; 12:1026–36.
- (10) Luz PM, Vanni R, Medlock J, Paltiel AD, Galvani AP. Dengue vector control strategies in an urban setting: an economic modelling assessment. *Lancet*. 2011; 377:1673–80. Roll Back Malaria (2015). Action and investment to defeat malaria 2016-2030. Geneva: World Health Organization.



2. Need for a global vector control response

Never has the need for a comprehensive approach to vector control to counter the impact of vector-borne diseases been more urgent. The unprecedented global spread of dengue and chikungunya viruses and outbreaks of Zika virus disease and yellow fever in 2015–2016 clearly highlight the challenges faced by Member States. 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 resistant to insecticides and evolving strains of pathogens. Rapid, unplanned urbanization in tropical and sub-tropical areas renders large populations at risk of emergence and expansion of arboviral diseases spread by mosquitoes.

Many countries are still unprepared to address these looming challenges. The strong influence of social and environmental factors on vector-borne pathogen transmission underscores the critical importance of flexible vector control delivery and monitoring and evaluation systems that support locally tailored approaches. Re-alignment of national programmes to optimize implementation of interventions against multiple vectors and diseases will maximize the impact of available resources (**Figure 2**). Health systems must be prepared to detect and respond quickly and effectively to changes. This response requires not only the availability of effective, evidence-based control interventions, but also well-trained government staff who can build sustainable systems for their delivery. To achieve these goals, reforms to vector control programmatic structures are urgently needed.

Vector-borne diseases are everyone's problem, not just the health sector. Achievement of Sustainable Development Goal 3 to ensure good health and well-being will rely on effective vector control, as will initiatives for clean water and sanitation (Goal 6), sustainable cities and communities (Goal 11) and climate action (Goal 13), among others. Multiple approaches that are implemented by different sectors will be required for control and elimination of vector borne disease, such as those promoting healthy environments.¹ Engaging local authorities and communities as part of broad-based

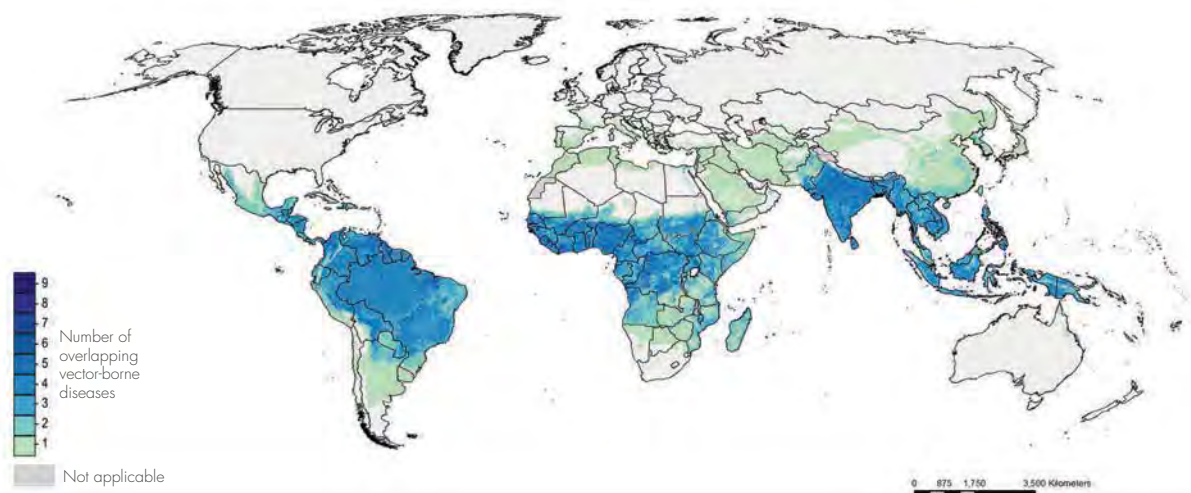
1. Pruss-Ustun A, Wolf J, Corvalan C, Bos R, Neira M. Preventing disease through health environments: a global assessment of the burden of disease from environmental risks. Geneva: World Health Organization; 2016.

intersectoral collaboration will be key to improved vector control delivery, through tailoring of interventions to specific scenarios as informed by local entomological and epidemiological data. Building sustainable control programmes that are resilient in the face of technical, operational and financial challenges will require the engagement and collaboration of local communities.

Recent advances to modernize and develop new vector control and surveillance tools mean that there has never been a better time to reinvigorate vector control. To be effective, strong political commitment and long-term investment are needed. This response seeks neither to replace or override existing disease-specific strategies (Annex 3) nor to shift the focus from other essential interventions, such as vaccines against yellow fever, Japanese encephalitis and tick-borne encephalitis; mass administration of medicines against lymphatic filariasis and human onchocerciasis; and artemisinin-based combination therapies against malaria. Rather, it aims to add to these efforts and help countries mount coherent and coordinated efforts to address the increasing burden and threat of vector-borne diseases.

This response provides strategic guidance to countries and development partners for urgent strengthening of vector control as a fundamental approach to preventing disease and responding to outbreaks. To achieve this requires re-alignment of vector control programmes, supported by increased technical capacity, strengthened monitoring and surveillance systems, and improved infrastructure. Ultimately, this will support implementation of a comprehensive approach to vector control that will enable the achievement of disease-specific national and global goals and contribute towards achievement of the Sustainable Development Goals.

Figure 2. Overlapping global distribution of nine major vector-borne diseases for which integration of vector control programmes may be beneficial, 2016. Reflects all locations where the population is at risk of at least one of the following: malaria, lymphatic filariasis, dengue, leishmaniasis, Japanese encephalitis, yellow fever, Chagas disease, human African trypanosomiasis or onchocerciasis.¹



Colours indicate the number of vector-borne diseases that pose a risk at each 5 × 5 km grid cell

1. C. Moyes, University of Oxford, personal communication (2017). Developed based on the data and methods outlined in Golding N, Wilson AL, Moyes CL, Cano J, Pigott DM, Velayudhan R et al. Integrating vector control across diseases. *BMC Med.* 2015; 13:249. doi:10.1186/s12916-015-0491-4.



2.1 Beyond integrated vector management

Integrated vector management is a rational decision-making process for the optimal use of resources for vector control, as presented in a WHO global strategic framework released in 2004, a WHO position statement issued in 2008, and other supporting documents.^{1,2,3} While this approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control, uptake has been poor, due to insufficient political buy-in for reorientation of programmes to support a harmonized approach to vector control across diseases. This has been largely due to limited human capacity to advocate, plan and implement, as well as fragmented global and national architecture to support a multi-disease approach.

Given the recent alarming increase in numerous vector-borne diseases and the serious threat posed to economic development, this response aims to reposition vector control as a key approach to prevent and eliminate vector-borne diseases. It builds on the basic concept of integrated vector management with renewed focus on improved human capacity at national and subnational levels. There is an emphasis on strengthening infrastructure and systems (e.g. sustainable development, access to potable water, adequate solid waste and excreta management), particularly for areas vulnerable to vector-borne disease upsurges. For sustainable impact in vector control, increased intersectoral and interdisciplinary action is needed, linking efforts in environmental management, health education, and reorienting relevant governments programmes around proactive strategies to control new and emerging threats. Critical attention is given to current opportunities available for leverage, as well as challenges that need to be addressed in order to enable effective and sustainable vector control adapted to local contexts.

1. Global strategic framework for integrated vector management. Geneva: World Health Organization; 2004 (http://www.who.int/malaria/publications/atoz/who_cds_cpe_pvc_2004_10/, accessed March 2017).

2. WHO position statement on integrated vector management. Geneva: World Health Organization; 2008 (http://www.who.int/malaria/publications/atoz/who_him_ntd_vem_2008_2/, accessed March 2017).

3. A toolkit for integrated vector management in sub-Saharan Africa. Geneva: World Health Organization; 2016. (http://www.who.int/neglected_diseases/resources/9789241549653/, accessed March 2017).

2.2 Opportunities

Many opportunities exist to enhance the impact of vector control.

1. **Development.** Environmentally sustainable and resilient development in urban centres^{1,2} that reduces poverty and improves living standards will reduce transmission of vector-borne pathogens. Achievement of Sustainable Development Goal 3 to ensure good health and well-being will rely on effective vector control along with contributions from initiatives that span numerous Sustainable Development Goals (**Figure 3; Annex 4**).
2. **Recognition.** Existing global and regional strategies against vector-borne diseases demonstrate their importance in the global health agenda and in other sectors, and represent high-level commitment for their reduction, elimination and, for some, eradication (**Annex 3**).
3. **Expansion.** Recent successes in vector control, such as against vectors of malaria, onchocerciasis and lymphatic filariasis, have led to major reductions in vector-borne diseases. Further impacts could be achieved through sustaining and expanding use of proven vector control interventions. There is the opportunity in some countries to build on broad experience, trained staff and past successes to tackle emerging threats.
4. **Optimization.** Re-aligning national programmes to optimize implementation of vector control against multiple vectors and diseases, across geographical areas and human populations, will leverage available resources to maximum impact (**Figure 2**).
5. **Collaboration.** Building on existing collaborations across ministries, sectors, partners and networks to share data and expertise will improve timely access to information and resources for the most effective vector-borne disease control (**Annex 5**).
6. **Adaptation.** The strong influence of social, demographic and environmental factors on vector-borne pathogen transmission underscores the critical importance of flexible vector control delivery, monitoring, and evaluation systems that support locally-tailored approaches that can be adapted to specific opportunities or challenges. Municipality and local administrative structures should also be adapted to enhance community engagement and mobilization in vector control. Health education can be adapted for communities to better understand diseases, transmission mechanisms and ways of avoiding exposure.
7. **Innovation.** Development of novel tools, technologies and approaches such as new insecticides or molluscicides and formulations, vector traps and baits, biocontrol through use of *Wolbachia* spp., genetic modification for population reduction or replacement, other forms of vector sterilization, larviciding via auto-dissemination, endectocides, spatial repellents and vapour active insecticides, and housing improvements to exclude vectors and reduce favourable harbourages have the potential to further reduce disease burden.
8. **Technology.** Advances that support evidence-based vector control such as information communication technologies that support real-time data capture or social media, or risk stratification and predictive geo-informatics tools such as geographical information systems, remote sensing, and climatic models can be leveraged to further optimize planning and implementation.

1. United Nations, Habitat III: new urban agenda [Final draft: 10 September 2016] (http://citiscopes.org/sites/default/files/h3/Habitat_III_New_Urban_Agenda_10_September_2016.pdf; accessed March 2017).

2. United smart cities: smart urban solutions for transition and developing countries 2014-2015. United Nations Economic Commission for Europe. (https://www.unece.org/fileadmin/DAM/hlm/projects/SMART_CITIES/United_Smart_Cities_Project_Document.pdf; accessed March 2017).



2.3 Challenges

Multiple interconnected challenges impede progress against vector-borne diseases. Threats to effective and impactful vector control can be grouped as systemic, structural, informational, environmental, human movement, political and financial, and ethical.

1. **Systemic.** Capacity for vector surveillance and control is insufficient in most countries at risk from vector-borne diseases. With a few notable exceptions, vector-borne disease prevention programmes at national and subnational levels have limited public health entomology capacity and poor infrastructure. This restricts the ability to perform basic functions beyond vector control implementation, such as surveillance, monitoring and evaluation. Career structures for technical specialists and technicians within the health system are absent or weak. Attrition of trained individuals is a major issue, whether due to retirement, reallocation to other health areas or to the agricultural sector, or exiting to work in the private sector either at home or abroad. This leads to a lack of continuity and consistency, and restricts opportunities for high-level and informed engagement with professionals from other sectors, such as sanitary engineering and urban planning.
2. **Structural.** Many countries that are endemic for more than one major vector-borne disease have disease-specific programmes and strategies that do not optimally leverage synergies and sometimes compete for resources. Well-funded programmes – such as for malaria in some countries of sub-Saharan Africa – are often expected to respond to outbreaks of other vector-borne diseases without adequate capacity

Figure 3. Effective vector control key linkages with key Sustainable Development Goals



and resources at the expense of routine, core activities. A central vector control unit may be lacking or may operate in relative isolation. While capacity may be present in external institutions such as research institutes contracted to conduct surveillance or research, linkages are often weak, which impedes data sharing for decision-making. Data are often aggregated and managed at a level that is not informative for locally-adaptive vector control. Non-technical issues can be key challenges in implementation, such as security and stability in endemic countries or consistent access to banking, power and utilities.

3. **Informational.** The evidence base to support effective vector control is limited for most vector-borne diseases due to lack of research support. Vector surveillance remains weak in many countries despite insecticide resistance and changes in vector behaviour threatening the efficacy of current interventions. Basic and applied research is limited in many settings, restricting the availability of such evidence to inform environmentally sound and effective deployment, combination, and scale up of interventions – especially for new tools, technologies and approaches. Entomological, epidemiological and intervention data are often managed separately without linkage, resulting in insufficient information on the impact of vector control interventions on entomological parameters and pathogen transmission.
4. **Environmental.** Changes in vector habitats such as those due to rapid urbanization or alterations in land use, water management and farming practices are often unpredictable, uncontrollable and complex. Climatic changes that extend the distribution of vectors to more temperate climes are also of concern. With two thirds of the global population expected to live in urban settings by 2050,¹ large populations in tropical and subtropical zones will be at particular risk of *Aedes*-borne diseases. The impact of vector control on the natural environment and biodiversity should also be considered, to prevent damage that may worsen the health and livelihood of the very populations it seeks to protect.
5. **Movement of humans and goods.** Increased global human population movement due to normal travel patterns, migration for employment or displacement resulting from humanitarian crises as well as increased global trade are likely to accelerate the introduction of invasive species or exotic pathogens into receptive areas and expose non-immune populations to new infections and disease. These factors further complicate the delivery of effective vector control and can undermine access to early diagnosis and treatment.
6. **Political and financial.** Substantial financial support has been provided for the scale up of insecticide-treated nets and indoor residual spraying against malaria vectors since 2000. However, there has been limited focus on other vector control interventions and other vector-borne diseases, especially in the absence of either large epidemics or high mortality rates. Investments in vector surveillance have remained minimal in general, and vector control monitoring and evaluation is often limited. Funds committed to the development of medicines, diagnostic tools and vaccines far exceed those for vector control. Expansion of domestic and global funding is urgently required to combat other diseases, especially those that are *Aedes*-borne, whilst maintaining investments in malaria prevention.

1. World urbanization prospects. New York (NY): United Nations; 2014 (<https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf>, accessed March 2017).



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7. **Ethical.** Vector control methods and their implementation, including novel interventions, raise several ethical challenges and concerns. Countries require support to identify and address ethical issues and to put in place relevant ethics advisory bodies particularly as vector control measures are scaled up and as new interventions become available for use. A WHO expert group has been formed to identify key issues and to begin to define the necessary support required by countries in this regard.

3. Response development process

The Secretariat began in June 2016 a fast-track global consultative process on a global vector control response with Member States and stakeholders, including organizations of the United Nations system, scientific and research groups, nongovernmental organizations and implementation partners. The process for developing the response was launched by three departments in the Secretariat: the WHO Global Malaria Programme (GMP), the WHO Department of Control of Neglected Tropical Diseases (NTD), and the Special Programme for Research and Training in Tropical Diseases (TDR). The process was supported by a dedicated steering committee consisting of leading vector-borne disease experts and other scientists as well as other stakeholders. Also consulted for input were WHO regional and country offices and the GMP Malaria Policy Advisory Committee, the NTD Strategic and Technical Advisory Group and the TDR Scientific and Technical Advisory Committee. Following these consultations, a revised draft was presented for feedback in various national and regional consultations between October 2016 and February 2017 and was used in an online consultation with Member States and other stakeholders in November 2016. The online consultation elicited feedback from 80 institutions or individuals that spanned all constituencies and WHO regions. This final version was considered by the Seventieth World Health Assembly in May 2017. The Health Assembly adopted resolution WHA.70.16, in which it welcomed the strategic approach for integrated global vector control and response.¹

1. Resolution WHA70.16. Global vector control response: an integrated approach for the control of vector-borne diseases (World Health Assembly, 2017).



4. Vision, aim and goals

The vision of WHO and the broader infectious diseases community is a world free of human suffering from vector-borne diseases. The ultimate aim of the current response is to reduce the burden and threat of vector-borne diseases through effective locally adapted sustainable vector control.

As part of this vision, the response sets ambitious yet feasible global targets aligned with the disease-specific strategic goals and Sustainable Development Goal 3.3,¹ with interim milestones to track progress (Table 1).

1. By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

Table 1. Goals, milestones and targets for the *Global vector control response, 2017–2030*

Goals	Milestones		Targets
	2020	2025	2030
Reduce mortality due to vector-borne diseases globally relative to 2016	By at least 30%	By at least 50%	By at least 75%
Reduce case incidence due to vector-borne diseases globally relative to 2016	By at least 25%	By at least 40%	By at least 60%
Prevent epidemics of vector-borne diseases*		In all countries without transmission in 2016	In all countries

* Rapid detection and curtailment of outbreaks to prevent spread beyond the country.

These goals apply to all major vector-borne diseases of humans.¹ Milestones and targets were formulated on the basis of relevant WHO global and regional strategies, plans, frameworks and resolutions on vector-borne diseases (**Annex 3**). It is anticipated that countries will set their own national or subnational targets, which may differ from global targets. Individual regional targets may also be set.

1. Currently defined as: malaria, dengue, lymphatic filariasis, Chagas disease, onchocerciasis, leishmaniasis, chikungunya, Zika virus disease, yellow fever, Japanese encephalitis and schistosomiasis.



5. Priority activities

To achieve the global targets, priority activities are set out with implementation targets for 2018, 2020 and the interim period of 2022 (**Table 2**). These have been developed after reviewing (1) available vector control needs assessments and (2) additional supporting documents¹, and after consulting with (3) WHO regional and country offices, (4) national vector-borne disease control programmes, and (5) partners including bilateral and multilateral donors and other organizations in the United Nations system. These are not all encompassing, and it is anticipated that additional activities will be required depending on the local context. It is envisioned that these priority activities and targets will be revised for the subsequent global response period of 2023–2030.

1. Comprehensive information was available for 22 countries with supplementary information available for 43 additional countries. This indicated that most countries endemic for multiple vector-borne diseases had single disease programmes (e.g. malaria or dengue), although there was evidence in some countries of collaboration between programmes. While vector control was a component of most vector-borne disease strategies, vector control was not being applied against all endemic diseases. It was apparent that synergies through the use of shared human capacity, infrastructure and vector control interventions were not being fully exploited.

Table 2. Priority national and regional activities and associated targets for 2017–2022^a for implementation of the global vector control response

Priority activities			2018		2020		2022	
			Countries	WHO regions	Countries	WHO regions	Countries	WHO regions
National and regional vector control strategic plans ^b developed/adapted to align with global vector control response			≥ 25%	≥ 2	≥ 50%	≥ 4	100%	All 6
FOUNDATION	A	National vector control needs assessment conducted or updated and resource mobilization plan developed (including for outbreak response)	≥ 25%		≥ 50%		≥ 75%	
	A	National entomology and cross-sectoral workforce appraised and enhanced to meet identified requirements for vector control	≥ 10%		≥ 25%		≥ 60%	
	A	Relevant staff from Ministries of Health and/or their supporting institutions trained in public health entomology	≥ 10%		≥ 25%		≥ 60%	
	A	National and regional institutional networks to support training/education in public health entomology and technical support established and functioning	≥ 25%	≥ 2	≥ 50%	≥ 4	≥ 75%	All 6
	B	National agenda for basic and applied research on entomology and vector control established and/or progress reviewed	≥ 25%		≥ 50%		≥ 75%	
PILLARS	1	National inter-ministerial task force for multi-sectoral engagement in vector control established and functioning ^c	≥ 50%		≥ 75%		≥ 90%	
	2	National plan for effective community engagement and mobilization in vector control developed	≥ 25%		≥ 50%		≥ 75%	
	3	National vector surveillance systems strengthened and integrated with health information systems to guide vector control	≥ 25%		≥ 50%		≥ 75%	
	4	National targets for protection of at-risk population with appropriate vector control ^d aligned across vector-borne diseases	≥ 25%		≥ 50%		≥ 75%	22

a. To be revised and updated for 2023–2030; b. or integrated vector management strategic plans, if available; c. as required dependent on national context; d in accordance with environmental impact assessment/s.

Note: Progress indicators for each priority activity are defined in **Table 3**.



6. Response framework

6.1 Foundation

Effective and locally-adaptive vector control systems depend on two foundational elements: (1) enhanced human, infrastructural and health system capacity within all locally relevant sectors for vector surveillance and vector control delivery, monitoring and evaluation; and (2) increased basic and applied research to underpin optimized vector control, and innovation for development of new tools, technologies and approaches. Both elements are required to ensure maximum impact of sustainable vector control by using an evidence-based approach to planning and implementation.

6.1.1 Enhance vector control capacity and capability

Effective and sustainable vector control is achievable only with sufficient human resources, an enabling infrastructure and a functional health system. A vector control needs-assessment will help to appraise current capacity, define the requisite capacity to conduct proposed activities, identify opportunities for improved vector control delivery efficiency, and guide resource mobilization to implement the national strategic plan. These should take into account ongoing, routine vector control as well as activities defined for specific circumstances, such as response to outbreaks, epidemics or humanitarian crises.

Formulating an inventory of the human, infrastructural, institutional and financial resources available and making an appraisal of existing organizational structures for vector control are essential first steps. The inventory should cover all resources available at national and subnational levels including districts. The internal programme inventory should be supplemented with a broader appraisal of additional relevant resources available outside of the vector-borne disease programme, including in municipal governments, non-health ministries, research institutions and implementing partners. Assessment processes are already established in many countries and specific disease needs assessments may already be available.

Since it is important to provide a career structure to attract and maintain capable staff at all technical levels of the vector control programme, an evaluation of career structures within national and subnational programmes must also be undertaken. The policy and institutional framework within which decisions on vector control are made should also be appraised, including institutional arrangements that support vector control planning and delivery, the management procedures leading to vector control operations, and the resource base which supports these operations. An analysis of the partnership landscape is also needed to identify all resources available to support vector control in the country.

Capacity requirements should then be carefully and comprehensively defined, in accordance with established national strategic plans and aligned with recommendations in this response. Programmes should include staff with knowledge and experience in multiple disciplines beyond the core technical fields of vector control, surveillance, and intervention monitoring and evaluation. Programme or project management expertise as well as experience in insecticide resistance (and pesticide) management will be highly beneficial. A sound understanding of the epidemiology of vector-borne diseases is essential. Database development and management experience is needed to ensure linkage of entomological, epidemiological and intervention data into a comprehensive monitoring and evaluation platform that ideally incorporates geo-referencing. Skills in information and communication technologies as well as behavioural change communication and community and local authority engagement are also required.

Infrastructural capacity essential to support the activities of the programme should be identified, including technical and operational facilities as well as facilities for research and training. At a minimum, technical staff should have access to a functional insectary and entomological laboratory to support assessments of vector species, insecticide susceptibility and intervention efficacy. A malacology laboratory for snail identification and infection testing should be available in schistosomiasis-endemic countries.

Key gaps should then be identified in reference to the established inventory and the capacity requirements identified. A comprehensive plan for developing the necessary human, infrastructural and institutional capacity within programmes should be formulated and agreed upon (**Box 3**). The plan should identify the additional resources and associated costs to achieve its objectives, with clear terms of reference for the different staffing positions required. A clear budgeted plan will support mobilization of resources to address identified gaps. Cost estimates should generally be conducted at national level. Sustainability of established posts should be a key consideration, in order to ensure mid- to long-term retention of recruited staff. Key institutional re-arrangements required in order to implement the activities outlined in this plan should be documented, such as civil service reforms to ensure sustained public health entomology capacity.¹

Resources for capacity building could come from various sources including central government budgets, local property taxes, public-private partnerships, tourism sectors or from external sources. Where human resources are inadequate, efforts should be made to recruit staff from across sectors, who operate in the fields of vector management and control and, more broadly, in public health, development, agriculture or environmental science. Opportunities to leverage resources beyond the health sector should be explored, such as staffing arrangements that involve collaboration and time-sharing across sectors,

1. A public health entomologist or malacologist is a professional with at least basic vector and ecological knowledge and skills, who is also a public health practitioner skilled in epidemiology and programme management. For the purpose of this document only, the term 'entomologist' will be extended to include those professionals engaged in malacology. Similarly, the term 'entomology' will be extended to include the field of 'malacology'.



or identification of common material resources such as facilities, equipment or transport. Experience of other ministries and organizations in addressing vector-borne diseases of animals could prove of particular value.

Box 3. Vector control programme staffing requirements

A clear definition of staffing requirements at national and subnational levels is imperative. This is primarily to be defined through a comprehensive vector control needs assessment. Requirements will vary widely between countries depending on vector-borne disease burden and population at risk, and will be driven by planned vector surveillance and control as well as monitoring and evaluation activities. A critical consideration will be how staffing is shared between sectors and between the central and peripheral levels. Needs can be periodically redefined based on outcomes from assessments and on resources available.

Roles and responsibilities should be clearly defined for all staff positions. A bare minimum would include public health entomologists, field technicians, laboratory technicians (including insectary staff), data clerks/database managers and administrative staff. Access to staff with other skill sets, such as social scientists, is also imperative. Skill and experience requirements for each role must be outlined, with a focus on leveraging expertise beyond entomology in order to ensure broad experience across the team(s) tasked with implementing vector surveillance and control. Training of community volunteers is also important as in some countries they are responsible for vector control implementation, such as the spraying of molluscicides.

Programmes should then establish the necessary posts and recruit into the civil service necessary public health entomology staff at central and decentralized levels. This should include operational staff required for ongoing implementation of vector control as well as those needed for outbreak or epidemic response. To ensure availability of a cadre of sufficiently trained personnel, there is a need to strengthen and upgrade pre-service education and training through revision of secondary and tertiary core curricula in line with programme needs. Inclusion of basic concepts and activities related to vectors and their control in primary level education will help to sensitize and engage community members and enable effective community-driven approaches. This will require engagement with ministries of education, subnational education departments, and tertiary institutes to ensure integration into the curriculum.

Capacity building priorities for established staff should be defined through a comprehensive training needs assessment led by the Ministry of Health, and aligned with available WHO guidance.¹ National and regional institutional networks offer the opportunity to leverage resources for education and training across sectors both within and outside of the country. Training opportunities and resources provided by technical partners, including those available online, should be considered. This should include theoretical training on public health entomology as well as sufficient practical training in vector control implementation with a focus on quality control. Technical training by relevant private sector entities may also be leveraged, such as through integration of requirements into tender specifications for supply of vector control commodities. Training should be complemented with periodic follow-up and ideally coaching or mentorship.

1. Core structure for training curricula on integrated vector management. Geneva: World Health Organization; 2012 (http://www.who.int/neglected_diseases/vector_ecology/resources/9789241502788/, accessed March 2017).

Technical support may also be organized through such networks, on the basis of an established registry of experts that details areas and years of experience and up-to-date availability and contact information. These registries should be established and maintained at both national and regional levels to ensure appropriateness to address any arising needs of programmes.

6.1.2 Increase basic and applied research, and innovation

Research has been and must continue to be a foundation upon which vector control programmes are built. Further basic research is needed to understand better the interactions between pathogens, vectors and human and non-human hosts in relation to changes in the physical and social environment. The results of such research should inform the development of innovative approaches and interventions for disease prevention through vector control. Applied research is also needed to assess the effectiveness of interventions and optimize programmatic delivery of vector control in an environmentally safe and sustainable manner. Vector control must be evidence-based to ensure local appropriateness and justify continued investment in implementation. Innovation is also needed to advance the development and evidence-base for new vector control and monitoring tools, technologies and approaches.

While a basic research agenda for vector control may be determined by the interests of particular research groups or institutions, the applied research agenda should be defined by the national vector-borne disease control programme in consultation with national and international experts in the relevant field. The agenda should outline a prioritized list of strategic focus areas required to inform vector control in the country, and should serve to guide research and academic institutions to align the focus of their work. A clearly defined national research agenda will help avoid overlap and gaps in the work conducted in-country, and will assist in identifying additional external resources to support priority work. Coordination of research activities within and between countries will maximize the benefits of research and avoid unnecessary replication. Research funding bodies should align their requirements as closely as possible with the national agenda of the country or countries in which research is undertaken.

Ideally, applied research should be led and conducted by the national vector-borne disease control programme. However, because human and financial capacity in national programmes will often be focused on implementation, research may best be performed through collaboration with national research centres such as polytechnics, universities and institutes. In some cases support may be provided by international partners to leverage advanced technologies and methodologies and strengthen research quality and outputs. Formal institutional agreements will help to strengthen linkages between the programme and collaborating institutions and ensure sustainability. Research findings of any relevant work conducted in the country should be presented to the national programme as soon as available. Where applicable, raw data should be provided in a format that is easy to manage and utilize. Basic and applied research and innovation must follow standard ethical guidelines to ensure that the results are obtained without adverse effects on humans and the environment.

Innovations such as novel tools, technologies and approaches require a clear evidence-base that demonstrates their potential value to public health leading to policy recommendation. This is usually provided through large-scale randomized controlled field trials. These trials can be expensive and technically challenging but provide important evidence on



efficacy and effectiveness of single or multiple interventions. Once validated, guidance on programmatic deployment of new interventions is developed by the relevant WHO disease-specific department with support from specialized expert groups depending on the vectors and diseases targeted. This guidance must be informed by sufficient data such as from small-scale pilot studies that inform optimized implementation, followed by scale-up accompanied by pre- and post-implementation monitoring and evaluation. The Vector Control Advisory Group supports the Secretariat by providing recommendations on products that span from early to late stages of development. Reforms are currently under way to optimize the normative pathway for new interventions.¹ Rapid activation of research and development activities during epidemics may assist in fast-tracking availability of effective interventions, with urgent vector control and surveillance needs to be defined based on the situation as was done for Zika virus disease.²

The following paragraphs summarize the research needed to improve the quality and delivery of vector control.

1. **Assessment of health-system resilience.** Research should assess the capacity, strengths and weaknesses of the present health system in order to optimize processes and methods for vector control delivery. Community engagement and mobilization outcomes also require careful evaluation. Case studies of good practice should be identified for different eco-epidemiological settings. Such information is imperative to maximize use of human resources and improve the cost-effectiveness of vector control.
2. **Better vector sampling tools.** Assessments of vector populations should use up-to-date methods and techniques to ensure that results are informative for guiding and assessing vector control. Of particular need are robust indicators for vector-borne disease risk, especially in low transmission settings, and methods for assessing vector behaviour such as mosquito outdoor biting. Opportunities may also exist to use new technologies (such as novel adult mosquito sampling tools, rapid antigen detection assays, xenomonitoring, remotely sensed data or mobile communications) or draw on experiences from other countries with similar vector ecologies or transmission conditions.
3. **Innovations for new tools, technologies and approaches.** Novel effective, safe and environmentally-friendly interventions or combinations of interventions are needed to reduce the burden or eliminate certain vector-borne diseases. This is especially important in the context of emerging biological challenges, such as vector resistance to public health insecticides. Investments should be made to support the initial research and innovation for the development of these interventions, such as through product development partnerships. Development should be based on clear target product profiles, such as those reviewed by the Vector Control Advisory Group.

1. An R & D blueprint for action to prevent epidemics. Geneva: World Health Organization; 2016 (www.who.int/entity/csr/research-and-development/; accessed March 2017).

2. Mosquito (vector) control emergency response and preparedness for Zika virus: outcomes of meeting 18 March 2016. Geneva: World Health Organization; 2016 (http://www.who.int/neglected_diseases/news/mosquito_vector_control_response/; accessed March 2017).

4. **Improved evidence base on impact of current and new interventions.** The evidence base showing impact of vector control on infection and human disease is generally weak beyond the core malaria interventions of long-lasting insecticidal nets and indoor residual spraying. For the other vector-borne diseases, there is an urgent need to understand the efficacy of current interventions, particularly against *Aedes*-borne diseases. Applied research is also required to measure the field suitability and performance of new interventions, such as through randomized controlled trials with entomological and clinical outcomes.
5. **Measurement of environmental change.** Changes in the local environment that may influence vector populations should be monitored as they may increase or reduce exposure of local communities to vector-borne pathogens. These include development projects such as dam construction, major irrigation projects, urbanization, large-scale changes in agricultural practices and emergency situations. For large development projects, health impact assessments should be mandatory. Those leading the development project should be responsible for appropriate action to ameliorate any risks or adverse health impacts.
6. **Strengthen trans-disciplinary approaches.** Research aimed at improving inter- and intra-sectoral collaboration should also be undertaken to document good practices. Identifying effective approaches for community engagement and mobilization underpin programme acceptance and sustainability. Research for behavioural change is imperative to ensure acceptability, participation and appropriate use of vector control tools including the adaptation of information, education and communication strategies. Environmental science research will improve understanding of the broader impact of various vector control strategies on local and regional ecosystems. Economic evaluations of vector control systems will also support cost-effectiveness evaluations and support selection of the most appropriate and efficient vector control interventions.

6.2 Pillars of action

Action is required in four key areas (pillars) to attain effective locally adapted and sustainable vector control. These four areas are aligned with integrated vector management, and include: (1) strengthening inter- and intra-sectoral action and collaboration; (2) engaging and mobilizing communities; (3) enhancing vector surveillance and monitoring and evaluation of interventions; and (4) scaling up and integrating tools and approaches. Activities within these four pillars complement one another and there is some evident overlap.

Pillar 1. Strengthen inter- and intra-sectoral action and collaboration

Reduction of disease burden through vector control is a shared responsibility of all members of society. Effective coordination of vector-control activities is required between health and non-health sectors (e.g. other ministries and authorities, development partners, and the private sector) as well as within the health sector (e.g. national malaria and other vector-borne disease programmes, water, hygiene and sanitation initiatives, health management information systems section). This will maximize efficiencies, have greater impact than isolated, uncoordinated activities and harness the diverse capital available in various areas (**Box 4**). Strong coordination, in addition to saving lives and reducing suffering, is also expected to yield other economic and social benefits.



Box 4. Control of *Aedes*-borne diseases

Aedes aegypti is the principal vector of dengue, Zika, yellow fever and chikungunya viruses. It is found in close association with humans, and lays its eggs in containers commonly found in domestic and peri-domestic habitats, such as water-storage jars, flower pots, and discarded plastics. Because it has spread to most tropical and sub-tropical towns and cities, this mosquito threatens the health of millions. In some areas, *Aedes albopictus* also sustains transmission including in the absence of *Ae. aegypti*. Interventions against *Aedes* mosquitoes often centre on the application of insecticides within domiciles, though this is difficult to do properly and is often insufficient. Vector control can be enhanced by educating and empowering communities to identify, empty, remove or treat mosquito aquatic habitats in and around their homes. Urban settings can also be made more resilient by “building out” *Aedes* mosquitoes, such as by providing reliable piped water supply to circumvent the storage of domestic water at the household level. Solid waste management can also reduce *Aedes* larval habitats and screened housing will reduce densities of mosquitoes biting humans. This multi-pronged approach requires that the health sector work closely with those involved in urban planning, water, sanitation, solid waste management, and housing design and construction to ensure adequate management of domestic and peri-domestic habitats. Control of *Aedes*-transmitted viruses by targeting vectors requires an integrated approach that involves multiple partners within and outside the health sector, and particularly involvement of the community. Promising new vector control tools against *Aedes* are on the horizon that will provide further options for control of these diseases.

Inter- and intra-sectoral collaboration will require strong political commitment from national governments including earmarked funds to support coordination activities. National vector control programmes should become an integral part of poverty-reduction strategies, national development plans and regional development cooperation strategies. While many countries have some form of vector control activities, the first step to strengthening them should be a situational analysis of the available capacity within the health sector and beyond. This will give a better understanding of the problems, opportunities, potential stakeholders and synergies available. Actors beyond the immediate health sectors could include authorities for agriculture, education, environment, finance, housing, tourism, transport and water. Stakeholders within the health sector include the directorates of infectious diseases, hygiene, sanitation, nutrition and finance (Figure 4). The *Multisectoral action framework for malaria*¹ and the One Health initiative² are examples of multidisciplinary collaborative approaches that elevate action beyond the health sector.

After analysis, key stakeholders should be convened into an inter-ministerial task force whose mandate is the oversight, coordination and strengthening of vector control. The core decision-making members should consist of high-level officers from relevant ministries. Membership should also extend to local authorities and communities as well as stakeholders from other constituencies such as development partners and the private sector (Figure 4). Supporting committees, working groups or networks should be formulated per needs identified by the core members. Roles and responsibilities of all members should be clearly defined to differentiate decision-makers from partners, with competing interests proactively managed.

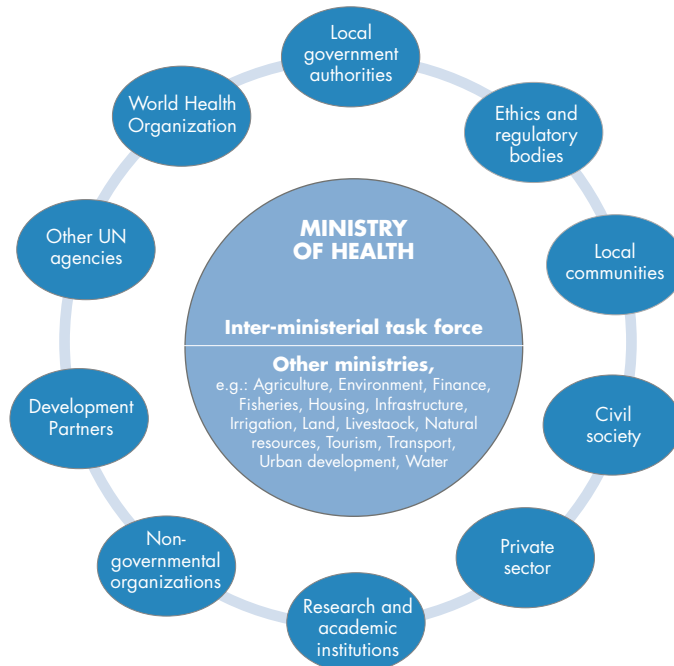
1. Roll Back Malaria Partnership and United Nations Development Programme. *Multisectoral action framework for malaria*. Geneva: World Health Organization; 2013 (<http://www.rollbackmalaria.org/files/files/about/MultisectoralApproach/Multisectoral-Action-Framework-for-Malaria.pdf>, accessed March 2017).

2. <http://www.onehealthinitiative.com/>; accessed March 2017.

The initial activity of the inter-ministerial task force should be to coordinate a national vector control needs assessment, if it is not already available, or support an update if needed as outlined for Foundation 1 above. After the needs assessment has been undertaken, countries should develop a costed work plan where actions can then be prioritized as required at national and subnational levels, in line with available resources. Municipalities should be involved in this process. Structures similar to the national task force should also be established at subnational and local levels as required in order to ensure necessary inter-sectoral collaboration at all levels. A multi-stakeholder body, such as existing donor groups or the country coordinating mechanism, should also be involved or constituted to prioritize the raising and effective investment of resources. Each relevant ministry should ensure that their respective strategic plan allocates adequate resources to vector control and that strategies are adapted to country-specific contexts.

Where possible, inter- and intra-sectoral action should be translated into national rules and regulations that mandate action at national and subnational levels, such as through municipality by-laws. Cross-sectoral collaboration will also be required to strengthen procurement, warehousing and supply chain systems to include insecticide- or molluscicide-based interventions, laboratory supplies and related commodities.

Figure 4. Intersectoral representation on inter-ministerial task force. Core decision-making function should reside with ministerial representatives, supported by partners as needed.





Pillar 2. Engage and mobilize communities

Communities play a major role in and are key to the success and sustainability of vector control (**Box 4**). While coordination between many stakeholders is required, vector control is critically dependent on harnessing local knowledge and skills within communities. Community engagement and mobilization requires working with local residents to improve vector control and build resilience against future disease outbreaks. Where appropriate participatory community-based approaches are in place, communities are supported to take responsibility for and implement vector control. Participatory community-based approaches aim to ensure that healthy behaviours become part of the social fabric and that communities take ownership of vector control at both the intra- and peri-domiciliary levels.

Engagement strategies that build upon social/anthropological and behavioural evaluations have a solid foundation to leverage local knowledge and skills i.e. cultural capital. Participatory community-based approaches involve a process of dialogue, learning, decision-making and action such that community members, including vulnerable and disempowered groups, are capacitated to recognize strengths, self-assess, collectively identify, analyse and prioritize problems that affect them. This leads to the identification of practical ways – including adaptation of traditional practices if appropriate – to address acknowledged problems. If well executed, this will strengthen the community's capacity to continually identify new issues where action is required and will build mutual accountability, trust and partnership. Communities and service providers should meet regularly for mutual advocacy and to assess progress with the two-fold aim of improving vector control while empowering communities to gain mastery over their risk of disease and ensure sustainable and locally owned development.

Communication strategies are needed in order to tailor approaches to local and disease-specific needs. These should use multiple channels including mass, local and social media and involve various actors in order to promote information and provoke dialogue. These actors could include community health workers, local and religious leaders, and school teachers. Good examples exist of communities engaged in efforts to reduce vectors in concert with local control departments and researchers such as for control of Chagas disease and dengue in the Americas.¹

Efforts to engage communities could act in concert with regulatory or legislative actions to support vector control, such as property access for larvicide application and source reduction. Training and capacity building are needed for community health workers and leaders that leverage existing training sources. New information and communications technologies such as social media and text messaging can be used to support implementation as well as monitoring and evaluation. Monitoring and evaluation of community engagement programmes and planning for long-term sustainability and scaling up should also be integrated. Documentation of existing community engagement strategies and their impact should be undertaken in order to share relevant best practices within and between countries.

Governments and disease control programmes should advocate for the inclusion of community engagement strategies in the policy agenda and budget. Advocacy could extend to explanations of current and emerging threats, the need for uptake of new interventions and the importance of dialogue to promote community ownership of vector control.

1. Sommerfield J, Kroeger A. Innovative community-based vector control interventions for improved dengue and Chagas disease prevention in Latin America. *Trans R Soc Trop Med Hyg.* 2015; 109:2 : 85–8; doi:10.1093/trstmh/tru76.

Pillar 3. Enhance vector surveillance and monitoring and evaluation of interventions

The capacity of vectors to transmit pathogens and their susceptibility to vector control measures can vary by species, location and time, depending on local environmental factors. Vector control must therefore be implemented on the basis of up-to-date local data generated by appropriate methods. Vector surveillance involves the regular and systematic collection, analysis and interpretation of entomological or snail distribution data for health risk assessment, and for planning, implementing, monitoring, and evaluating vector control.^{1,2,3,4} Vector surveillance should be routinely conducted at representative sites in areas where vector-borne diseases are endemic as well as those with low or no ongoing transmission but receptivity to pathogen transmission. Routine activities can be supplemented with preliminary surveys, spot checks and focal investigations as required, such as in situations of epidemics, outbreaks or increased transmission risk. Surveillance activities must be strategically and purposefully planned to provide information that will enable stratification of areas for further investigation or prioritized resources, will detect increases in risk or transmission, and will identify specific threats to the effectiveness of vector control such as insecticide resistance. Essential data requirements may differ between areas and over time, hence adaptability is required to ensure collection of appropriate data and avoid unnecessary activities that will not inform programme planning or implementation.

Monitoring refers to the continuous tracking of programme implementation and performance and involves checking progress against predetermined objectives and targets, and adapting activities accordingly. Monitoring includes coverage and implementation quality for vector control interventions, which is essential to maintaining vector control effectiveness. Social and behaviour change communication strategies should also be assessed. Information should be used to inform sound decision-making for policy, planning and implementation of vector control and assist in early response to the build-up of vector populations before outbreaks occur. Evaluation of programmatic progress and outcomes is needed to periodically document whether programme activities lead to the expected impact on human health.

Surveillance, monitoring and evaluation are core responsibilities of the vector control programme. Adequate human and infrastructural capacity is required at national and subnational levels to support necessary activities.⁵ A well-defined operational structure is fundamental to support systematic vector surveillance and proactively identify and manage arising programmatic issues. Strengthened vector surveillance will require significant new investments that are sustained in the face of potential shifting priorities. Ongoing training, such as for insecticide resistance monitoring and management, is a

1. Dengue guidelines for diagnosis, treatment, prevention and control: new edition. Geneva: World Health Organization; 2009 (<http://www.who.int/rpc/guidelines/9789241547871/>, accessed March 2017).

2. Vector surveillance and control at ports, airports, and ground crossings. International Health Regulations. Geneva: World Health Organization; 2016 (http://www.who.int/neglected_diseases/vector_ecology/resources/9789241549592/, accessed March 2017).

3. Entomological surveillance for *Aedes* spp. in the context of Zika virus. Interim guidance for entomologists. Geneva: World Health Organization; 2016 (<http://www.who.int/csr/resources/publications/zika/aedes-entomological-surveillance/>, accessed March 2017).

4. Field use of molluscicides in schistosomiasis control programmes: an operational manual for programme managers. Geneva: World Health Organization; 2017 (<http://www.who.int/schistosomiasis/resources/9789241511995/>; accessed March 2017).

5. Framework for a national plan for monitoring and management of insecticide resistance in malaria vectors. Geneva: World Health Organization; 2017 (<http://www.who.int/malaria/publications/atoz/9789241512138/>, accessed March 2017).



critical need. Engagement of partners such as research institutions may be necessary as the programme goes through the process of building internal capacity to fulfil this function. This involvement should not, however, be seen as a replacement for establishing and sustaining the requisite capacity within national programmes. Data-sharing agreements with partners should be managed through institutional agreements that hold partners responsible for providing data to the national programme in a timely and proactive manner and in a predetermined format aligned with programmatic requirements.

Programmes must be aware of the entomological and vector-borne disease situation in neighbouring countries and more broadly in the region as well as globally. Knowledge of regional and global trends can allow countries to be vigilant against threats such as importation of new pathogens or the emergence of insecticide resistance. Regional networks play a pivotal role in sharing data and experience across relevant settings and regional reference laboratories improve the quality of available information. Regular communication and reporting of key summary data will help to promote collaboration and experience sharing. As an example, WHO has established a global database on insecticide resistance in malaria vectors based on reports from national programmes through WHO country and regional offices. These data are managed at regional and headquarters level and are used to track this biological threat in order to inform policy updates, with frequent reporting in technical fora and regional or global reports such as the World Malaria Report, and collation in the WHO Global Health Observatory. This database will be extended to include other vectors of public health importance, prioritizing *Aedes* mosquitoes.

Evidence-based decision-making at national level requires entomological, epidemiological and intervention data. These data should be linked in order to stratify transmission risk for planning preventive control measures, guiding routine vector and epidemiological surveillance, and facilitating assessments of the impact of interventions. Such linkages can be supported through the use of a single, flexible data storage system to collate, validate, analyse and present aggregate statistical data required for vector control planning and implementation. For example, District Health Information Software 2 (DHIS 2)¹ – a flexible, web-based open-source information system that is increasingly being used by health ministries – could be expanded to provide a good platform for the integration of routine entomological data. This platform is also adaptable to support real-time reporting of events, and could be used for outbreak detection and response.

Other data from outside of the health sector should also be utilized. These data include information on urban planning, housing, water and sanitation as well as from the agricultural sector such as insecticide usage. Climate conditions are routinely measured, modelled and predicted at a local and global scale using standardized methodologies, providing the opportunity for use in public health policy and planning. Information can be used to predict changes in vector populations or the risk of disease transmission, and therefore aid stratification and prioritization for vector control planning and implementation. Climate and ecosystems data may also be used for early warning of vector distribution expansion, disease upsurges or outbreaks, or other changes in vector populations or transmission dynamics and thereby be used to re-direct vector control services or surveillance activities. Monitoring of human demographic and socioeconomic changes is also imperative given the association of vector-borne diseases with societal factors such as unplanned urbanization and migration. Geographical information system techniques and technologies should be leveraged to aid data interpretation.

1. <https://www.dhis2.org/>; accessed March 2017.

Pillar 4. Scale up and integrate tools and approaches

A key action to maximize the public health impact of vector control is the deployment and expansion of interventions appropriate to the epidemiological and entomological context. Proven and cost-effective vector control interventions include long-lasting insecticidal nets, indoor residual spraying, space sprays, larvicides, molluscicides and environmental management for specific target vectors. In addition, a rich pipeline of products is under development to address key challenges, such as malaria vector insecticide resistance and residual malaria parasite transmission. Personal protection through repellents and coverage with clothing offer supplemental approaches appropriate for specific settings and situations.

One intervention can have multiple effects against several vectors and diseases. For example, insecticide-treated nets against malaria and lymphatic filariasis (in settings where *Anopheles* are the principal vector), indoor residual spraying against malaria and leishmaniasis in India, and larval control for malaria and dengue vectors in cities with particular vector habitats. Approaches effective against *Aedes* spp. can impact on dengue, chikungunya, Zika virus disease and yellow fever where their distributions overlap, and can impact on malaria in urban settings where *Anopheles* inhabit similar habitats or exhibit similar behaviours, e.g. *An. stephensi*.

Each vector control intervention selected for use in a particular setting or situation should be done so on the basis of clear evidence of efficacy.^{1,2} Implementation must be to a high standard and at optimal coverage. Attaining sufficient coverage for at-risk populations with evidence-based and cost-effective tools offers the greatest immediate opportunity to reduce infections and disease. Where high coverage has not been achieved, it should be prioritized. Scale up is dependent on the availability of product and capacity for delivery. Good product quality is essential during manufacture, distribution and use to ensure effectiveness and safety. Systematic approaches to quality control of interventions, such as calibration of equipment for indoor residual and ultra-low volume spraying, are important. Sound pesticide management practices that minimize potential health and environmental risks should be adopted.³

Decisions to deploy and scale up individual vector control interventions must be informed by local information on vector distribution and disease transmission including receptivity or potential for disease spread. Ideally, local evidence should be used to inform scale up, with monitoring and evaluation systems in place to track implementation and impact. Practical approaches to scale up are required, supported by local information to guide adaptations in vector control delivery. Community-driven interventions such as those targeting *Aedes* spp. in domestic environments can prove more difficult to roll out than the core malaria interventions. Community engagement and mobilization are critical components of scale up for most vector control interventions (see Pillar 4).

1. A toolkit for integrated vector management in sub-Saharan Africa. Geneva: World Health Organization; 2016. (http://www.who.int/neglected_diseases/resources/9789241549653/, accessed March 2017).

2. Guidance on the selection of appropriate tools across different eco-epidemiological settings and conditions is beyond the scope of this document. For up-to-date information and guidance, see relevant pages at www.who.int

3. The international code of conduct on pesticide management. Food and Agriculture Organization of the United Nations and World Health Organization: Rome; 2014 (http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/CODE_2014Sep_ENG.pdf, accessed March 2017).



In some settings, multiple vector control interventions can have greater impact in reducing transmission or disease burden than one alone. Core interventions may need to be supplemented with additional tools, technologies or approaches to address specific challenges, such as insecticide resistance.^{1,2} When considering whether to supplement core interventions, control programmes should first determine whether any additional protection can be afforded by existing interventions through improved delivery mechanisms or strategies. The appropriate and evidence-based combination of interventions is important; programmes should avoid an approach that overlays multiple interventions to compensate for deficiencies in implementation of any one tool, because this may divert resources and attention from reaching the full impact of existing interventions and may lead to resource wastage. Prioritization should be on the basis of evidence on cost-effectiveness, with feedback of monitoring and evaluation outcomes to inform adjustments. This is especially important for environmental management and source reduction. Targeted distribution of interventions to improve access or adaptation of social and behaviour change communication strategies can further improve uptake and use.

Strategies that alter the domestic environment to reduce vector habitats, such as improved water supply to prevent household-level storage, or to prevent vector entry into human dwellings through house screening, should also be considered as part of larger-scale sustainable mitigation measures. Proper town and country planning, including adequate basic sanitation and drainage as well as effective solid waste and excreta management, is a sustainable long-term approach to vector control. These involve engagement across sectors (see Pillar 1). Opportunities for engagement outside the health sector in scaling up and integrating vector control interventions must be actively pursued (**Annex 5**). These opportunities are of particular importance for the control of *Aedes* vectors because linkages are crucial with professionals working in the housing and water sectors, such as urban planners and sanitary engineers (**Box 3**).

Vector control strategies should be applied in the broader context of vector-borne disease prevention and control along with other proven strategies. For some diseases, vector control should be used in combination with a vaccine or mass administration of appropriate medicines. For example, increased use of molluscicides to interrupt transmission beyond preventive chemotherapy is required to eliminate schistosomiasis. Vaccines can contribute to herd immunity strengthening and, as is the case for specific medicines, can decrease the number of susceptible or transmitting individuals, thereby making it easier to sustain disease reductions through vector control. Coverage goals for vaccines and prophylactic medicines will also be dependent on vector control that effectively lowers the risk of vector-borne pathogen infection. Combination of the best available interventions – whether they directly target vectors, human immune systems or pathogens – should be undertaken on the basis of evidence and in line with WHO policy recommendations.

1. Global plan for insecticide resistance management in malaria vectors. Geneva: World Health Organization; 2012 (<http://www.who.int/malaria/publications/atoz/gpirm/en/>, accessed March 2017).

2. WHO guidance for countries on combining indoor residual spraying and long-lasting insecticidal nets. Geneva: World Health Organization; 2014 (<http://www.who.int/malaria/publications/atoz/who-guidance-combining-irs-lins/>, accessed March 2017).

6.3 Enabling factors

Implementation of the *Global vector control response 2017–2030* will require strengthening of three key areas: (1) country leadership; (2) advocacy, resource mobilization and partner coordination; and (3) regulatory, policy and normative support.

6.3.1 Country leadership

Strong political commitment is needed to enable an integrated approach to vector control at national and sub-national levels, including within local governments and municipalities. Establishing clear roles and responsibilities at the outset is key to sustainability. High-level commitment of multiple ministries is central to the intersectoral interactions required to plan, fund, and implement priority activities outlined in this response. Sustained political engagement will be required to maintain momentum for systems reforms required to adjust to an integrated approach. Establishment and regular convening of a national inter-ministerial task force for vector control as described for Pillar 1 is essential to enable multisectoral engagement, and will require dedicated funding to each stakeholder. This will ensure there is the scope for adapting to any new challenges and opportunities, and to respond to changing trends in vector-borne diseases. Local mayors and state administrators in collaboration with other community leaders could oversee decentralized city, town or village task forces.

Collaboration between neighbouring countries is also important because vectors and pathogens are easily transported among and across countries. Such collaboration affords the opportunity for trans-border initiatives that more broadly impact vector populations and protect human health through timely action and development of preparedness plans. The International Health Regulations (2005) assist the international community by preventing and responding to acute public health risks that have the potential to cross borders, including vector-borne diseases.¹ An International Health Regulations network of country level focal points and coordination of expertise may play a vital role in prevention and control of potential outbreaks. Regional engagement is of particular importance if there is significant cross-border labour migration or tourism. Active leadership along with strengthened human capacity at national and subnational levels will be required to foster productive engagement and collaboration in the shared vision of vector-borne diseases reduction. At the country level, support by national or international technical agencies should be coordinated to ensure effective use of resources.

6.3.2 Advocacy, resource mobilization and partner coordination

Broad advocacy initiatives are required to ensure awareness and involvement of those beyond the formal health sector and to secure adequate funding. Representatives of each of the ministries on the inter-ministerial task force are responsible for ensuring that relevant vector control components are integrated into respective strategic plans. This will require effective communication across and among ministries, all of which should be centred on the national vector control strategy. A strong advocacy case needs to be built including information on the health, economic, social and cultural impacts of vector-borne diseases, cost-effectiveness of vector control tools and benefits of inter-sectoral collaboration, including resource- and cost-savings.

1. International health regulations (2005): third edition. Geneva: World Health Organization; 2005 (<http://www.who.int/ihr/publications/9789241580496/>, accessed March 2017).



Predictable and long-term financing will be required to support vector control programming. International donors are encouraged to maintain and increase commitments to national vector-borne disease goals and programmes. Dedicated resources are urgently required to establish and convene inter-ministerial task forces and to commence and sustain priority activities outlined in this response. It is anticipated that refined national vector control strategies will further set out the costs required for implementation of vector control in line with this response. Endemic countries are urged to increase domestic resources directed to strengthening health systems and combating vector-borne diseases. As is the case with other regular health interventions, vector control should be included as part of the regular health budget consistent with operations that will be recurrent and long term.

Increased global financing will be required to support the implementation of this response. A critical assessment of the global funding architecture for vector-borne diseases is required to ascertain if revisions will better serve the needs of national programmes. Donor financing can then be directed to the most relevant portions of the strategy, with resource mobilization focused on filling resource gaps. Innovative financing options should be leveraged where possible. Human resources should be leveraged from within and beyond the health sector.

New financing solutions should be conceived to tap into emerging development financing and private sector resources, including through public–private partnerships. As well as traditional funding sources in global health, other potential funding streams include major international programmes aimed at achieving the Sustainable Development Goals. Income streams outside of the traditional global health funding sector should be tapped into, such as for climate change and healthy cities initiatives for sustainable development.¹ At local level, funding can be obtained from philanthropic groups, and from local building or sales taxes or tourism taxes. Robust and predictable financing is essential to consolidate vector control successes, as has been the case for malaria. If intervention coverage is reduced, gains will be lost. Maintenance of robust vector-borne disease control programmes and capacities is paramount across all disease settings in order to attain and sustain strong returns on investment both for the disease programme and donors. A particular priority is to address the acute lack of resources for *Aedes*-borne disease prevention through better management, technical support and sustained operational capacity.

A large number of stakeholders are involved in providing support to national programmes for vector control, including development partners, private industry, research and academia, nongovernmental organizations and community health workers. National public health programmes need to improve the overall coordination of work on vector control for the most efficient use of resources by harmonizing efforts, avoiding replication, and identifying and filling gaps. National programmes should ensure that all work on vector control implementation is fully in line with national strategic priorities and complies with WHO recommendations. Appropriate guidelines and operational procedures need to be identified, developed and adapted to needs of the national programmes.

1. Zagreb declaration for healthy cities: health and health equity in all local policies. Copenhagen: World Health Organization Regional Office for Europe; 2009 (http://www.euro.who.int/__data/assets/pdf_file/0015/101076/E92343.pdf, accessed March 2017).

6.3.3 Regulatory, policy, ethics and normative support

Regulatory and legislative controls for public health will need to be updated or revised in line with the enhanced focus on vector control outlined in this response. At national and subnational levels, appropriate regulatory frameworks are required to ensure safe use of quality-assured interventions by appropriately trained personnel. New legislation may be needed in order to support changes in programmatic structures, regulatory processes, and supporting mechanisms to elevate vector control as a public health service. Introduction and enforcement of local by-laws may be required to enable effective vector control delivery, including outbreak response, legislation permitting property access and inspection and treatment or removal of potential vector habitats. Introduction and enforcement of legislation will require strong inter-sectoral coordination, leadership of local authorities and involvement of the judiciary.

Numerous potential vector control and surveillance tools and approaches are under development and are currently being evaluated by WHO. These could mitigate specific biological challenges that threaten to undermine effective vector control, such as vector insecticide resistance or residual malaria parasite transmission. Moreover, they may address the dire need for large-scale delivery of interventions appropriate for urban environments. As candidate tools, technologies and approaches become available, they will be reviewed by WHO for their public health value primarily on the basis of evidence of effectiveness. This may lead to listing as a WHO prequalified product. This process will provide countries with clear product specifications and performance data to identify appropriate and high-quality interventions that are relevant to their particular setting.

National regulatory bodies will need to adapt to enable rapid introduction of proven tools, technologies and approaches. Careful and rapid assessment of product dossiers is required to ensure registration and appropriate uptake of validated interventions. Ethical and research review committees as well as Environment Impact Assessment mechanisms need to be strengthened at national and regional levels to facilitate appropriate evaluation, especially for novel vector control interventions. Taxes and tariffs for vector control products should be waived as part of the national commitment to vector control.

Robust ethical analysis is required to facilitate the introduction of novel interventions, including new tools, technologies and approaches that have a WHO policy recommendation based on sufficient evidence of epidemiological impact. Such an analysis should identify and propose solutions to mitigate risks and challenges to the introduction of the intervention/s in a particular setting. This includes ensuring that equity concerns have been addressed, that vulnerabilities are not exploited and that community concerns are taken into account. National capacity for this function will need to be enhanced to appropriately address these ethical concerns, such as the strengthening of national bioethics and research ethics committees.

Robust quality assurance processes must be in place at national level to ensure that vector control interventions are of the highest possible quality. Product specifications should be assessed by competent national or regional regulatory mechanisms prior to deployment, and performance monitored throughout their lifetime. Regulatory and procurement processes should ensure that any quality issues are identified, reported and addressed immediately to minimize adverse impact on the environment or effective delivery of vector control which may have financial implications for the programme.



7. Cost of implementing the response

Achievement of the targets and milestones set out in this response will need significant investment from both international and domestic sources to strengthen vector control capacity and capability, research and innovation, cross-sectoral coordination, community involvement, and surveillance and monitoring systems. It is estimated that full implementation of the priority activities defined for the interim period 2017–2022 will require an annual investment of US\$ 330 million (**Annex 6**). This represents a maximum value, as it is assumed that over time adequate and well-trained local workforces will expand to undertake surveillance and coordination functions. The figures exclude the costs of vector control commodities and their deployment, and implementation of research and innovation. In comparison, the global annual investment for vector control implementation (including for commodities) projected for 2022 as outlined in global strategies for malaria, dengue and Chagas disease is over US\$ 4000 million.^{1,2}

The estimated cost for implementation of the *Global vector control response 2017–2030* equates to an average of US\$ 0.05 per person per year at risk from at least one vector-borne disease, with variation by burden and risk as well as other local factors such as income level. These costs for workforce, coordination and surveillance represent a relatively modest investment in relation to implementation of core interventions, such as insecticide-treated nets (US\$ 1.27 per person protected per year), indoor residual spraying (US\$ 4.24 per person protected per year) and community-based activities for dengue prevention (estimated to exceed US\$ 1.00 per person protected per year).

Accurate estimates of resource requirements and costs are expected to be made through comprehensive vector control needs assessments at country and subnational levels.

1. Patouillard E, Griffin JT, Bhatt S, Ghani AC, Cibulskis R. Global investment targets for malaria control and elimination 2016-2030. *BMJ Global Health*.

2. Investing to overcome the global impact of neglected tropical diseases. Third WHO report on neglected tropical diseases. Geneva: World Health Organization; 2015. (http://www.who.int/neglected_diseases/9789241564861/en/; accessed March 2017).

8. Role of the WHO secretariat

The Secretariat will continue to provide support to Member States and work closely with organizations in the United Nations system, donors, intergovernmental organizations, institutions of research and academia, and all other technical partners whose work is fundamental to successful implementation of this response. Recent WHO reforms will improve support to countries for response to outbreaks and emergence of vector-borne diseases.

The Secretariat will continue to set, communicate and disseminate normative guidance, policy advice and implementation guidance to support country action. It will ensure that its policy-setting process, which includes the Malaria Policy Advisory Committee and the Strategic and Technical Advisory Group for Neglected Tropical Diseases, is responsive to the rapidly changing context of vector-borne diseases and that its global technical guidance is regularly updated in collaboration with partners and regional networks¹ for harmonization and to ensure inclusion of novel tools, technologies and approaches that are proven safe, effective and of public health value. Due consideration will be given to ethical issues and impact on the natural environment. The Secretariat will continue to assess such interventions with support from the Vector Control Advisory Group and specialized disease-specific expert groups such as the Malaria Vector Control Technical Expert Group and other technical working groups. Support will be provided to countries for the improvement of regulatory environments.

The Secretariat will provide guidance and technical support to Member States in reviewing and updating their national vector-borne disease strategies in line with the priority activities for strengthening vector control as outlined in this response. It will further provide guidance for capacity development including training. It will ensure that its own



capacities are strengthened at the global, regional and country levels to enable it to lead a coordinated global effort to reduce the vector-borne disease burden by 2030 and to support the implementation of all recommendations in this response. It will work with Member States to develop regional implementation plans, where appropriate. Capacities and resources of existing networks and partners¹ will be leveraged to ensure harmonized work plans and efficient implementation at global, regional and national levels.

The Secretariat and partners will support countries in strengthening their national information systems in order to improve the quality, availability and management of vector surveillance and intervention monitoring and evaluation data, and to streamline disease data and optimize their use for decision-making and programmatic responses. It will monitor implementation of the strategy and regularly evaluate progress towards the milestones and targets set. It will also provide support to countries for developing nationally appropriate targets and indicators to facilitate the subregional monitoring of progress.

Dissemination of information will be an important function of the Secretariat. In line with its core roles, it will continue to monitor regional and global vector-borne disease trends, and make these data available to countries and global health partners. It will support efforts to monitor vector control intervention coverage, quality and efficacy, and to this end, will maintain global and regional databases for insecticide resistance. It will regularly collaborate with and report to the regional and global governing bodies of the Organization, the United Nations General Assembly, and other United Nations bodies.

WHO will promote the research and knowledge generation that is required to accelerate progress towards a world free of human suffering from vector-borne diseases. It will continue to coordinate activities across related programmes and initiatives of the Organization, including the Health Emergencies Programme, the International Health Regulations (2005), and the research and development Blueprint for action to prevent epidemics. It will also provide support to initiatives on advocacy, resource mobilization and partner coordination.

The response will be updated at regular intervals in order to ensure linkage with disease situations and strategies, latest policy recommendation and complementary technical guidance.

1. Including but not limited to partners and networks such as the African Network on Vector Resistance, African Union, Asia Pacific Malaria Elimination Network, Association of Southeast Asian Nations, Center for Diseases Control and Prevention in Africa, European Centre for Disease Prevention and Control, European Union, Roll Back Malaria partnership, Partnership for Dengue Control, Worldwide Insecticide resistance Network and other United Nations agencies such as the Food and Agriculture Organization, UN-Habitat and UNICEF.

9. Proposed progress indicators

The following annual progress indicators are proposed for tracking progress at national and regional levels in implementing the *Global vector control response 2017–2030*. Initial assessments will be required to establish the baseline and to verify the indicators and targets set.



Table 3. National and regional progress indicators for priority activities for 2017–2022^a for implementation of the global vector control response

Priority activities		Level	Indicators
National and regional vector control strategic plans ^b developed/adapted to align with global vector control response		National	National vector control strategic plan ^b aligned with priority activities defined in global vector control response completed
		Regional	Regional vector control strategy ^b aligned with priority activities defined in global vector control response completed
FOUNDATION	A National vector control needs assessment conducted or updated and resource mobilization plan developed (including for outbreak response)	National	National vector control needs assessment and resource mobilization plan completed within the previous 3 years through a consultative process
		Regional	% of countries with national vector control needs assessment and resource mobilization plan completed within the previous 3 years through a consultative process
	A National entomology and cross-sectoral workforce appraised and enhanced to meet identified requirements for vector control	National	National human resource development plan aligned with global vector control response completed within previous 2–3 years
		National	% of required national staff in position in previous 12 months
		National	% attrition of required national staff in previous 12 months
		National	% of required state/provincial staff in position in previous 12 months
		National	% attrition of required state/provincial staff in previous 12 months
		National	% of required district/municipality staff in position in previous 12 months
	A Relevant staff from Ministries of Health and/or their supporting institutions trained in public health entomology	National	% of relevant staff at national level who have received training in public health entomology within the previous 3 years
		National	% of relevant staff at state/provincial level who have received training in public health entomology within the previous 3 years
		National	% of relevant staff at district/municipality level who have received training in public health entomology within the previous 3 years
	A National and regional institutional networks to support training/education in public health entomology and technical support established and functioning	National	National programme of training or education (degree/diploma/certificate) that includes vector surveillance, urban development, programme planning and implementation for vector control conducted in the previous 12 months
		National	National registry of experts with relevant experience available and updated within the previous 2 years
		Regional	Regional programme of training or education (degree/diploma/certificate) that includes vector surveillance, urban development, programme planning and implementation for vector control conducted in the previous 12 months
		Regional	Regional registry of experts with relevant experience available and updated within the previous 2 years
		Global	Number of countries of region for which national programme staff have accessed training/education or other support from a regional network in the past 12 months
	B National agenda for basic and applied research on entomology and vector control established and/or progress reviewed	National	Defined national agenda for basic and applied research that has been established or reviewed to determine research activities conducted for each priority area within the past 12 months

Priority activities		Level	Indicators
PILLARS	1	National	Representative national task force for multisectoral engagement in vector control functional and meeting convened within previous 12 months
		National	Supporting committees, working groups or networks established ^a with clear terms of reference and convened within previous 12 months
	2	National	National vector control strategy ^b incorporates effective community engagement and mobilization for sustained ownership of vector control initiatives
	3	National	Routine and systematic vector surveillance for all significant local vectors conducted within previous 12 months
		National	National entomological or snail distribution database established and updated within previous 12 months
		National	Vector surveillance system integrated with health information system to allow linkage of vector, epidemiology and intervention data
		National	Entomological, epidemiological and intervention data reviewed by national expert committee within previous 12 months
	4	National	Proportion of national population at-risk of vector-borne disease/s covered by effective vector control in previous 12 months

a. To be revised and updated for 2023–2030; b. or integrated vector management strategic plans, if available; c. as required dependent on national context; d. in accordance with environmental impact assessment/s; e. in accordance with needs identified by the inter-ministerial task force.

Note: Targets for each priority activity are defined in **Table 2**.



Annex 1. Global burden of major vector-borne diseases, as of March 2017

Some vector-borne diseases of specific local importance are included, as indicated by blue shading.

Vector	Disease	Estimated or reported annual number of cases	Estimated annual number of deaths	Estimated annual disability-adjusted life years
Mosquitoes	Malaria ¹	212 000 000 (148 000 000–304 000 000) ¹	429 000 (235 000–639 000) ¹	NA
	Dengue	96 000 000 (67 000 000–136 000 000) ²	9 110 (5630–10 842) ³	1 892 200 (1 266 700–2 925 500) ⁵
	Lymphatic filariasis	38 464 000 (31 328 000–46 783 000) ⁶	NA	2 075 000 (1 120 500–3 311 500) ⁵
	Chikungunya (Americas)	693 000 ⁷ suspected, 2015	NA	NA
	Zika virus disease (Americas)	500 000 ⁸ suspected, 2016	NA	NA
	Yellow fever (Africa)	130 000 (84 000–170 000) ⁹	500* (400–600) ³	31 000* (25 000–37 000) ³
	Japanese encephalitis	42 500* (35 000–50 000) ¹⁰	9 250* (3500–15 000) ¹⁰	431 552* (107 435–755 670) ¹⁰
	West Nile fever	2 588 ¹¹	111 ¹¹	NA
Blackflies	Onchocerciasis	15 531 500 (11 963 500 – 19 993 800) ⁶	NA	1 135 700 (545 800–2 005 700) ⁵
Sandflies	Muco/cutaneous leishmaniasis	3 895 000 (3 324 000–4 767 000) ⁶	NA	41 500 (19 000–80 000) ⁵
	Visceral leishmaniasis	60 800 (57 500–64 700) ⁶	62 500 (52 300–73 300) ³	1 377 400 (3 488 000–5 045 000) ⁵
Triatomine bugs	Chagas disease	6 653 000 (5 750 000–7 575 000) ⁶	10 600 (4200–33 000) ³	236 100 (211 800–265 300) ⁵
Ticks	Borreliosis (Lyme disease)	532 125 ^{12,13}	NA	10.5 (7.6 – 16.9) per 100 000 population in the Netherlands ¹⁴
	Tick-borne encephalitis (North Eurasia)	10 000 – 12 000 ¹⁵	NA	167.8 per 100 000 population in Slovenia ¹⁶
Tsetse flies	Human African trypanosomiasis (Africa)	10 700 (6 000–17 000) ⁶	6 900 (3700–10 900) ³	202 400 (104 600–322 300) ⁵
Snails	Schistosomiasis	207 000 000 ¹⁷	200 000 ⁶	2 613 300 ⁵
Various	Other: ** Rift Valley fever, O'nyong nyong virus, Mayaro virus, Crimean-Congo haemorrhagic fever, rickettsial diseases, plague	NA	NA	NA

NA, not available

* Best estimate based on average of range.

** Potential emerging vector-borne diseases causing outbreaks, for which global data are currently limited.

1. World malaria report 2016. Geneva: World Health Organization; 2016 (<http://www.who.int/malaria/publications/world-malaria-report-2016/en/>, accessed December 2016).
2. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL et al. The global distribution and burden of dengue. *Nature*. 2013;496:504–7.
3. Global Burden of Disease Mortality and Causes of Death Collaborators. Global, regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2015;385:13–71.
4. Stanaway JD, Shepard DS, Undurraga EA, Halasa YA, Coffeng LE, Brady OJ et al. The global burden of dengue: an analysis from the Global Burden of Disease study 2013. *Lancet Infect Dis*. 2016; S1473–3099:00026-8.
5. Global Burden of Disease Study 2015 Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016; 388:1603–58.
6. Global Burden of Disease Study 2015 Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016; 388:1603–58.
7. Chikungunya cumulative cases, 17 Jan 2017. Washington (DC): Pan American Health Organization/World Health Organization; 2016.
8. Zika epidemiological update, 22 September 2016. Washington (DC): Pan American Health Organization/World Health Organization; 2016.
9. Yellow fever burden estimation study. Geneva: World Health Organization; 2013.
10. LaBeaud AD, Bashir F, King CH. Measuring the burden of arboviral diseases: the spectrum of morbidity and mortality from four prevalent infections. *Popul Health Metr*. 2011;9:1.
11. West Nile fever: diseases and conditions [webpage]. Atlanta (GA): United States Centers for Disease Control and Prevention; 2016: <https://www.cdc.gov/features/westnilevirus/>
12. Kuehn BM. CDC estimates 300,000 US cases of Lyme disease annually. *JAMA*. 2013; 18: 310:1110. doi:10.1001/jama.2013.278331.
13. Sykes RA, Makiello P. An estimate of Lyme borreliosis incidence in Western Europe. *J Public Health* 2016; 38. doi:10.1093/pubmed/fdw017.
14. van den Wijngaard CC, Hofhuis A, Harms MG, Haagsma JA, Wong A, de Wit GA et al. The burden of Lyme borreliosis expressed in disability-adjusted life years. *Eur J Public Health*. 2015;25:1071–8. doi:10.1093/eurpub/ckv091.
15. Gritsun TS1, Lashkevich VA, Gould EA. Tick-borne encephalitis. *Antiviral Res*. 2003; 57:129–46.
16. Šmit R, Postma MJ. The burden of tick-borne encephalitis in disability-adjusted life years (DALYs) for Slovenia. *PLoS One* 2015; 10(12): e0144988. doi:10.1371/journal.pone.0144988.
17. Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J. Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk. *Lancet Infect Dis*. 2006;6(7):411–25.



Annex 2. Examples of major successes achieved through vector control

Place	Year	Disease	Intervention	Impact	Ref.
Malaysia	1900	Malaria	Environmental management: draining larval habitats, forest clearing	Markedly less disease	1
Cuba	1903	Yellow fever	Integrated vector management in Havana: drainage or oiling of standing water, fumigation and isolation of yellow fever patients with screening and netting	Elimination of yellow fever	2
Panama	1904	Malaria and yellow fever	Integrated vector management: screening living quarters, draining or filling standing water, installing drains, larviciding using oil or Paris Green	Reduced malaria to low levels and elimination of yellow fever	2
Japan	1938–1977	Schistosomiasis	Vector control through changes of agricultural practices, cementing of water canals and application of molluscicides	Schistosomiasis transmission interrupted. Last human case recorded in 1977	3
Brazil	1942	Malaria	Larviciding with Paris Green and house spraying using short-acting pyrethroids	Eradication of <i>Anopheles gambiae</i> , the most efficient global malaria major (introduced species)	4
Global	1955–1967	Malaria	Global Malaria Eradication Programme based largely on indoor residual spraying with DDT and other residual insecticides, larval control and antimalarial medicines	Elimination of malaria from large parts of the world, particularly those with more temperate climates and seasonal transmission	5,6
Latin America	1950s and 1960s	Yellow fever and dengue	Container inspections, oiling of larval habitats and later perifocal spraying of DDT in water containers and nearby walls	Elimination or eradication of <i>Aedes aegypti</i> from large parts of the region	7
Tunisia	1970–1982	Schistosomiasis	Integrated strategy combining mass chemotherapy and snail control through the use of molluscicides	Schistosomiasis transmission interrupted. No indigenous cases found since 1982	8
West Africa	1974–2002	Onchocerciasis	Aerial larviciding largely with antimicrobial agents	Near-elimination of river blindness from much of West Africa	9,10
Singapore	1970–present	Dengue	Entomological surveillance and larval source reduction	1.5-year period of low dengue incidence	11
Latin America	1991–2005	Chagas	Indoor residual spraying, house improvements and community education	Decline in infestation rate and a sharp decline in the infection rates of children born since the programme began; interruption of domestic transmission in many countries	12–14
Cuba	1980s–1990s	Dengue	Community-based combination interventions, indoor residual spraying	No outbreaks, low incidence, majority of island free from vector	15
Australia	2003	Dengue	Indoor residual spraying	Significant protective effect when coverage $\geq 60\%$ in neighbouring premises	16
Tropics	2000–2015	Malaria	Long-lasting insecticidal nets, indoor residual spraying and prompt treatment	50% reduction in malaria prevalence and a 40% reduction in morbidity	17

DDT: 1, 1, 1-trichloro-2, 2-di(4-chlorophenyl)ethane

1. Watson M. The prevention of malaria in the Federated Malay States. Liverpool: John Murray; 1921.
2. Le Prince JA, Orenstein AJ. Mosquito control in Panama; the eradication of malaria and yellow fever in Cuba and Panama. New York and London: G.P. Putnam's Sons; 1916.
3. Minai M, Hosaka Y, Ohta N. Historical view of schistosomiasis japonica in Japan: implementation and evaluation of disease-control strategies in Yamanashi Prefecture. *Parasitol Int.* 2003 Dec;52(4):321-6.
4. Soper FL, Wilson DB. *Anopheles gambiae* in Brazil 1930 to 1940. New York (NY): Rockefeller Foundation; 1943.
5. Nájera JA, González-Silva M, Alonso PL. Some lessons for the future from the Global Malaria Eradication Programme (1955–1969). *PLoS Med.* 2011; 8:e1000412.
6. Nájera JA. Malaria control: achievements, problems and strategies. Geneva: World Health Organization; 1999.
7. Severo OP. Eradication of the *Aedes aegypti* mosquito from the Americas (1955). Yellow fever, a symposium in commemoration of Carlos Juan Finlay, 1955. Paper 6. http://jdc.jefferson.edu/yellow_fever_symposium/6. 1955.
8. The control of schistosomiasis, Second report of the WHO Expert Committee, Geneva: World Health Organization; 1993 (WHO Technical Report Series N°830).
9. Boatin B. The Onchocerciasis Control Programme in West Africa (OCP). *Ann Trop Med Parasitol.* 2008; 102:13–7.
10. Sékétéli A, Adeoye G, Eyamba A, Nnoruka E, Drameh P, Amazigo UV et al. The achievements and challenges of the African Programme for Onchocerciasis Control (APOC). *Ann Trop Med Parasitol.* 2002; 96:S15–28.
11. Ooi E-E, Goh K-T, Gubler DJ. Dengue prevention and 35 years of vector control in Singapore. *Emerg Infect Dis* [serial on the Internet]. 2006 Jun. <http://dx.doi.org/10.3201/eid1206.051210>.
12. Dias JC. Southern Cone Initiative for the elimination of domestic populations of *Triatoma infestans* and the interruption of transfusional Chagas disease. Historical aspects, present situation, and perspectives. *Mem Inst Oswaldo Cruz.* 2007; 102:11–8.
13. Dias JCP, Silveira AC, Schofield CJ. The impact of Chagas disease control in Latin America – a review. *Mem Inst Oswaldo Cruz.* 2002; 97:603–12.
14. Schofield CJ, Dias JC. The Southern Cone Initiative against Chagas disease. *Adv Parasitol.* 1999; 42:1–27.
15. Arias Jorge. El dengue en Cuba [Dengue in Cuba]. *Rev Panam Salud Publica.* 2002; 11:221–2 [in Spanish].
16. Vazquez-Prokopec GM, Kitron U, Montgomery B, Horne P, Ritchie SA. Quantifying the spatial dimension of dengue virus epidemic spread within a tropical urban environment. *PLoS Negl Trop Dis.* 2010; 4:e920.
17. Cibulskis RE, Alonso P, Aponte J, Aregawi M, Barrette M, Bergeron L et al. Malaria: Global progress 2000–2015 and future challenges. *Infect Dis Poverty.* 2016; 5:61. doi:10.1186/s40249-016-0151-8.



Annex 3. List of relevant global and regional strategies, plans, frameworks and resolutions, as of March 2017

- Resolution WHA42.31 Control of disease vectors and pests (World Health Assembly, 1989)
- Global programme to eliminate lymphatic filariasis (WHO, 2000)
- Resolution WHA55.17 Dengue fever and dengue haemorrhagic fever prevention and control (World Health Assembly Agenda item 12.14, 18 May 2002)
- Global strategic framework for Integrated Vector Management (WHO, 2004)
- Resolution WHA57.2 Control of human African trypanosomiasis (World Health Assembly, 21 May 2004)
- International Health Regulations (WHO, 2005)
- Regional framework for an integrated vector management strategy for the South-East Asia Region (WHO Regional Office for South-East Asia, 2005)
- Resolution WHA60.13 Control of leishmaniasis (World Health Assembly, 21 May 2007)
- Dengue Strategic Plan for Asia Pacific 2008–2015 (WHO Regional Office for the Western Pacific, 2008)
- Resolution WHA63.20 Chagas disease: control and elimination (World Health Assembly, 21 May 2010)
- Global dengue control strategy 2012–2020 (WHO, 2011)
- Global plan for insecticide resistance management in malaria vectors (WHO, 2012)
- Resolution WHA65.21 Elimination of schistosomiasis (World Health Assembly, 26 May 2012)
- Accelerating work to overcome the global impact of neglected tropical diseases. A roadmap for implementation (WHO, 2012)
- Schistosomiasis: progress report 2001–2011 and strategic plan 2012–2020 (WHO, 2013)
- Regional framework for surveillance and control of invasive mosquito vectors and re-emerging vector-borne diseases 2014–2020 (WHO Regional Office for Europe, 2013)
- Resolution EUR/RC63/R6 Regional framework for surveillance and control of invasive mosquito vectors and re-emerging vector-borne diseases (18 September 2013)
- Multisectoral action framework for malaria (Roll Back Malaria/UNDP, 2013)
- Resolution WHA66.12 Neglected tropical diseases (World Health Assembly Agenda item 16.2, 27 May 2013)
- Strategic framework for leishmaniasis control in the WHO European Region 2014–2020 (WHO Regional Office for Europe, 2014)
- Global technical strategy for malaria 2016–2030 (WHO, 2015)
- Integrated strategy for dengue prevention and control in the Region of the Americas (EGI-dengue) (WHO/Pan-American Health Organization, 2015)
- Regional strategic framework for elimination of kala-azar 2016–2020 (WHO Regional Office for South-East Asia, 2015)
- Resolution WHA68.2 Global technical strategy and targets for malaria 2016–2030 (World Health Assembly Agenda item 16.2, 22 May 2015)
- Zika strategic response plan: revised for July 2016 – December 2017 (WHO, 2016)
- Framework for implementing the Global Technical Strategy for Malaria 2016–2030 in the African Region (WHO Regional Office for Africa, 2016)

- Strategy for arboviral disease prevention and control in the Americas (WHO Regional Office for the Americas/Pan American Health Organization, 2016)
- A toolkit for Integrated Vector Management in sub-Saharan Africa (WHO, 2016)
- Regional action plan for dengue 2016–2025 (WHO Regional Office for the Western Pacific, 2016)
- Resolution WPR/RC67.R4 Dengue (13 October 2016)






In preparation

- Strategic framework for integrated vector management in the Eastern Mediterranean Region (WHO Regional Office for the Eastern Mediterranean)



Annex 4. Relationship between Sustainable Development Goals and control of vector-borne diseases

Sustainable Development Goal	Relationship	Examples
	Ending VBDs will reduce poverty and increase economic prosperity	<ul style="list-style-type: none"> ■ In Cambodia and Viet Nam, between half and two-thirds of affected households have incurred debt as a result of treatment for dengue ■ The poorest of the poor are twice as likely to have malaria as those who are less poor
	Ending VBDs improves nutritional intake and increases agricultural productivity	<ul style="list-style-type: none"> ■ Among children of the same socioeconomic status, those with malaria have poorer nutritional status than non-malarial children ■ Adults suffering from malaria, visceral leishmaniasis and lymphatic filariasis have a reduced labour output, threatening food production ■ Agricultural practices strongly influence transmission of VBDs
	VBDs are a major contributor to global morbidity and mortality	<ul style="list-style-type: none"> ■ VBDs account for > 17% of the global burden of infectious diseases; > 80% of the global population is at risk from one VBD, with > 50% at risk of two or more VBDs
	Ending VBDs improves school attendance and educational outcomes	<ul style="list-style-type: none"> ■ Of those who survive cerebral malaria, 5–20% experience neurological sequelae that impair their ability to initiate, plan and carry out tasks ■ Many children who survive Japanese encephalitis develop neurological sequelae and become physically and mentally disabled, which limits educational outcomes and requires the provision of special syllabuses ■ Education can be leveraged to reduce larval habitats of numerous vectors
	Investment in clean water and sanitation can reduce the risk from VBDs	<ul style="list-style-type: none"> ■ Open stored water containers are a major habitat for immature dengue, chikungunya and Zika virus vectors worldwide and for malaria vectors in India • Provision of piped water and/or mosquito-proof water storage containers can reduce the transmission of these diseases • Similarly, improved latrines can reduce biting by vectors of lymphatic filariasis in urban settings and environmental transmission of schistosomiasis
	Ending VBDs decreases productivity losses due to death and disability, and is likely to reduce birth rates	<ul style="list-style-type: none"> ■ Malaria constrains economic development in endemic countries ■ A 10% reduction in malaria has been associated with 0.3% higher economic growth
	Enhancing infrastructure will help control VBDs	<ul style="list-style-type: none"> ■ Cities and towns need to be constructed and operate so that they reduce vector aquatic habitats; this can be achieved by piped water, well-designed toilets, adequate rubbish collection, efficient drainage and house improvements ■ Development projects need to be designed so they do not increase vector aquatic habitats (roads, irrigation, buildings)
	Ending VBDs reduces inequality in health and economic outcomes	<ul style="list-style-type: none"> ■ VBDs disproportionately affect the bottom billion ■ The poorest of the poor are twice as likely to be infected with malaria as the less poor ■ Controlling VBDs will help the poorest to prosper ■ Health inequity is an important factor in urban centres

Sustainable Development Goal	Relationship	Examples
	Ending VBDs makes cities (and slums) safer	<ul style="list-style-type: none"> ■ The world's tropical and subtropical towns and cities need to "build out" vectors of diseases; this is best achieved with an intersectoral approach involving the urban communities ■ Resilience against VBDs needs to be included in strategic planning for urban development
	Sustainable waste removal will contribute to the reduction of VBDs	<ul style="list-style-type: none"> ■ Reducing the amount of chemicals used for the control of VBDs is feasible by including environmental management such as environmental sanitation ■ Reducing solid waste generation will reduce aquatic habitats for <i>Aedes</i> mosquitoes and flies
	Mitigating the impacts of climate change has the potential to reduce VBDs	<ul style="list-style-type: none"> ■ VBDs are highly sensitive to climatic conditions, especially temperature, rainfall and relative humidity ■ Patterns of epidemiology change more rapidly than health policy can respond ■ Climate change can impact all VBDs
	Maintaining terrestrial ecosystems and halting biodiversity loss will help reduce VBDs in some places, but increase it in others	<ul style="list-style-type: none"> ■ Reforestation could impact malaria in complex ways depending on the vector; e.g. reduce malaria transmission in Latin America, but increase malaria in South-East Asia ■ An increase of rubber plantations in South-East Asia potentially increases the risk of <i>Aedes</i>-borne disease to forest workers ■ Bio-reserves can harbour vector populations
	Mobilizing financial resources will help end VBDs	<ul style="list-style-type: none"> ■ The global effort to control and eliminate VBDs is one of the largest public health initiatives ever undertaken ■ Examples of successful partnerships are the Onchocerciasis Control Programme in West Africa, the Southern Cone Initiative against Chagas disease in South America and the Global Fund to Fight AIDS, Tuberculosis and Malaria

VBD, vectorborne disease



Annex 5. Examples of collaboration for implementing vector control beyond the health sector

Intervention	Ministries/organizations involved in implementation
Insecticide-treated nets, indoor residual spraying, insecticide-treated sheeting or tents	United Nations agencies, nongovernmental organizations, bilateral and multilateral donors, Department of the Environment, private sector
Personal protection with repellents or clothing	Private sector, nongovernmental organizations, bilateral and multilateral donors
Drainage	Department of Public Works, municipalities
Drain clearance	Youth clubs that collect rubbish to sell, community members
Drying larval habitats	Department of Forestry, community participation
Swampland restoration	Department of the Environment
Removal of obsolete concrete water storage containers (used for building)	Department of Public Works, contractor, communities
Filling and levelling of areas with ground pools	Department of Public Works, community participation
Maintenance of irrigation channels	Farmers, Ministry of Agriculture, irrigation authority
Intermittent irrigation	Farmers, Ministry of Agriculture, irrigation authority
Improved housing	Department of Housing, nongovernmental organizations, microfinance initiatives, communities
Improved water supply	Department of Public Works, contractor, municipalities, communities
Larval surveys, application of larvicides	Schools, community groups, municipal corporations, public health staff, Department of the Environment
Improvement of environmental sanitation including solid waste and excreta management	Nongovernmental organizations, Department of Public Works, environmental health departments of health ministries, municipalities
Health education and promotion	Schools, work places, the media (TV, radio, internet), drama groups, religious and community groups, local authority education departments
Monitoring for and preventing spread of invasive species at ports of entry	Border control agencies, trade organizations

Annex 6. Method for estimating costs for workforce, coordination, and vector surveillance and intervention monitoring and evaluation as set out in the response

Costing for implementation of the *Global vector control response 2017–2030* was reliant on numerous assumptions and therefore represents an estimate. Accurate estimates of resource and cost requirements are expected to be made through comprehensive assessments of vector control needs at country and subnational levels.

Method

The cost of implementing the response was derived from estimated quantities of resources required for priority activities¹ (Table 2), multiplied by their associated estimated unit costs. Resource requirements covered: a) staffing of the workforce and their training; b) coordination mechanisms (e.g. meetings for staff, committees and networks); and c) vector surveillance and intervention monitoring and evaluation. The costs of vector control commodities and their deployment or distribution² and of conducting basic or applied research were not included as in general these are accounted for in existing disease-specific strategies, plans, frameworks and resolutions (Annex 3). While there may be some minor replication of costings, such as for components of vector surveillance, in general cost estimates in disease-specific strategies have not considered resources required to enhance public health entomology capacity and capability, improve vector surveillance, or strengthen mechanisms to improve collaboration across and within sectors and promote community involvement in order to address multiple vector-borne diseases.

Resource needs were defined on the basis of country categorizations that considered historic and current vector-borne disease burden.³ This aggregated approach was required to adequately capture transmission potential for the various vector-borne diseases, since burden has been significantly reduced for some as a result of interventions whereas for others recrudescence or emergence has been observed recently. Therefore the maximum annual disability-adjusted life years (DALYs)⁴ observed for each vector-borne disease in the period 2000–2015⁵ was used to generate a total aggregate DALY for each country. Countries were then classified as low (DALYs <1 000 per 100 000 population), medium (1 000 ≤ DALYs <10 000) or high (DALYs ≥10 000). Categorizations were refined on the basis of the number of vector-borne diseases present in the period 2000–2015, whereby a country was increased to a higher category if there were four or was assigned to the upper (“high”) category if there were five or more present. Categorizations were then reviewed by WHO regional offices with adjustment made as necessary (i.e. in the event that there were local vector-borne diseases with significant burden for which DALY estimates were not available).

Total global resource requirements were quantified for a given year in which it is assumed that full implementation of priority activities¹ was achieved. Therefore, these represent a maximum to be reached during the response period once there has been scale-up of personnel and activities. Certain resources were quantified on a per capita basis (e.g. per 500 000 persons at risk), including staffing and coordination at subnational levels. Estimates of the population at risk from at least one major vector-borne disease were generated following the method outlined by Golding and colleagues¹, with adjustment to include human African trypanosomiasis and onchocerciasis. Estimates of populations at risk for each country were adjusted at the request of WHO

1. As defined for interim period of 2017–2022.

2. Such as for long-lasting insecticidal mosquito nets, indoor residual spraying, space spraying and larvicides.

3. A comprehensive risk analysis would incorporate other indicators related to prevention, preparedness and response. An epidemic risk analysis for infectious disease outbreaks at country level is currently being undertaken by the WHO Health Emergencies Programme.

4. DALY is the summary measure used to give an indication of overall burden of disease. Because mortality does not give a complete picture of the burden of disease borne by individuals in different populations, DALYs are used to represent the loss of the equivalent of one year of full health. In this way, the burden of diseases that causes premature death but little disability can be compared to that of diseases that predominantly cause disability but not death.

5. Included American trypanosomiasis, dengue, malaria, human African trypanosomiasis, Japanese encephalitis, leishmaniasis, lymphatic filariasis, onchocerciasis and yellow fever on the basis of available data.



regional offices. Certain resources were quantified on the basis of income level, such as the number of consultants required. Countries were classified by income level according to the World Bank for 2015² except with lower middle and upper middle categories merged to make a middle income category. Income classifications were adjusted one category upwards for those countries in complex humanitarian emergencies or which are highly reliant on an international workforce.

In brief, resource requirements were quantified as follows:

- Staffing: supervisory and technical staff at national level (range: 2–4 persons) and supervisory and field staff at subnational level per 500 000 persons at risk (range: 1–4 persons); consultant full days required (range: 0–16 days);
- Trainings: all staff at national level and subnational level by the number of training days required over 12 months (range: 5–15 days); facilities and supplies for national training (1 meeting room and amenities; pens, paper and other equipment);³
- Meetings: number of meetings (range: 3–5 meetings), attendees (range: 3–10 persons) and days required (range: 1–5 days) for national meetings; attendees (range: 3–10 persons) and days required (range: 1–4 days) for additional subnational (including community-level) meetings for each additional population unit of 500 000 persons at risk; facilities and supplies as above;
- Networks: national supervisory staff to perform coordination function (range: 0.5–1 of full-time equivalent); annual national meeting as above; meeting facilities and supplies as above;
- Surveillance: number of sentinel surveillance or monitoring locations per 500 000 persons at risk (range: 1–2 sites, to a maximum of 25 per country); entomological facilities and equipment (1 package per sentinel site).

Costings for staff salaries and convening of meetings (i.e. transport, per diems, supplies) were estimated using WHO's tools for cost-effectiveness and strategic planning and cost assumptions.⁴ Certain resources were assigned a fixed cost on the basis of income level, such as the vector control needs assessment (range: US\$ 10 000–30 000), national insectary or basic laboratory (US\$ 20 000–60 000), field equipment and field insectary per sentinel site (US\$ 10 000–US\$ 30 000), and additional miscellaneous expenses for administration, document printing and distribution (US\$ 5 000–15 000).

Country-specific estimates were generated and are expressed in constant US\$ 2016. An indication of human resources for 2016 committed to vector control by national vector-borne disease programmes was obtained from selected countries representing a range of disease risk and income categories. Information was used to adjust estimated resource needs and costs as required.

1. Golding N, Wilson AL, Moyes CL, Cano J, Pigott DM, Velayudhan R et al. Integrating vector control across diseases. *BMC Med.* 2015; 13:249. doi:10.1186/s12916-015-0491-4.

2. World Bank (<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>; accessed March 2017).

3. It is assumed that for subnational trainings there will be no additional cost for convening as spare capacities would be utilized (i.e. available meeting rooms and supplies).

4. Cost-effectiveness and strategic planning (WHO-CHOICE), available at <http://www.who.int/choice/en/#> (accessed March 2017); accessed March 2017).

The **Global vector control response 2017–2030 (GVCR)** provides a new strategy to strengthen vector control worldwide through increased capacity, improved surveillance, better coordination and integrated action across sectors and diseases.

In May 2017, the World Health Assembly adopted resolution WHA 70.16, which calls on Member States to develop or adapt national vector control strategies and operational plans to align with this strategy.

Pillars of action

- Strengthen inter- and intra-sectoral action and collaboration
- Engage and mobilize communities
- Enhance vector surveillance, and monitoring and evaluation of interventions
- Scale up and integrate tools and approaches

Foundation

- Enhance vector control capacity and capability
- Increase basic and applied research, and innovation

Successful implementation of the GVCR will require strong country leadership, advocacy, resource mobilization and partner coordination, along with regulatory, policy and normative support.

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