Global framework for the response to malaria in urban areas

World Health Organization

UN HABITAT
FOR A BETTER URBAN FUTURE

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Contents

Foreword

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By 2050, nearly 7 out of 10 people globally will live in cities and other urban settings. Although many will benefit from their urban status, rapid and unplanned urbanization can have negative social and environmental health impacts. The poorest and most vulnerable will be the hardest hit by the effects of climate change and the increased risk of new and re-emerging epidemics, including vector-borne diseases such as malaria, which already kills more than 600 000 people per year.

The poorest communities already face deep health inequities, both in their access to care and economic vulnerability. Urbanization without proper planning further exacerbates the risk of malaria transmission and other diseases. The risk of malaria is heightened by the growth of informal settlements without adequate water, sanitation and drainage facilities. This is compounded by the invasion of new species of mosquitoes.

Cities are uniquely positioned to understand local needs, convene coalitions, and respond rapidly to changing conditions to safeguard health. These changes require strong city leadership to implement multi-sectoral, health-relevant policies and public services that engage communities. The response to malaria must be an integral part of such policies and processes.

The world today has a unique opportunity to guide urbanization and other major urban development trends. Urban areas are expected to more than double by 2050. Well thought-out urban planning now can both improve health equity and make cities more resilient against the threat of malaria and other vector-borne diseases.

This framework supports the control and elimination of malaria in urban environments. It provides guidance for city leaders, health programmes and urban planners as they respond to the challenges of rapid urbanization. The framework was developed as part of a Memorandum of Understanding between WHO and UN-Habitat signed in 2021, aimed at improving urban health.

As described in this framework, much of the essential infrastructure required for any town or city – such as reliable piped water, surface water drainage, sanitation, waste management, and well governed, accessible quality health care – can contribute to the control of malaria and other mosquito-borne diseases.

Innovation can play an important role in the response to malaria in urban settings. Technology can help to improve disease surveillance systems, map changes in land use, and deliver malaria interventions where they are needed the most.

Controlling and eliminating malaria in urban areas can contribute directly to the health targets of the 2030 Sustainable Development Goals, the New Urban Agenda, and the WHO *Global technical strategy for malaria 2016-2030*. Through targeted action, working together, we can help ensure healthier and more sustainable cities for all.

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Abbreviations

CDR	call data records
CORP	community-owned resource persons
GIS	geographic information system
GPS	global positioning system
GTS	*Global technical strategy for malaria 2016–2030*
IRS	indoor residual spraying
ITN	insecticide-treated net
LMIC	low-and middle-income country
LMIS	logistic management information systems
MAAR	Ministry of Agriculture and Animal Resources (Sudan)
MFI	Khartoum Malaria Free Initiative
RDT	rapid diagnostic test
SDG	Sustainable Development Goal
TFA	Transform Freetown Agenda
UN	United Nations
UMCP	Urban Malaria Control Programme (Sudan)
WHO	World Health Organization

Glossary

Anthropophagic: The tendency of some malaria mosquitoes to feed on humans.

Climate change: A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

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

Environmental management: Changing the environment to reduce the risk of malaria transmission, particularly improving drainage, water storage, sanitation and waste management, housing with screens on doors and windows, urban agriculture without surface water pooling, filling of swamp areas and other stagnant water sources other construction activities that eliminate potential breeding sites.

House screening: Installing mesh barriers or closing gaps to prevent malaria mosquitoes from entering houses.

Horizontal coordination/horizontal integration: Coordination of the functions, activities or operating units that are at the same stage of the service production process; examples of this type of integration are consolidations, mergers and shared services within a single level of care.

Informal settlement: The terms "informal settlement" and "slum" and are often used interchangeably. Informal settlements are areas developed outside of planning regulations and legally sanctioned housing and land markets, whilst slums are urban areas characterized by poverty and substandard living conditions (see definition of *slum* below).

Malaria case, imported: Malaria case or infection in which the infection was acquired outside the area where it is diagnosed.

Malaria control: Reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level as a result of deliberate efforts. Continued interventions are required to sustain control.

Malaria treatment, preventive: Intermittent administration of a full therapeutic course of an antimalarial either alone or in combination to prevent malarial illness by maintaining therapeutic drug levels in the blood throughout the period of greatest risk.

Note: World Health Organization–recommended preventive treatment includes intermittent preventive treatment of infants and pregnant women, seasonal malaria chemoprevention, perrenial malaria chemoprevention and mass drug administration, depending on context.

Monitoring and evaluation: "Monitoring" is the gathering and use of data on programme implementation (weekly, monthly, quarterly or annually); its aim is to ensure that programmes are working satisfactorily and to make adjustments if necessary. "Evaluation" involves a more comprehensive assessment of a programme; it is normally undertaken at discrete times and addresses the longer-term outcomes and impacts of programmes. The goal of monitoring and evaluation is to improve the effectiveness, efficiency and equity of programmes.

Peri-urbanization: To express the urbanization of former rural areas on the fringe, both in a qualitative sense (e.g. diffusion of urban lifestyle) and in a quantitative sense (e.g. new residential zones).

Prevalence: The proportion of a human population infected with malaria.

Primary health care: A whole-of-society approach to health that aims to maximize the level and distribution of health and well-being through three components: (1) primary care and essential public health functions as the core of integrated health services, (2) multisectoral policy and action, and (3) empowered people and communities.

Quality care: Care that is safe, effective, people centred, timely, efficient, equitable and integrated.

Slum: A group of individuals living under the same roof in an urban area who lack one or more of the following: (1) durable housing of a permanent nature that protects against extreme climate conditions, (2) sufficient living space which means not more than three people sharing the same room, (3) Easy access to safe water in sufficient amounts at an affordable price, (4) access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people and (5) security of tenure that prevents forced evictions.

Stratification, malaria: Classification of geographical areas or localities according to epidemiological, ecological, health system, socioeconomic and other determinants for the purpose of guiding malaria interventions.

Note: Microstratification, which is the stratification of malaria risk and its determinants at a granular and operationally relevant level when the disease transmission is focal, is essential to ensuring a tailored response.

Subnational tailoring, interventions and strategies: Use of local data and contextual information to determine the appropriate mixes of interventions, and in some cases delivery strategies, for a given area, such as a district, health facility catchment or village, for optimum impact on transmission and burden of disease, within the context of value-based healthcare delivery.

Surveillance: Continuous, systematic collection, analysis and interpretation of disease-related data and use in planning, implementing and evaluating public health practice.

Note: Surveillance can be done at different levels of the healthcare system (e.g. health facilities, the community), with different detection systems (e.g. case based: active or passive) and sampling strategies (e.g. sentinel sites, surveys).

Universal health coverage: Ensuring that all people have access to needed promotive, preventive, curative, rehabilitative and palliative health services, of sufficient quality to be effective, while also ensuring that the use of these services does not expose any users to financial hardship.

Urban: In this document urban areas are seen as a continuum, from rural settings to growing towns to cities and mega-cities of many millions (see Box 1). In relation to this global framework, this is a built-up area that has a mayor, municipal or city leader that can help with a degree of autonomy to rapidly initiate and manage a locally adapted and sustainable malaria control programme within the boundaries of their settlements. This response should be done with guidance and support from national malaria programmes.

Urban resilience: The capacity of individuals, communities, institutions, businesses, and systems within in a city to survive, adapt, and grow no matter what kind of chronic stresses and acute shocks they experience.

Urban and territorial planning: A decision-making process aimed at realizing economic, social, cultural and environmental goals through the development of spatial visions, strategies and plans, and the application of sets of policy principles, tools, institutional and participatory mechanisms, and regulatory procedures.

Urban governance: The software that enables the urban hardware to function, the enabling environment (requiring adequate legal frameworks; and efficient political, managerial and administrative processes), and strong and capable local institutions able to respond to citizens' needs.

Vector: Insects or ticks which spread a pathogen from one person to another during blood feeding. In malaria, adult females of any mosquito species in which Plasmodium undergoes its sexual cycle (whereby the mosquito is the definitive host of the parasite) to the infective sporozoite stage (completion of extrinsic development), ready for transmission when a vertebrate host is bitten.

Note: Malaria vector species are usually implicated (incriminated) after field collection and dissection indicates that the salivary glands are infected with sporozoites; specific assays can be used to detect and identify circumsporozoite protein, especially where infection rates are low.

Vertical coordination/vertical integration: The coordination of functions, activities or operational units that are in different phases of the service production process. This type of integration includes the links between platforms of health service delivery – for example, between primary and referral care, hospitals and medical groups, or outpatient surgery centres and home-based care agencies.

Zoophagic: The tendency of some malaria vectors to feed largely on animals.

Executive summary

This executive summary presents an overview of the *Global framework for the response to malaria in urban areas* for policy-makers and relevant stakeholders. The framework has been developed through wide and multidisciplinary consultations, and is based on published evidence and best practices. This response to malaria in towns and cities is expected to have many co-benefits in improving health and well-being.

The framework provides guidance to countries on undertaking a comprehensive malaria response in urban areas,[1] recognizing the following facts.

- In a few years, most people living in malaria-endemic countries will reside in urban areas.
- Urban areas and rural areas can differ in the dynamics of the transmission and burden of malaria and other vector-borne diseases.
- Invasion by vectors that are adapted to breeding in urban environments, such as the recent spread of *Anopheles stephensi* in Africa, may be putting urban populations at increased risk.
- In urban settings, approaches that work to prevent disease transmission in rural areas may not work, or may need to occur at a smaller, more targeted scale.
- Consequently, the malaria response in urban areas requires data on the determinants that are unique to urban ecosystems and lead to a focal malaria transmission and disease burden.
- Leadership of government departments, industry and finance, research, academia and other sectors tend to be concentrated in urban areas. This provides a greater opportunity for integrated, multisectoral policies, strategies and actions.
- As urbanization rapidly increases, there is greater focus on healthier and more resilient cities, including global political will to address the threats posed by climate change.

Who is this document for?

The target audience for this framework includes:

- city leaders;
- heads of national public health and malaria programmes; and
- communities and other stakeholders in governance, policies and service delivery affecting people exposed to malaria living in urban areas.

1 In most malaria-endemic countries, rural populations still bear the greatest burden of malaria. This *Global framework for the response to malaria in urban areas* does not recommend removing resources from rural areas, where the need is greatest and the biggest gains are likely to be achieved. However, it does recognize the need for the response in urban areas to be tailored to that context.

The framework is aligned with the World Health Organization (WHO) principles on universal health coverage *(1)* and primary healthcare provision *(2)*, the Sustainable Development Goals (SDGs) *(3)*, the *Global technical strategy for malaria 2016–2030 (4)* and the *Global vector control response 2017–2030 (5)*.

Why control and eliminate malaria and other mosquito-transmitted diseases in urban areas?

Health and well-being are basic human rights across all settings and communities. The malaria response in urban areas, first and foremost, aims to ensure the protection of these basic rights for urban communities. A healthier city is a wealthier city, in terms of both social and economic capital. Most of the global gross domestic product is generated in cities. Cities that prosper also generate the public and private revenues required for urban and rural development, and emergence of better-planned cities in the future.

Malaria is one of several important mosquito-transmitted diseases, together with dengue, chikungunya, yellow fever and Zika, found in cities. To build resilient and sustainable cities for the future, it is important to reduce biting by all species of urban mosquitoes, not just those that transmit malaria.

As in rural settings, the poorest urban residents are most impacted by malaria. They are at greater risk of becoming infected, are less able to access quality services and suffer the most from the impact of getting ill. Therefore, malaria control in the poorest areas should be a public health and societal priority.

Much of the essential infrastructure and services required for any town or city – including adequate housing and the provision of basic services such as reliable piped water, rainwater drainage and waste management – will have a direct impact on reducing the transmission of malaria and other mosquito-transmitted diseases.

Tackling climate-related threats can have direct benefits for controlling mosquito-transmitted diseases. Preventing flooding, for example, would reduce the breeding sites of malaria-transmitting mosquitoes. During periods of drought, people store drinking water in containers in an unsafe manner, providing breeding sites for *Anopheles stephensi* and other important malaria mosquitoes, as well as *Aedes* mosquitoes that transmit major viral diseases such as dengue, chikungunya, yellow fever and Zika. Provision of reliable piped water would reduce the threat from all these mosquito-transmitted diseases.

Why focus on malaria in urban areas?

By 2050, the global urban population is likely to more than double, and nearly seven out of 10 people will live in cities. Of this growth, 90% will occur in Asia and Africa *(6)*. Rapidly increasing urbanization has been recognized as a major determinant of economic, social and health outcomes. For this reason, the United Nations launched the 2016 New Urban Agenda *(7)* as part of the 2030 Agenda for Sustainable Development.

Globally, malaria kills more than 600 000 people per year and makes more than 200 million sick *(8)*, predominantly in rural areas. However, in most malaria-endemic countries, the percentage of the population living in urban areas will soon exceed

that in rural areas. For example, in seven of the 11 countries with the highest burden of malaria (which account for 70% of the global burden), the percentage of the population in urban areas ranges between 30% and 50% *(6)*. Even though the burden of malaria in these countries is still higher in rural areas, most of the population is already in urban areas or will be in a few years.

Furthermore, 60% of urban areas that will exist in 2050 have not yet been built *(9)*. The malaria response must now transition from one designed for rural areas to one that addresses the needs of both rural and urban populations. Urbanization presents a unique opportunity to plan and make these cities resilient to the threat of malaria and other vector-borne diseases, and equipped to deliver quality services to all those in need.

Malaria transmission in urban areas is modified considerably by human activities *(10)*. Generally, well-planned urbanization reduces malaria transmission through the destruction of the aquatic habitats of mosquitoes, prevention of mosquito biting indoors through improved housing and expanded access to health care *(10–12)*. However, urbanization in malaria-endemic countries comes with risks. Large-scale rural to urban migration results in the expansion of unplanned settlements and increased socioeconomic inequity, especially in peri-urban areas and urban informal settlements. It may also lead to irregular and unsafe water supplies, and poorly managed urban agriculture, which are also associated with increased malaria risk.

Urbanization can also lead to the adaptation of mosquitoes to polluted waters, invasion by new mosquito species and, potentially, changes in the biting behaviour of mosquitoes *(13, 14)*.

In some countries, a considerable proportion of the population in urban areas seeks malaria treatment in the private sector. This can lead to very poor urban households incurring punitive health expenditures and/or seeking health care from poor-quality sources *(15)*.

Finally, many urban malaria cases may be due to infections acquired outside the city or town, without major risks of onward transmission in the urban setting *(16, 17)*.

These characteristics of malaria transmission and the malaria burden in urban areas require specific adaptations of preventive interventions and strategies to expand access to care to target clusters of transmission. Surveillance systems to document sources of infections are also needed.

Many towns and cities around the world are currently unprepared to deal with the control and elimination of malaria and other mosquito-transmitted diseases. This framework explains the action needed to make urban settings resilient to the threat of these diseases. It is designed to support the control and elimination of urban malaria to achieve the targets set in the *Global technical strategy for malaria 2016–2030 (4)*. It provides comprehensive guidance to town and city governors, health programmes and urban planners on moving towards a malaria-free vision for their towns and cities.

How can malaria and other mosquito-transmitted diseases be controlled in towns and cities?

As described in details in Parts 2–9, the framework has one leadership element, two strategic elements (community engagement and multisectoral response, and integrated strategic and response planning), three pillars (surveillance, prevention and quality clinical care) and one enabling element (innovation, research and development).

- **Urban leadership.** City leaders should lead the response, with support from national programmes, communities, partners and funding organizations. The response must be an integral part of the urban planning, policy-making and budgeting processes.

- **Community engagement and multisectoral response.** Full engagement of communities is essential in decision-making, priority setting and demand for services. The response also requires a multisectoral approach to disease control and elimination.

- **Integrated strategic and response planning.** The malaria response must be part of the established processes for urban health planning. It should be led by urban or municipality governments, with strong technical support from national malaria programmes and close links to central authorities, partners, the private sector and communities. In some settings, integrated disease and mosquito surveillance are essential.

- **Surveillance systems.** Malaria transmission in urban areas is usually focal, concentrated in pockets that have the right conditions for mosquito breeding. Some foci of transmission may also be transient, related to time-bound development and other activities. High-resolution mapping of foci of transmission, through the process of microstratification (stratification of risk and its determinants at a granular and operationally relevant level), is essential to achieve a tailored response. Imported malaria is an important concern in urban areas. Disease surveillance systems should therefore be case based, collecting information on patient residence and travel history to assess the possible place of infection. This information will help to ensure an effective, targeted response.

- **Malaria prevention.** Mosquito control requires provision of reliable piped water, improved housing, drainage and environmental management. These should be combined with judicious use of insecticide and microbial-based interventions, complemented by chemoprevention and use of vaccines in high-risk groups, where appropriate. Malaria control, where possible, should be integrated with the response to other vector-borne diseases, including integrated vector surveillance. The uniform delivery of preventive interventions, such as insecticide-treated nets and indoor residual spraying, to entire urban populations is unlikely to be cost-effective.

- **Quality clinical care.** Access to equitable, quality health care, with prompt diagnosis and effective treatment, is important. Special attention should be paid to the poorest and most vulnerable, who are least likely to be able to afford care.

- **Innovation, research and development.** Research and innovation in interventions, surveillance and analytics, delivery systems, social and behavioural change, community and multisector engagement, and other

relevant aspects are key to an effective malaria response in urban areas. Careful evaluation of these approaches is required to provide the evidence needed for policy change (See Part 9 for more details).

What is the role of city leaders?

City, local government and district leaders have a central role to play in the global fight against malaria and other vector-borne diseases. Malaria is a disease of the environment that is modulated by human activities and social determinants. Local governments have a large influence on these through their responsibility for housing, infrastructure and other basic services. City leaders have already united to tackle global issues – such as climate change, HIV/AIDS and the impact of the COVID-19 pandemic – to create healthier cities. Eliminating urban malaria is central to SDG 11: "Make cities and human settlements inclusive, safe, resilient and sustainable". Local governments are essential to achieving this goal and to establishing trust, coordination and collaboration with local communities, who play a key role in the response. This approach builds onto the resilient cities network where urban areas have the capacity to adapt to chronic stresses and acute shocks.

What is the role of communities?

Malaria control is critically dependent on harnessing local knowledge and skills within communities by engaging with residents through enhanced communication and support. This will ensure that the fight against malaria is based on the community's context, to build resilience against future disease outbreaks. Urban community networks and organizing systems may be different from those in rural areas in access to and use of information, organizing structures (e.g. familial, ethnic, peer, occupational), lifestyles and health behaviours.

Participatory community-based approaches involve a process of dialogue, learning, decision-making and action such that community members can collectively identify, analyse and prioritize problems that affect them. These approaches must be proactive and led by the relevant city authorities. All members of the community, including vulnerable and disempowered groups, must have their voices heard and be able to participate in the malaria response. In the context of health services, emphasis is on:

- not what gets done, but how things get done and by whom;
- the quality of relationships between stakeholders;
- the patterns of interaction over time;
- the strength of connection between different parts of the health system; and
- the link between staff experience, patient experience and outcomes of interest – in this case, a malaria-free city.

How do we secure resources for urban malaria control?

Despite the clear benefits of malaria control, the framework recognizes that accessing resources for any initiative is challenging for local governments and provides suggestions on funding sources. The framework is a call to domestic and international funding agencies and donors to support the response to the unique challenges of urban

malaria and other mosquito-transmitted diseases, and to maximize opportunities for prevention. Communities, city leaders and multisectoral stakeholders must be at the centre of resource mobilization and advocacy efforts, and defining their priority actions. The framework provides information on some international mechanisms that can be engaged to support the response to malaria in urban areas.

What does success look like?

In the short term, a measure of success is an effective malaria response policy, integrated within a broad development agenda, for urban areas for each malaria-endemic country. There will be no single strategy that works for all urban settings in a country, and each urban government should develop approaches for its own context, in alignment with national health sector policies and strategies.

Led by leaders of cities, strong engagement is required between national malaria programmes and urban governments in developing, implementing and monitoring the integrated response to urban malaria.

Appropriate indicators for response, monitoring and evaluation should be developed for each urban context. These should be measured through surveillance systems and other data sources. City programmes should have the appropriate digital platforms to track the malaria response, and changes in malaria transmission and burden.

In the long term, the aim is to contribute to building cities that "work" – that is, cities that are healthy, inclusive, resilient and sustainable. This requires intensive policy coordination, and multisectoral engagement and investment *(18)*. National and local governments, supported by international agencies and domestic partners, have an important role to play – they need to act now to shape the future of their cities and create opportunities for all. Eliminating malaria and *Aedes*-transmitted viral diseases, such as dengue, chikungunya, yellow fever and Zika, as a public health problem will be essential to this ambition.

What are the challenges and opportunities in the response to malaria in urban areas?

Challenges

Multiple interconnected challenges can impede the establishment of multisectoral urban malaria programmes. Many of these are outside the influence of the health sector and require engagement of urban leaders. In some instances, they require the intervention of national leaders. In all instances, multi-stakeholder engagement is essential. Challenges include the following.

- **Mindset.** In many malaria-endemic countries, especially those with moderate and high transmission, investment in malaria goes mainly to commodities, with little distinction between the response in rural and urban areas. Wider environmental and social determinants of malaria, although recognized, are neglected. In addition, few city governments consider malaria as an integral part of their urban health and development agenda.

- **Resources.** Most malaria-endemic countries are of low or low–middle income. This means that resources are limited for urban development activities that

affect transmission of vector-borne diseases, and for direct interventions to prevent and treat malaria, surveillance, monitoring and evaluation.

- **Policy and development.** Development of urban settings in malaria-endemic countries is often poorly planned, with limited coordination between various sectors, increasing the challenge of addressing infectious diseases. As future cities emerge, this trend will hamper the malaria response in urban settings.

- **Governance structures and processes.** In many countries, especially those with centralized governance and budgetary processes, many urban governments do not have sufficient authority to make key decisions. National programmes historically also do not have the experience and skills to develop and implement an integrated multisectoral urban response plan for malaria. Efficient investment of resources may be hampered by system wastages and corruption. Relevant by-laws need to be enacted across all sectors, and compliance with them monitored.

- **Information and evidence.** Since malariain urban areas is under-studied, there is a dearth of information about the magnitude of the burden and what constitutes an effective intervention. High-resolution data and sophisticated surveillance systems are needed to inform the response because of the high concentration of people in small geographic areas, as are well designed research studies to evaluate the impact of interventions.

- **Environment and behaviour.** Urban settings often have specific vulnerabilities to infectious diseases because of informal settlements, poor housing, poor drainage, poor waste management, insecurity, high population mobility, and deep inequalities in disease prevention and care. As well, high population densities increase the risk of large outbreaks that are not detected early by surveillance systems.

- **Geography.** Many cities are not well suited to further expansion because of geographical and topographical limitations. This can result in undesirable development, burdens on services and social tensions that inhibit healthy living conditions.

- **Movement of people and goods.** Increased movement of people both nationally and internationally through migration, displacement or employment will increase the speed with which new strains of malaria parasites, other pathogens and mosquitoes move around the globe. These factors further complicate the delivery of effective malaria control, and can undermine access to diagnosis and treatment.

- **Inequities and lack of inclusion.** The urban poor are subject to a broad range of unacceptable and complex challenges that make them more vulnerable to disease and the consequences of ill health. As well as economic hardship, they have fewer rights and less access to planned services, and face other challenges such as insecurity, poor housing and poor sanitation. Their voices are not heard, and they are often invisible to the authorities.

- **Biological threats.** Parasites and vectors are continuously adapting their behaviour and genetically evolving to evade malaria interventions. Insecticide and drug resistance, *Pfhrp2/3* gene deletions and invasion of vector species in new habitats all present important challenges.

Opportunities

A large proportion of the population in malaria-endemic countries resides in urban areas. This is rapidly increasing; in a few years, most of the population in malaria-endemic countries will be urban. Now is the time to adapt to these changes and implement effective malaria programmes. Opportunities across all sectors and stakeholders include the following.

- **Development.** As well as controlling malaria, environmentally sustainable and resilient development will control other infectious diseases, improve living conditions for citizens, and enhance well-being and economic productivity. The potential benefits of this framework in contributing in these ways to the New Urban Agenda and the accompanying Healthy Cities, Healthy People initiative are enormous.

- **Leadership.** Much can be achieved with dynamic city leadership, leaving a long-lasting legacy for the health and well-being of the citizens of a town or city. National malaria programmes have an important role to play in assisting towns and cities to adopt this framework.

- **Innovation.** Towns and cities are the engines for change and innovation. National and international academic communities, alongside product innovators, can collaborate with multisectoral programmes to develop new innovations for the control and treatment of malaria.

- **Cost opportunities.** Compared with rural residents, urban communities have greater access to senior management, health workers, financial resources, effective infrastructure, electricity, transport, communications and supply chain management. High population densities facilitate wide access to healthcare facilities and services, and reduce costs per person, particularly for large infrastructure development projects.

- **Technology.** Towns and cities are often centres for innovation, with many having centres of research and development. Local talent can be used to develop advanced surveillance systems and innovations in malaria control.

- **Environmental management.** Urban areas are associated with intense infrastructure development and land-cover change. The design of new housing and screening approaches, as well as the modification or manipulation of the urban environment can reduce the number of mosquito breeding sites, the number of mosquitoes emerging from these sites and the number of adult mosquitoes biting people. This could considerably reduce malaria transmission.

- **Urban resilience.** As cities develop mitigations against future threats, many are working through resilient city networks to achieve these goals. Control of mosquito-transmitted diseases in urban areas is a considerable threat and one that can be integrated into a resilient city network approach.

- **Research and development.** Ongoing investment in malaria research and development is likely to yield new high-impact tools. Field evaluations of such tools must include urban settings. Investment across the different aspects of the response, such as household and engineering solutions, is needed; where such work is ongoing, studies should ensure a component of impact of interventions on malaria risk.

Part 1. Background

1.1 Current global malaria context

Malaria remains a major public health problem in many parts of the world, particularly in sub-Saharan Africa, where more than 95% of cases occur *(8)*. Although impressive gains have been achieved in reducing the incidence of the disease since 2000, progress has slowed in recent years, with some countries registering increases in burden. In response to the stalling of progress, the World Health Organization (WHO) and the RBM Partnership to End Malaria launched the "high burden to high impact" approach *(19)*. Also more than half of malaria-endemic countries now have fewer than 10 000 cases each year and are close to malaria elimination *(8)*. To support their efforts, WHO launched the E-2020 initiative, later progressing to the E-2025 initiative, to accelerate malaria elimination in several countries that have a very low burden of malaria *(20)*.

The epidemiology of malaria varies considerably around the world. In areas of moderate and high transmission – defined by WHO as areas with an annual incidence of more than 250 cases per 1000 population or a prevalence of *Plasmodium falciparum* infection in children aged 2–10 years of 10% or more – the disease is concentrated in young children. As transmission declines, the age pattern changes, and older children and adults make up a higher percentage of cases, with population movement and occupation-related exposure becoming key drivers.

Even in moderate- and high-transmission countries, urban areas have unique transmission dynamics (**Table 1**) because of differences in environmental, socioeconomic and health system factors between urban and rural areas. Overall, transmission is lower in urban areas, and increasing urbanization is likely to further reduce malaria transmission. However, without careful planning, urbanization may result in a disproportionately high disease burden, including malaria, particularly among low-income, poorly served communities.

WHO does not currently have recommendations or implementation guidance specific to malaria in urban areas. Most of the evidence underpinning current WHO recommendations on malaria prevention relies on efficacy data from rural malaria-endemic settings. Consequently, most countries implement similar interventions in both urban and rural settings, despite important differences in the transmission dynamics of malaria, and environmental, behavioural, socioeconomic and care-seeking determinants (**Table 1**). Various interventions for which there are no WHO recommendation have been implemented in different settings. While these may work within specific contexts, often there is no systematic evidence of impact and their adaptations to other settings should be done judiciously. Some interventions such as piped water, better drainage, good housing and cleaner environments are the basic rights of urban citizens.

Table 1. Differences between rural and urban areas that may elicit a different response to malaria

RURAL	URBAN
Transmission is mainly due to natural ecology, although some human activities (e.g. mining) may lead to increased risk	Transmission is influenced considerably by environmental modifications, and prevalence and incidence are influenced by human population movement
Transmission is generalized in most moderate- and high-transmission settings, but focal in low-transmission and elimination settings	Transmission is mostly focal – often higher in peri-urban areas and informal settlements – with a few areas accounting for most local infections
In moderate- and high-transmission settings, most older children and adults have immunity	Overall population immunity is low
Most infections are locally acquired	A large proportion of infections may be linked to travel to and from rural areas with higher transmission
The public health sector is often the main source of care for fevers	The private health sector is a major source of care for fevers, especially in sub-Saharan Africa
High acceptability of IRS and ITNs, and use of ITNs	Moderate or low acceptability of IRS and ITNs, and use of ITNs in some settings
Most housing types allow high levels of indoor mosquito biting	Many housing types reduce indoor biting, except in poor-quality housing in low-income areas
Aquatic habitats of malaria mosquitoes are often large and plentiful (e.g. flooded grasslands, drainage channels, large pools)	Aquatic habitats are more diverse (e.g. polluted pools, flooded fields, overhead tanks, stagnant pools, other exposed water features)

IRS: indoor residual spraying; ITN: insecticide-treated net.

1.2 Defining urban areas

In practice, it is difficult to establish a universal method for defining urban areas. This makes it challenging to conceptualize malaria in urban areas, characterize its unique determinants, define malaria risk and develop urban-specific malaria control recommendations.

Some areas defined as urban may have transmission and disease risk characteristics and determinants that resemble those of rural areas, and thus could benefit from similar interventions and strategies. Others have unique characteristics and may require a different set of targeted approaches.

In reality, the distinction between urban and rural is often a continuum of degrees of urbanicity, and the definition of "urban" may depend on the context. Various approaches to defining urban areas that have been used by countries are described in **Box 1**. Countries can use one of these definitions, or a combination, to suit their context.

Additional guidance on the definition of urbanicity can be found in a methodological manual to define cities, towns and rural areas for international comparisons that has been produced by UN-Habitat, in close collaboration with other international organizations *(21)*.

BOX 1. WHAT IS AN URBAN CENTRE?

In this document, urban areas are seen as a continuum, from rural settings to growing towns to cities and mega-cities of many millions.

A combination of the following criteria can be useful in defining urban entities:

- administrative governance;
- population size and density;
- types of housing, infrastructure and economic activities; and
- levels of connectivity and mobility.

Countries should, therefore, use relevant national criteria and contextual information to define urban areas. Descriptions that may help guide urban definitions include the following.

Large urban centres include megacities, urban areas with a clear central business district (CBD) and suburbs with varying levels of population density (e.g. Lagos, Nigeria; Manaus, Brazil).

Large urban centres resulting from conurbations occur where two or more distinct urban centres progressively grow and see their population density increase, until they merge into a single metropolitan area (e.g. Accra-Tema, Ghana; Metro Manila, Philippines).

Smaller or secondary urban centres are typically towns that have a small CBD, possibly some small satellite areas and radial linear expansion along major transport routes (e.g. Mbale, Uganda; Aboisso, Côte d'Ivoire).

Large villages and small towns are relatively compact settlements but differ from urban centres in having little fringe expansion (e.g. Nyanga, Zimbabwe; Bonsaaso, Ghana).

Rural areas are disbursed settlements with low-density housing (e.g. rural Burkina Faso or Uganda) or settlements with high-density housing confined to a small area (e.g. rural Gambia).

In relation to the the response to malaria in urban areas, who has a degree of autonomy to rapidly initiate and manage a locally adapted and sustainable malaria control programme within the boundaries of the settlement. This response should be done with guidance and support from national malaria programmes.

1.3 Urban growth

Today, 56% of the global population – 4.4 billion people – live in cities *(6)*, signalling an unprecedented era of urban growth (**Fig. 1**). By 2050, with the urban population more than doubling, nearly seven out of 10 people will live in cities; 90% of this growth is occurring in Asia and Africa *(22)*, associated with changing demographic age patterns *(23)*.

The speed and scale of urbanization bring many challenges, including access to basic services such as adequate housing, clean water, sanitation, areas resistant to flooding and green spaces. Addressing these issues will reduce the threat of malaria

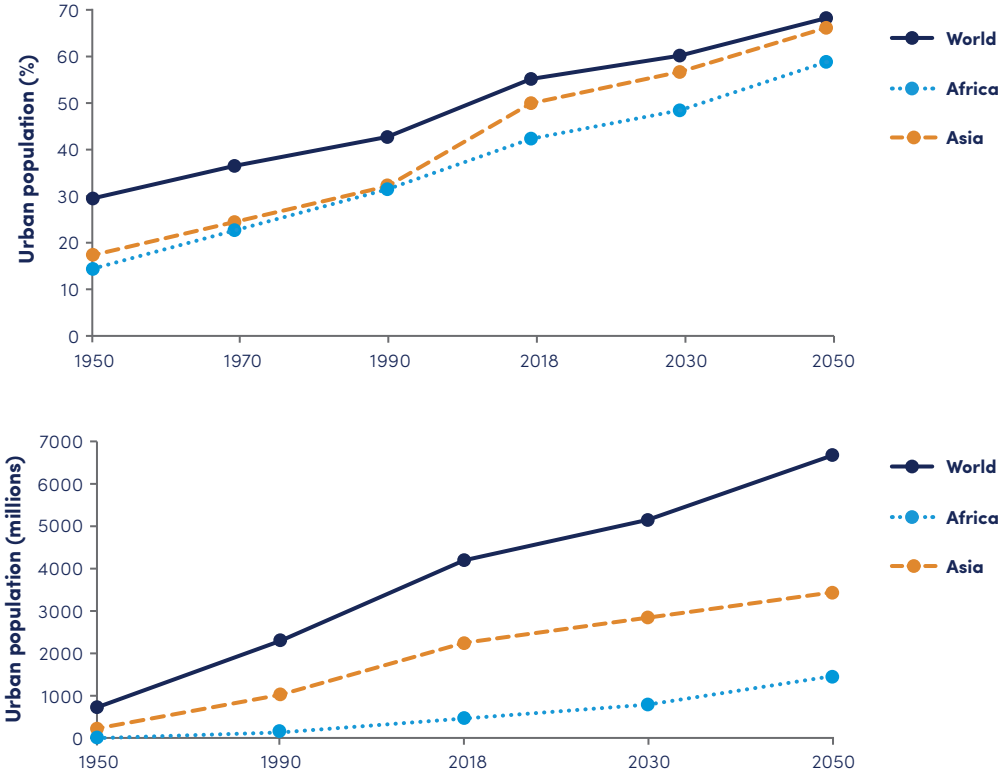
and other major mosquito-transmitted diseases, such as dengue, chikungunya, yellow fever and Zika. Since 60% of urban areas that will exist in 2050 have not yet been built *(9)*, we have a unique opportunity to plan ahead and make our cities resilient to the threat of these diseases.

Sub-Saharan Africa has the fastest urban growth worldwide and currently accounts for more than 95% of the burden of malaria. By 2050, the current population of 1.4 billion people in Africa is expected to increase by nearly 1 billion people, roughly equivalent to the current population of India or China *(22)*. Worryingly, nearly half of Africa's urban population currently lives in inadequate housing, a proportion that has changed little since the start of the century *(24)*. Asia's urban population is the second-fastest growing worldwide, expected to increase from 50% of the total population in 2018 to 66% by 2050. More than 69% of the population of the Western Pacific region and more than 80% of the population of the Americas currently reside in urban areas; projections suggest that nearly all of the populations of these regions will be urban by 2050.

Of particular concern are secondary cities, which account for most urban growth but are particularly under-resourced and have high levels of deprivation. Secondary cities attract less investment than administrative and financial capitals, face unregulated growth and often develop in unfavourable locations from a health perspective (e.g. mining towns).

In many urban settlements, malaria is peri-urban – that is, transmission is focused on the periphery of the settlement. However, it is not unusual for mosquito breeding sites to be found within the heart of the settlement. Where there are malaria vectors that breed in water-storage containers, such as in Asia, the pattern may be defined by lack of access to reliable piped water.

Fig. 1. Rate of urban growth of population in Africa and Asia



Source: United Nations (22).

1.4 Malaria in urban areas

WHO recognizes that urbanization is a major environmental challenge that will affect malaria; understanding the benefits of urbanization and mitigating its risks are necessary to achieving global malaria eradication *(10–12)*. Globally, malaria remains predominantly entrenched in rural sub-Saharan Africa *(8)*. In this region, the disease spills into urban areas either by direct transmission within urban settings or by importation by human movement from the countryside (**Table 1**). Almost invariably, the risk of malaria in urban areas is greatest in informal and low-income settlements. The 10 countries with the highest malaria burden in sub-Saharan Africa are predicted to reach 50% urbanization by 2030, an increase of 119 million urban citizens *(22)*. Therefore, it is essential that this urban growth is appropriately managed to mitigate the risks of malaria.

In Asia, malaria is also a persistent problem, although most cities are now free from malaria. The South-East Asia region contributed nearly 5 million cases in 2020, equivalent to 2% of the global burden *(8)*. Here, there are also concerns that rapid urban growth will increase the threat of malaria in urban areas. India, which will have 416 million new urban citizens by 2050, is one of the world's 10 highest malaria burden countries, accounting for more than 80% of cases in South-East Asia in 2020.

In the Americas, where there were more than 650 000 malaria cases in 2020, the rate of urbanization is lower. However, the region will have an additional 159 million urban citizens by 2050, with 88% of the population living in cities by that time *(22)*.

With such rapid urban expansion adding to the already large urban populations in malaria-endemic settings, national malaria responses must be adapted accordingly. Overall, urbanization will reduce the transmission of malaria. However, depending on the extent of planning and development, growing urban populations can be vulnerable to malaria and other mosquito-borne diseases. Importantly, malaria in urban areas is likely to disproportionately affect the most vulnerable, marginalized poor.

Urban settings also face the challenge of other mosquito-borne diseases, particularly those transmitted by *Aedes* mosquitoes, including dengue, Zika and yellow fever – all diseases that have the potential to cause epidemics. Dengue is the fastest-increasing arbovirus (arthropod-borne virus) disease in the world. Globally, 2.3 billion more people will be at risk of this disease in 2080 than in 2015, bringing the world's total population at risk to more than 6.1 billion people *(25)*. Those most at risk from *Aedes*-transmitted viruses are urban citizens of Asia, followed by Latin America and sub-Saharan Africa. In the future, the potential for epidemics of dengue and other arboviruses in African towns and cities is enormous and represents a huge threat to urban populations. An integrated response to the control of malaria and *Aedes*-transmitted diseases, as described in the WHO *Global vector control response 2017–2030 (5)* and, more recently, the Global Arbovirus Initiative *(26)*, is essential.

1.4.1 Ecology of malaria in urban areas

As urbanization increases and the nature of cities changes, mosquitoes are adapting to this new world (see **Box 2**). The urban environment represents a unique combination of rural, peri-urban and suburban living conditions. Urban agriculture, gardens and parks, as well as new human-made aquatic habitats formed by poor drainage, excavations, accumulation of solid waste and built features like open water-storage tanks, may contribute to the risk of malaria in these settings. Mosquitoes constantly adapt to new niches and are now increasingly found in habitats that are polluted, shaded or underground *(27)*. Mosquitoes may also change their behaviour by biting outdoors in the early evening *(28)*.

The characteristics of malaria vary markedly according to the ecology of local mosquitoes; these regional differences are summarized in **Annex 2**. Evolution never stops, and towns and cities need to be alert to changes in the ecology and behaviour of mosquitoes, including the expansion of mosquito species such as *Anopheles stephensi*. This mosquito is a highly efficient transmitter of malaria and ideally adapted to urban environments. Originally from South-East Asia, it is now expanding its range in Africa *(27)*.

1.4.2 Epidemiology of malaria in urban areas

In general, the transmission intensity of malaria is lower in urban areas than in rural areas, and further urbanization is likely to contribute to declines in malaria *(10–12)*. In many settings, a considerable number of cases are imported that are not due to local transmission *(16, 17)*. However, transmission can be high but focal, associated with localized vector breeding sites. **Box 2** describes the potential typologies of malaria in urban settings.

In many countries, urbanization results in expansion of unplanned settlements and greater socioeconomic inequity, especially in peri-urban areas and urban informal settlements. Dispersal of mosquitoes is limited because of the high human population density and urban structures. These areas have the greatest potential for local malaria transmission. As in all settings with unstable malaria, epidemics in towns and cities need to be identified and dealt with quickly and efficiently, since they may be particularly severe because of low levels of immunity in affected communities.

Frequently, urban residents become infected when travelling out of town and become sick on their return home. In addition, people from outside the city may seek care within the city. Therefore, identifying whether people may have contracted malaria inside or outside the urban area is important, since control interventions that target the malaria mosquito are only relevant where there is local transmission. Wherever people get their malaria infection, many people seek treatment in the private sector, particularly in sub-Saharan Africa, potentially leading to substandard care, especially in the uncontrolled informal sector.

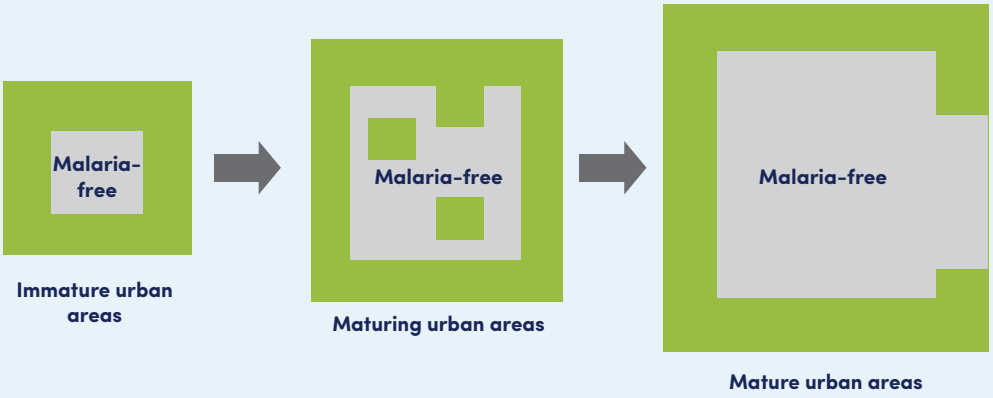
BOX 2. TYPOLOGIES OF MALARIA IN URBAN SETTINGS

Patterns of local malaria transmission vary between urban centres, but there are three basic typologies that change over time as urban centres grow (see diagram below).

- In young and expanding small rural towns (immature urban centres), the ecology of malaria is typically rural. Most malaria mosquitoes breed in the fields surrounding the settlement and in human-made constructions, such as along the sides of new highways and in cement-lined pits used for holding water during building construction (but left full of water after construction has ended). Relatively few areas are malaria-free, although the intensity of transmission is often less than in rural locations. Transient populations who come to seek temporary employment in urban areas and cannot afford accommodation in the city are often found here.
- As settlements continue to grow (maturing urban centres), market gardens often form within the urban centre and along floodplains where water accumulates during the rainy season, giving the town or city a rural flavour. Here malaria transmission is located around particular sites within the urban centre, not just at the periphery (the rural–urban interface). However, at the periphery, new settlers often congregate in poor housing with little infrastructure, and flooding during heavy rains may provide breeding sites for mosquitoes.
- As towns grow to become large cities (mature urban centres), the overall level of malaria declines further, with most malaria transmission occurring at the periphery, again often focused in informal settlements.

In all three types of urban centres, many malaria cases will be related to infections that have occurred outside the urban centre when people visit family or friends, or on business trips.

The diagram below shows the transition of malaria in urban areas. Green shows local transmission areas; grey shows areas free from local transmission. All typologies will have cases of imported malaria, which will be heterogeneously distributed within the town or city.



Part 2.
A vision for the response to malaria in urban areas

This framework is the first to outline a comprehensive global response to malaria in urban areas. The town or city is the operating unit, led by the city leader(s) – in combination with the local public health and national malaria programmes – and assisted by international and domestic stakeholders and partners. Communities are the key drivers and beneficiaries of the response. The response requires effective targeting using granular data on ecological, environmental, epidemiological, social and other determinants of malaria transmission and burden in urban settings. The framework builds on WHO principles on universal health coverage *(1)* and primary healthcare provision (2), the Sustainable Development Goals (SDGs) *(3)*, the *Global technical strategy for malaria 2016–2030 (4)* and the *Global vector control response 2017–2030 (5)*.

2.1 Vision

A world where towns and cities are free from malaria and other mosquito-transmitted diseases.

2.2 Aim

Reduce the transmission and burden of malaria, and eventually eliminate the disease through effective, locally adapted and sustainable control measures for urban areas.

2.3 Focus

This framework offers guidance to implementing effective interventions that contribute to malaria elimination, to improve the lives of millions of citizens of towns and cities in malaria-endemic countries. The framework goes beyond conventional malaria control in several important aspects.

- It identifies the town or city as the operating unit and recognizes the role of city leader(s) in setting the vision and providing continuous oversight of this multisectoral malaria response. The response is part of the urban development agenda and forms a multisectoral collaboration across town and city government departments, the communities, local public health and national malaria programmes, assisted by international and domestic stakeholders and partners.

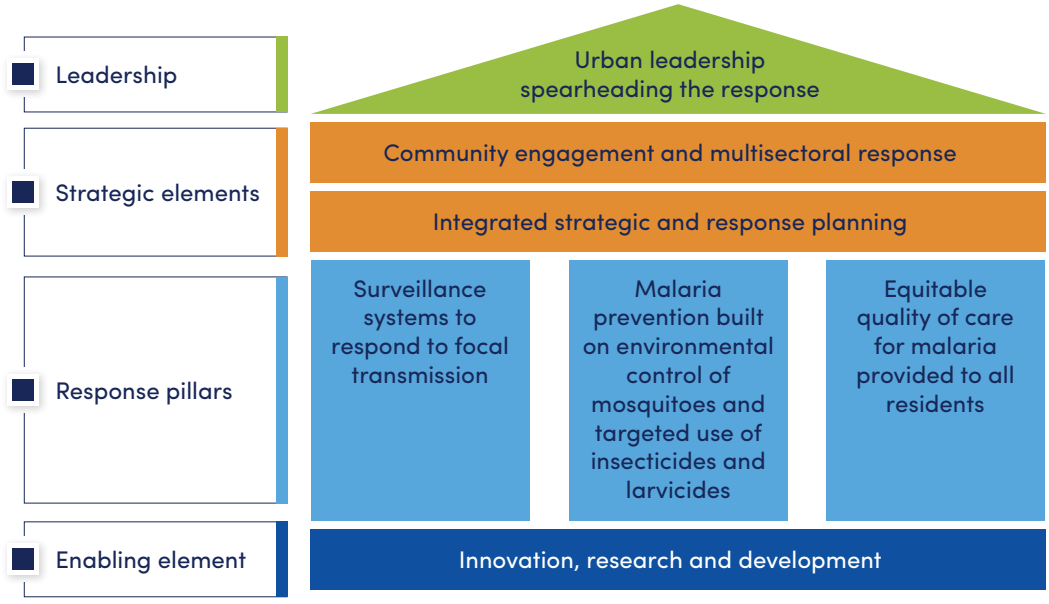
- It recognizes that urban settings are suited to effective multisectoral responses to malaria.

- It prioritizes the need to collect and use information on ecological (including built environment), epidemiological, entomological, social and economic factors that drive malaria transmission and inform care seeking; this information is essential to inform the response to malaria in urban settings.
- It focuses on the need for city-wide routine surveillance systems to provide disaggregated, timely detection of malaria cases, with travel information to distinguish between local transmission and imported malaria. This should be integrated into surveillance of other epidemic infectious diseases.
- It emphasizes the need for year-round monitoring of vector mosquito species, mapping their spatial distribution, assessing insecticide resistance levels and assessing biting behaviour (indoor versus outdoor and peak biting times). This should be implemented as part of integrated vector surveillance, with strong community participation.
- It promotes the use of microstratification using geographically disaggregated data. This is essential for tailoring interventions and establishing an adaptive response.
- It supports the harnessing of research and innovation, which are key to providing effective solutions to reduce malaria in urban areas.

2.4 Building blocks of the framework

The framework is designed around a city/town leadership element, two strategic elements, three response pillars and one enabling element (**Fig. 2**). These are described briefly below and in detail in Parts 3–9 of this document.

Fig. 2. Building blocks of the framework



2.4.1 Leadership element

Urban leadership should lead the response, with support from relevant urban departments, national programmes, communities, partners and funding organizations. Mobilization of resources across multiple sectors, including funds earmarked for infrastructure development, should contribute to the malaria response in urban areas. Therefore, the response must be an integral part of the urban planning, policy-making and budgeting processes.

2.4.2 Strategic elements

The two strategic elements are community engagement and multisectoral response, and integrated strategic and response planning.

Full engagement of communities is essential in decision-making, priority setting and demand for services. The response also requires a multisectoral approach to disease control and elimination.

An integrated response plan is essential. The malaria response should be part of the established processes for urban health planning. It should be led by urban or municipal governments, with strong technical support from national malaria programmes and close links to central authorities, partners, the private sector and communities. In some settings, integrated disease and mosquito may be explored.

2.4.3 Response pillars

The three response pillars are surveillance, prevention and quality clinical care.

Malaria transmission in urban areas is usually focal, concentrated in pockets that have the right conditions for mosquito breeding. Some foci of transmission may also be transient, related to time-bound development and other activities. As a result, high-resolution mapping of foci of transmission, through the process of microstratification (stratification of risk and its determinants at the most granular and operationally relevant level), is essential to ensuring a tailored response. Imported malaria is an important concern in urban areas. Surveillance systems should therefore be case based, collecting information on patient residence and travel history to assess the possible place of infection. This information will help to ensure an effective, targeted response.

Malaria prevention in urban areas should be built on a foundation of mosquito control by preventing the creation of breeding sites, e.g. through building regulations and the provision of reliable piped water, management of existing breeding sites by means of drainage and environmental management, and by minimizing exposure to mosquito biting by means of improved housing. This can be combined with judicious use of insecticide- and microbial-based interventions against adult mosquitoes and/or aquatic stages of mosquitoes, complemented by chemoprevention and use of vaccines in high-risk groups, where appropriate. New vector control interventions ranging from spatial repellents to genetically modified mosquitoes may hold additional promise and should be evaluated for use in these settings. As much as is possible, malaria control should be integrated with the response to other vector-borne diseases, including integrated vector surveillance for *Aedes*. The uniform delivery of preventive interventions, such as ITNs and IRS, to entire urban populations is unlikely to be necessary for optimal malaria control nor cost-effective.

Access to equitable, quality health care, with prompt diagnosis and effective treatment, is important. Special attention should be paid to the poorest and most vulnerable, who are least likely to be able to afford care. Delivery of health care should take into consideration that malaria in urban areas is likely to be concentrated in the most socioeconomically vulnerable populations, who are least able to access services. By engaging communities, it is possible to identify who is missing out and the barriers they face. Mechanisms of delivery (public, private and community) can then be designed and orchestrated to ensure that all those in need can access quality services. Although there is limited experience with the use of community health workers in providing malaria diagnosis and treatment in urban areas, under some conditions this may be an effective delivery strategy, provided that the differences between urban and rural community structures and networks are taken into account.

2.4.4 Enabling element

The urban context is dynamic and varies between and within countries. As a result, there is no single set of approaches that will work everywhere or every time. Innovation, research and development are therefore key to providing effective solutions to reduce malaria in urban areas. Research and innovation in interventions, surveillance and analytics, delivery systems, social and behavioural change communication, community and multisector engagement, and other relevant aspects are key to an effective malaria response in urban areas.

2.5 Country adaptation of the framework

Adaptation of the response to malaria to specific urban areas will require close collaboration between urban and national governments, communities, the private sector, development partners and other stakeholders. Some important components are as follows.

- Urban governments, in collaboration with national malaria programmes and partners, undertake a detailed analysis of the intensity and extent of malaria transmission across cities. This will require data on epidemiology, entomology, ecology, the built and natural environments, the health system, community experience and social determinants. It is also important to undertake a political economy analysis to situate malaria interventions within an understanding of the prevailing political and economic processes in the specific urban setting and society.

- This information should then be used for stratification and identification of hotspots. After identifying clusters of transmission, burden and their determinants, the appropriate response interventions and strategies can be identified. This will be the basis of the response plan for malaria in the urban setting.

- Urban governments, led by town or city leaders and with support from national programmes, will then carry out a resource needs assessment and identify gaps to inform resource mobilization. Since a large part of the response is related to city development activities, close engagement across sectors will be required to define sectoral contributions and estimate actual resource gaps. This can best be achieved if the plan is part of the broad urban development agenda.

- The response plans to malaria in the towns or cities in a country should be considered within broader national malaria strategic plans. This will ensure that resources are used efficiently and that targets in urban response plans are reflected in broad national targets. Good practice needs to be shared between towns and cities within a country and across regions.

- Close links should be established with the strategic planning processes of the national health sector to optimize functions that are usually defined centrally, such as human resources for health, strategic purchasing and procurement services, and response to national epidemics.

- The workforces of city health and related agencies, and national malaria programmes are then apprised of the response plan. Enhanced training of the workforce in various sectors may be required to ensure an efficient, integrated response.

- Leaders of urban centres establish a fully functioning taskforce for multisectoral engagement in response to malaria in urban areas. The taskforce should include representatives of line ministries, civil society, the private sector, research institutions, nongovernmental organizations and communities.

- Following mapping of key stakeholders, an engagement strategy is established alongside a coordination structure to ensure that investments, including by donors and the private sector (financial and in kind), are aligned with the malaria response plan of the city.

- To ensure continuous improvements in the response plan and to reliably monitor progress, integrated surveillance systems that address core information needs must be strengthened. Digitization of these systems is essential to implement case-based surveillance; identify case increases and hotspots; and manage other relevant programmatic, social and ecological data.

- Regular information exchanges, through malaria bulletins, should be implemented across all relevant sectors to facilitate an adaptive response.

Part 3.
Urban leadership and the malaria response

Sustainable urban development relies on strong local leadership to address socioeconomic disparities, increase access to quality services and improve the local environment. This results in healthier urban populations, which in turn are an asset for urban development, productivity, resilience and sustainability. Urban health is therefore a good litmus test of sustainable and equitable development.

Tackling malaria is urban settings will contribute to health and development because it requires the same level of attention to equity, quality services and the environment. The malaria response can be a useful entry point to integrated control of urban vectors and to equitable access to quality health services for all people, including slum dwellers and marginalized populations. Malaria control can also improve intersectoral planning and meaningful engagement of communities in their own health and development.

3.1 Role of urban leadership and governance

Urban leadership is central to reducing urban health risks, including those due to vector-borne diseases. City leaders can play a transformative role in tackling diseases such as malaria and progressively achieving universal health coverage. By demonstrating the benefits to individuals, societies and socioeconomic development, local leaders can position malaria, health and health equity high on the social and political agenda of cities. Healthy Cities, Healthy People – a joint initiative of the Commonwealth Local Government Forum, the RBM Partnership to End Malaria, UN-Habitat, Uniting to Combat Neglected Tropical Diseases and the BOVA (Building Out Vector-Borne Diseases in Sub-Saharan Africa) Network – aims to put city and local government leaders at the heart of national and global health debates. The initiative calls for more political support and resources to be directed towards healthy urban centres, and for information, experiences and best practices to be shared among mayors and municipal leaders.

The challenges of health and malaria in urban areas cannot be solved by the health sector alone. Different actors and levels of government must be provided with opportunities to collaborate to ensure inclusive, secure, resilient and sustainable urban health and development. Success requires a whole-of-government and whole-of-society approach that includes citizen participation and community-based efforts. This approach is sometimes referred to as horizontal coordination (coordination across all levels of government) and vertical coordination (engagement between governments and non-state actors, including the private sector, civil society and the community).

> "Housing, access to clean water and sanitation and waste management are as important as access to a doctor. These are matters being handled by local government, outside the conventional remit of the health sector."
> **Ms. Maimunah Mohd Sharif,** Executive Director, UN-Habitat, during the launch of the Healthy Cities, Healthy People campaign

Mayors are well placed to facilitate horizontal coordination through their interface with central government and sector ministries. Local authorities need to develop urban plans that articulate with national sectoral plans. They are responsible for an orchestrated government response that is suited to the local context and for promoting governance for health – by influencing governance in other policy arenas to promote and protect health. Municipalities therefore need to provide the leadership, cohesive force, guidance, and administrative structures and processes that ensure that urban planning and actions will have a positive impact on malaria and health. This entails mainstreaming of health into urban planning, governance, finance, communication and implementation. It also includes monitoring and assessing the health effects of policies, plans and projects through approaches such as health impact assessment.

> "Building healthy cities is not a job for one sector. It takes a coordinated, multisectoral approach, led by local governments." **Dr Tedros Adhanom Ghebreyesus,** Director-General, WHO, during the launch of the Healthy Cities, Healthy People campaign

Success in tackling malaria will require the active, free and meaningful participation of a broad range of stakeholders during all stages of urban planning: conceptualization, design, participatory budgeting, implementation, citizen-based monitoring, evaluation and review. This includes engaging the most marginalized, such as informal settlement dwellers, whose experiential knowledge can add real value to tackling the social determinants of health when designing programmes to improve availability, accessibility, acceptability and quality of services. The decisions made by policy-makers, planners, financers, communities and citizens should nurture, and not harm, a healthy urban environment and society.

3.2 Benefiting from alignment with international goals

Control of malaria in urban areas is supported by several major international goals, agreements and policies. The leadership of urban areas can use these instruments to make the case for domestic and external support for the response to malaria in their settings. Relevant international goals, agreements and policies include the following.

- The **Sustainable Development Goals (SDGs)** *(3)*, many of which align with the holistic vision of malaria control and elimination in the world's towns and cities. The most relevant SDGs are SDG 3 (health) and SDG 11 (sustainable cities and communities). The methods of control envisaged also support other SDGs, including SDG 1 (ending poverty), SDG 6 (clean water and sanitation), SDG 13 (climate action) and SDG 17 (working in partnership).

- The **New Urban Agenda** *(7)*, adopted at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in Quito, Ecuador, on 20 October 2016, and endorsed by the United Nations General Assembly in December 2016. The agenda, rooted in the SDGs, recognizes that urban centres worldwide are vulnerable to mosquito-transmitted diseases, especially malaria. This provides a basis for malaria-endemic countries to integrate malaria control with the broader urban health response.

- The ***Global technical strategy for malaria 2016–2030*** (GTS) *(4)*, which was launched in 2016 following approval by the World Health Assembly in its

May 2015 session. The GTS has a vision of a world free from malaria. Its key target is 90% reduction in morbidity and mortality from malaria globally by 2030 (from a 2015 baseline), with 2020 and 2025 milestones of 75% and 40% reductions, respectively. In addition, the GTS has a target of eliminating malaria in 35 countries by 2030 (from a 2015 baseline), as well as preventing re-establishment of malaria in countries that have eliminated the disease.

- The **Sendai Framework of the United Nations Office for Disaster Risk Reduction** *(30)*, which recognizes that health is at the heart of disaster risk reduction and calls for work "to incorporate disaster risk reduction measures into multilateral and bilateral development assistance programmes within and across all sectors, as appropriate, related to poverty reduction, sustainable development, natural resource management, the environment, urban development and adaptation to climate change".

- The **UN-Habitat and WHO joint report on integrating health in urban and territorial planning,** which recognizes that planning decisions can create or exacerbate health risks for urban populations or, alternatively, foster healthier environments and lifestyles, and create healthy and resilient cities and societies *(31)*.

- The report of the **WHO Strategic Advisory Group on Malaria Eradication** *(10)*, which considers urbanization as a threat to malaria eradication, since "... with urban areas expected to grow at unprecedented rates in conjunction with equally important new population dynamics of short- and longer-term peri-urban migration, the historical association between urban migration and rising living standards may break down".

- The WHO ***Global vector control response 2017–2030*** *(5)*, which emphasizes the importance of a multidisciplinary approach to control of multiple diseases. It provides a new strategy to strengthen vector control worldwide through increased capacity, improved surveillance, better coordination and integrated action across sectors and diseases.

3.3 Integration with sustainable city growth and the One Health approach

Health sector actors play a key role in supporting urban decision-makers to integrate health into the urban development agenda. They are essential for delivery of healthcare services and prevention of disease. Health sector actors play an important role in synthesizing knowledge and providing evidence-based guidance about the health impacts of sector-based strategies, policies, plans and projects.

WHO has identified, through a consultative process, seven ways of integrating health into the urban development agenda *(31, 32)*:

- developing a common vision for social cohesion and health equity, and a commitment to leave no one behind – urban leadership and governance are essential to achieve this;

- fostering a commitment to healthy cities as sustainable cities, and recognizing the need for actions that involve all urban sectors;

- assessment – mainstreaming health into urban policies through locally relevant responses; political economy analysis will be helpful at this stage;
- urban economies – financing healthy, sustainable urban development and avoiding unintended health risks;
- urban planning – designing for health through regulation, sustainable planning and use of evidence of health and disease transmission risks to ensure that city planning mitigates these threats;
- urban health resilience – strengthening health systems' capacity to prepare for, anticipate and respond to health shocks and stresses in a sustainable and effective manner at the urban level; and
- participatory action for change – involving communities in the participatory planning and management of their own neighbourhoods and cities.

The malaria response in urban areas builds on these key approaches. Many cities have adopted plans for sustainable growth, into which malaria control can be integrated *(33)*. For example, the Revitalising Informal Settlements and their Environments (RISE) project is a randomized controlled trial of a green engineering intervention to improve health and environments in informal settlements in Suva, Fiji, and Makassar, Indonesia *(34)*. The goal is to demonstrate how a novel, nature-based approach can reduce environmental contamination by improving sanitation and increase access to clean water by reducing stormwater impacts. One of the four environmental improvements being sought is a reduction in numbers of mosquito vectors associated with poor sanitation, poor drainage and limited hard waste solutions. Among other initiatives, the Global Platform for Sustainable Cities *(35)* works to support city leaders to achieve sustainable city growth.

3.4 Mobilizing resources for control of malaria in urban areas

In many malaria-endemic countries, urban governments do not have sufficient resources. This includes decentralized systems where subnational entities are responsible for health policy implementation and resource decisions. City leaders are on the front line of making tough choices about how best to allocate the limited financial resources in the most efficient, effective and equitable way. This requires accountable and transparent urban governance that benefits from the active participation of citizens and communities. Advocacy and quality data help to hold local and central governments accountable, ensuring that the limited resources are appropriately devoted to priority needs, such as health – for example, malaria and vector control.

Recognizing that many mayors will be motivated to implement malaria control but face difficulty in accessing resources, major donors must continue to support malaria control in both rural and urban settings, including multisectoral interventions in addition to medicines and insecticides. The financial resources needed for the broad malaria response in urban areas should be reflected in national malaria strategic plans, and plans and local budgets for health and other relevant sectors.

Funding from multiple sources and revenue streams can be sought for funding the malaria response in urban areas.

- **Domestic funding and government budget allocations.** These should emphasize protecting the populations that are most vulnerable and at highest risk in urban informal settlements. Funding sources comprise:
    - national government funding by ministries of planning, economic development and finance – this funding, and the associated planning and budgeting processes, are essential to the success of the response to malaria in urban areas; and
    - funding at the local government level – city councils in areas where malaria is endemic must have a dedicated budget line for the control of malaria and other mosquito-transmitted diseases. Each local government sector that is part of the multisectoral steering committee should have a budget for its activities, so representation by the local finance department is key. Revenue from property taxation is an important revenue stream, and local tourist taxes may be appropriate in some urban centres.
- **Development banks.** Major infrastructure developments can be supported by loans or grants from development banks for the development of infrastructure, access to piped water and quality housing.
- **Development agencies.** Many development agencies, including the Global Fund to Fight AIDS, Tuberculosis and Malaria, and the United States President's Malaria Initiative, have supported malaria control over the past 20 years and should be encouraged to continue their support for a targeted malaria response in urban centres. Local charities may also be supportive of malaria control programmes in urban areas.
- **Innovative services.** Microfinance initiatives support and grow businesses that collect and repurpose domestic waste (which might collect water to form mosquito breeding sites) to produce new products, fertilizer and biogas. Small businesses involved in the circular economy can be engaged to collect solid waste to be used to produce products such as paving stones and plastic furniture. Businesses should be incentivized to provide house-screening and mosquito-proofing services to households in affected communities *(36)*. Initiatives to provide accessible microfinance for housing to low-income households can contribute to improved housing *(37)*.
- **Research funders.** Funders of health research should support research into multisectoral malaria control in the urban ecosystem. In many countries, there are multiple vector-borne disease initiatives that can synergize investments to contribute to research and innovations.

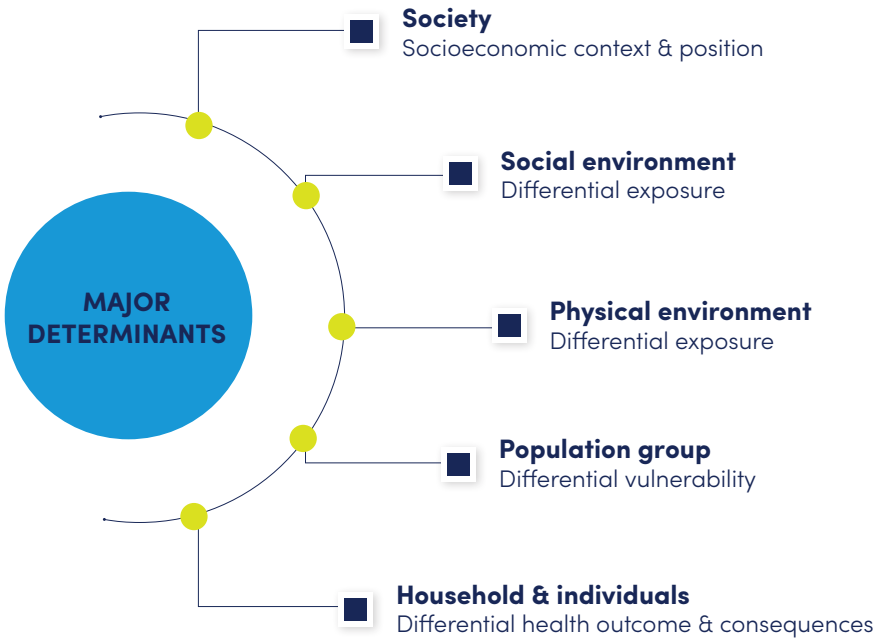
Part 4. Multisectoral and community engagement

4.1 Multisectoral collaboration

The engine for change is people working together from different sectors to control and eliminate malaria. This includes sectors within health and other departments, other actors and communities. Multisector action is critical to creating an environment where malaria and other mosquito-borne diseases can be eliminated efficiently. This collaboration needs to be steered by senior city members, under the direction of the mayor or city leader.

The collaboration is guided by the role each sector plays in contributing to and controlling malaria in urban areas. The recently published Comprehensive Multisectoral Action Framework for malaria *(38)* outlines the major determinants of malaria across five levels (**Fig. 3**). Although these are all important in all malaria settings, their dynamics and characteristics are likely to vary between rural and urban settings. This means that different types of information and adaptations are necessary. To help countries define multisectoral information needs, the Comprehensive Multisectoral Action Framework provides a matrix of levels of determinants and the relevant sectors. Countries are advised to use the guidance in that document to develop "malaria-smart", sector-wide policies to respond to malaria in urban settings. Sectors will be required to act at different levels depending on their levels of engagement with the environment and communities.

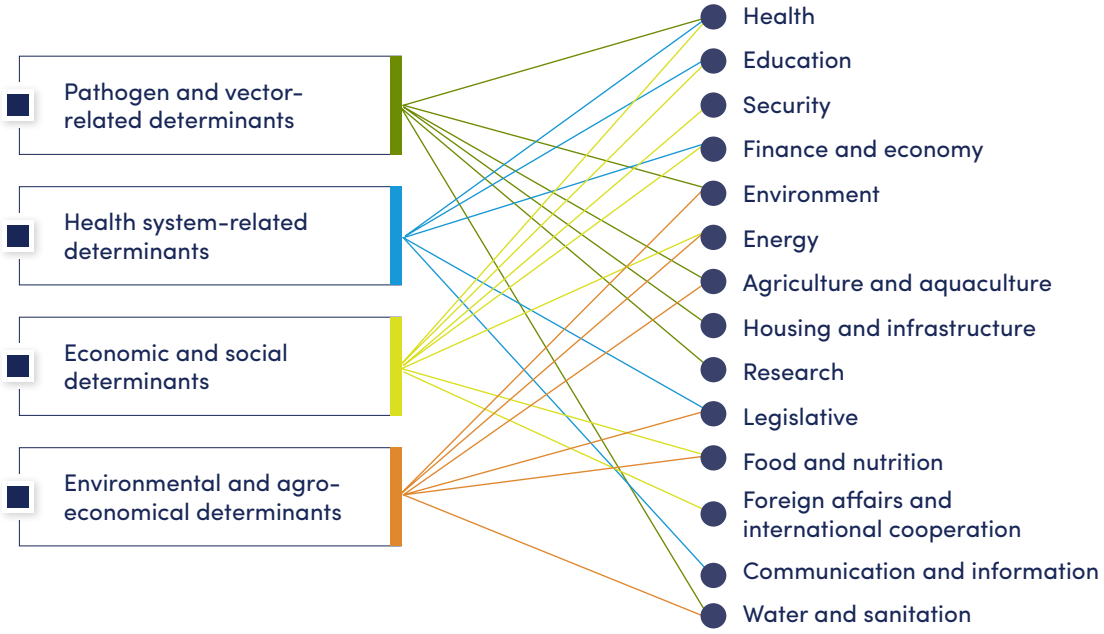
Fig. 3. Major determinants of malaria across different levels



Source: UNDP *(38)*.

Fig. 4 illustrates the links between different sectors and the determinants of vector-borne diseases. This is drawn from the WHO *Multisectoral approach to the prevention and control of vector-borne diseases: a conceptual framework (39)*.

Fig. 4. Examples of associations between determinants of vector-borne diseases and various sectors

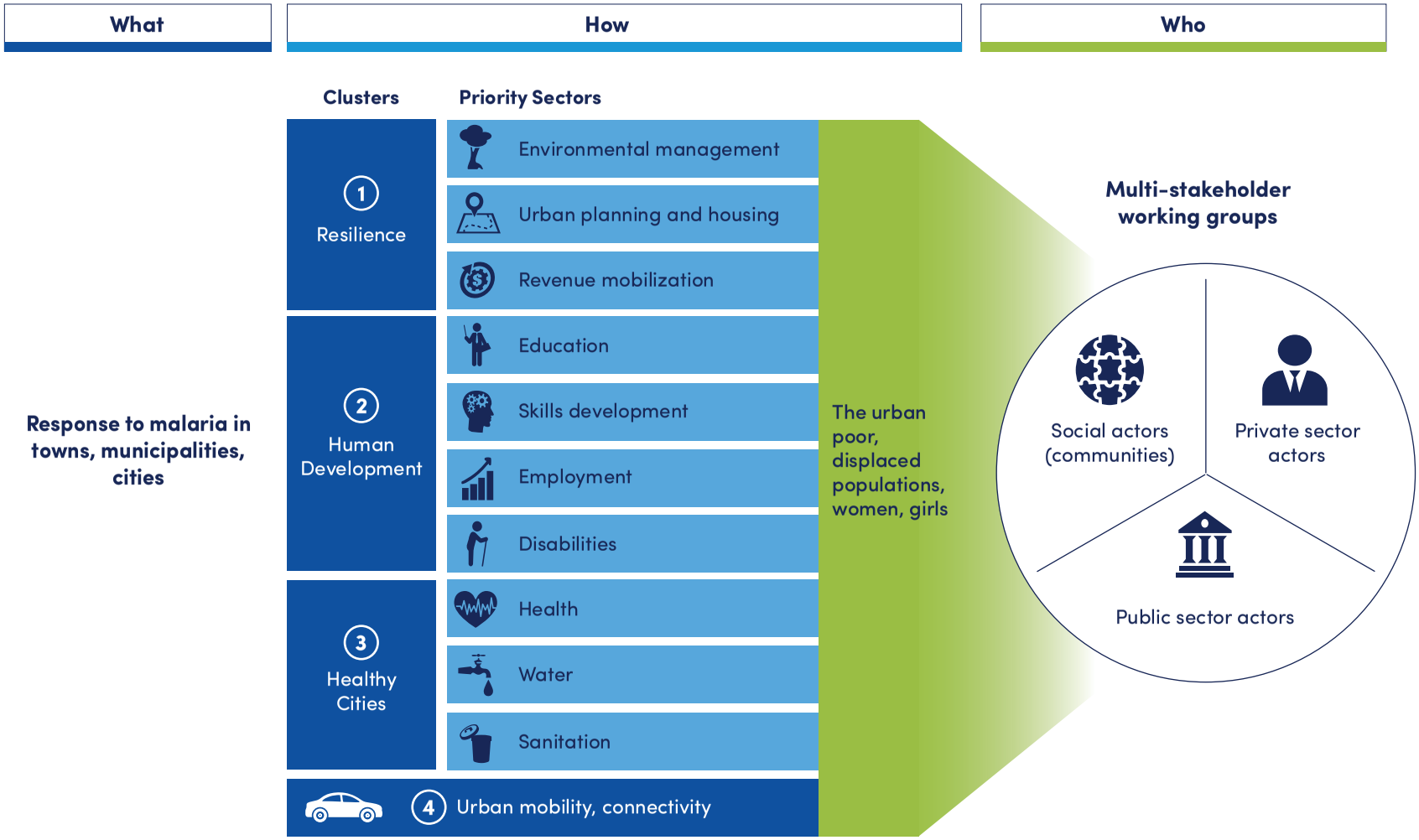


Source: UNDP *(39)*.

There is increasing recognition by city leaders of the need to establish a multisectoral response to malaria in urban areas. In 2019, the International Association of Francophone Mayors marked World Malaria Day by committing to international efforts to create a malaria-free world by recognizing the need to include a response plan to malaria in urban areas within each city plan *(40)*.

The Transform Freetown Agenda (TFA) that was launched in 2019 is another example of how health (including malaria) can be addressed through the broad development agenda *(41)*. The TFA was launched under the leadership of the Honourable Yvonne Aki-Sawyerr, Mayor of Freetown, Sierra Leone. The agenda recognized that a major transformation of city policies, planning, governance and development was required in response to rapid growth of unplanned settlements, growing demand for government services, increasing burden on existing service networks, and pressure on the environment leading to biodiversity loss, soil erosion and flooding. The TFA identified 11 priority sectors using an inclusive approach, underpinned by innovation and data-driven performance management. Targets aligned with the SDGs were developed for each priority sector. These were closely monitored, and a reward scheme was developed for communities and sectors that achieved these targets. Although malaria was not explicitly targeted, the health of vulnerable populations was a major area of focus, and the plan is easily adaptable to the response to malaria in urban areas (**Fig. 5**).

Fig. 5. Priority sectors and actors for multisectoral response to malaria in urban settings

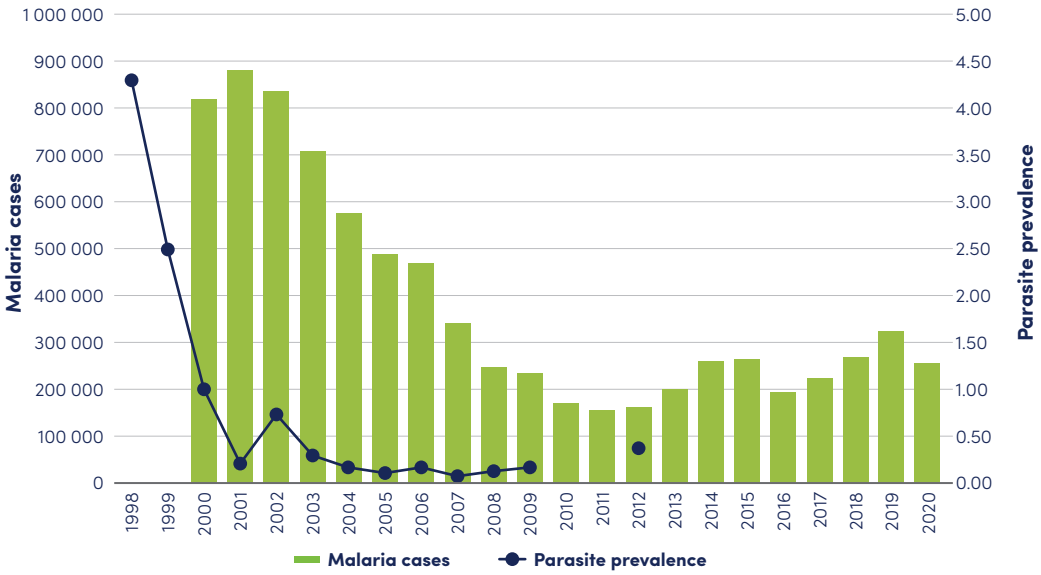


Source: Transform Freetown Agenda presentation by Mayor Yvonne Aki-Sawyerr.

Perhaps one of the most successful integrated and multisectoral responses to malaria in urban areas is the Khartoum Malaria Free Initiative (MFI), especially during the period 2002–2011 *(42, 43)* before funding constraints, governance issues and political instability disrupted the initiative (**Fig. 6**; **Annex 3**). The MFI has three main components: diagnosis and treatment, prevention and epidemic surveillance. Its mainstay is control of the population of the primary malaria mosquito *Anopheles arabiensis*, which breeds largely in irrigation canals, and pools created from broken water pipes, water basins and storage tanks. To achieve this, the removal of water basins and storage tanks is enforceable by law, and the Ministry of Health collaborates with the Urban Water Corporation to repair broken water pipes. The MFI is responsible for surveillance, reporting and transportation, while the Urban Water Corporation provides engineers and equipment. By 2004, just under 4 km of water pipes had been replaced, and more than 6 km had been repaired.

The regular drying of irrigated fields (intermittent irrigation), which reduces the availability of mosquito larval sites, is also compulsory in both government and private irrigation schemes. This initiative is supported by the Farmers Union and the Ministry of Agriculture and Animal Resources (MAAR). In 2011, 98% of irrigation schemes were dried for at least 24 hours. Leakages from irrigation canals are also repaired, and vegetation around canals is cleared, in conjunction with the MAAR. The MFI employs 14 trained medical entomologists, 60 public health officers, 180 sanitary overseers, 360 assistant sanitary overseers and 1170 spraying personnel, who are responsible for routine larviciding and environmental management to reduce mosquito larval sites. In the period 1999–2004, malaria deaths in Khartoum fell by 75%; from 1995 to 2008, parasite prevalence dropped from 0.78% to 0.04% *(43–45)*.

Fig. 6. Malaria cases and *Plasmodium falciparum* prevalence in Khartoum state, 1998–2020



Notes: Case data were not available for 1998–1999. The parasite prevalence estimates for 2009 and 2012 were tests in children under the age of 5 years collected during national malaria indicator surveys *(44)*. Parasite prevalence data in other years were for all ages.

Sources: Nourein et al. *(43)*; Snow *(44)*.

4.2 Community engagement and support

Community engagement is "a process of continuous relationship-building in which those affected are central to decision-making" *(46)*. Local communities play a major role in, and are key to the success and sustainability of malaria control and elimination in urban areas. Urban leadership has a critical role to play in the coordination of communities at different levels.

Community engagement is concerned with the intentional and purposeful engagement of stakeholders that need to work together to address malaria. It recognizes that some voices, particularly those of vulnerable communities, may not be heard without the health sector directly engaging with them. The focus of this relationship is on:

- not what gets done. But how things get done and by whom;
- the quality of relationships between stakeholders;
- the patterns of interaction over time;
- the strength of connection between different parts of the health system; and
- the link between staff experience, patient experience and outcomes of interest.

Ideally, communities are supported to take responsibility for and implement malaria control, including active participation in the identification and removal of larval habitats. Participatory community-based approaches aim to ensure that healthy behaviours become part of the social fabric and that communities take ownership of malaria control at both the intra- and peri-domiciliary levels. Countries are advised to consider the following for effective community engagement and support in the response to malaria in urban areas.

- Engagement strategies should be used that build on social/anthropological and behavioural evaluations that have a solid foundation for leveraging local knowledge and skills (i.e. cultural capital).
- A process of dialogue, learning, decision-making and action is needed, such that community members, including vulnerable and disempowered groups, are able to recognize strengths; self-assess; and collectively identify, analyse and prioritize problems that affect them.
- This leads to the identification of practical ways to address acknowledged problems, including adaptation of traditional practices, if appropriate. If well executed, this will strengthen the community's capacity to continually identify new issues that require action, and will build mutual accountability, trust and partnership.
- Local communities should be engaged to participate in the planning and priority-setting processes. This involves developing local action plans, and making clear the roles of different stakeholders and sectors. This is not left to chance – an effort is made to link service delivery and governance mechanisms.

- Local context, data and evidence should underpin the priorities for the response to malaria in urban areas. Communities play an important role in collecting data, contextualizing the outputs of analysis and disseminating the results.

- Communities and service providers should meet regularly for mutual advocacy and to assess progress. The aims should be to improving the fight against malaria, empower communities to gain mastery over their risk of disease, and ensure sustainable and locally owned development.

- The relationship between service providers and service users, and how they communicate and interact with each other should be key concerns of the urban leadership. This means identifying what is working well and what needs to be addressed so that they plan and monitor progress together.

- Multiple channels should be used, and various actors should be involved, to promote information sharing and provoke dialogue, including through local and social media. Actors could include community health workers, local and religious leaders, and schoolteachers.

- Efforts to engage communities should act in concert with regulatory or legislative actions to support the malaria response – for example, 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.

- It is important to identify existing community engagement activities for other health outcomes, to avoid community fatigue, identify the right community leader or influencer, and maximize the efficiency and impact of community engagement.

Although the focus for community engagement and participation in malaria control has traditionally been in the delivery of diagnosis and treatment, the community can also play an important role in malaria prevention.

For example, during the Urban Malaria Control Programme (UMCP) in Dar es Salaam, United Republic of Tanzania, a community-led larviciding programme showed considerable impact and promise in the control of malaria in an urban setting *(47, 48)*. The Dar es Salaam UMCP was launched in 2004, and targeted 15 wards, five in each of the three municipalities, totalling 67 *mtaa* (streets). Each *mtaa* was further divided into 10-cell units – the smallest administrative unit – that each contained approximately 10–20 houses. Between May 2004 and February 2006, systems for mapping and surveillance of potential mosquito breeding sites were developed; routine surveillance of immature and adult mosquitoes started in 2005. Larviciding of identified breeding sites was eventually implemented in 24 wards. While the UMCP was responsible for overall management and supervision, the field activities were community based, and tasks for routine mosquito control and surveillance were delegated to Community-Owned Resource Persons (CORP) who were offered a small stipend for their work. Each *mtaa*, or portion of a *mtaa*, was under the responsibility of a designated CORP, who was instructed to treat breeding habitats on a weekly basis. During the project period, randomized cluster-sampled household surveys were carried out to assess impact. The results showed that, after adjustment for confounders, children under 5 years old living in areas treated with larviciding had 72% lower odds of being infected with malaria than those who lived in areas without larviciding *(48)*.

Part 5. Surveillance systems for malaria in urban areas

The risk and burden of malaria in urban areas differ over small areas and are often highly seasonal. Strong surveillance systems are essential to identify clusters of high-risk communities so that they can be targeted with the appropriate interventions and strategies. WHO has published guidance on malaria surveillance, monitoring and evaluation across the transmission continuum and sectors *(49)*, which sets out the relevant systems and data for local response.

The dynamics of malaria transmission within the urban ecosystem require information across several domains, including epidemiology, entomology, environment, health systems and social determinants. Malaria surveillance in urban areas requires the collection of more detailed information than is normally required for rural areas. It requires interdepartmental and multisectoral participation, with the private sector playing a critical role in some settings. Integrated databases that allow joint analysis of different indicators to support effective decision-making are essential *(50)*.

Fig. 7 describes the interconnection between the different surveillance domains and the epidemiological impact end-point. Based on guidance in the WHO reference manual on surveillance, monitoring and evaluation *(49)* and the WHO framework for malaria elimination *(51)*, this schematic can be adapted to settings with different transmission intensities. Using this schematic and other guidance documents, countries are advised to identify the core information needs for their context and develop systems to capture, report and analyse this information. Further details are provided in subsequent sections.

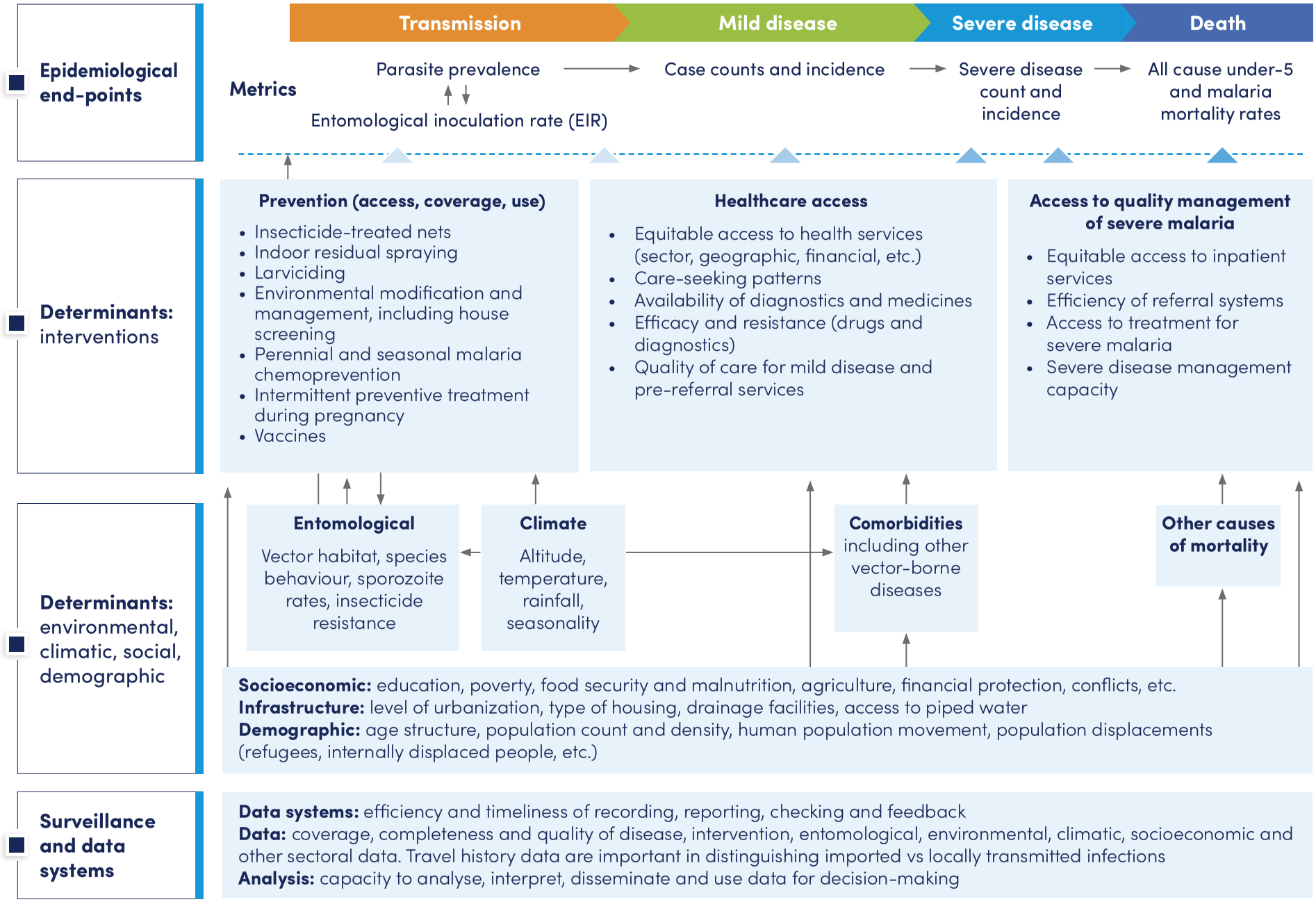
5.1 Disease surveillance

The unique features of the epidemiology of malaria and care seeking in urban areas require the development of appropriate malaria surveillance systems, across the different determinants and impact domains (**Fig. 7**).

Because the distribution of malaria in urban areas is heterogeneous, small-scale surveys may be helpful to provide a baseline measurement of transmission, since standard national household surveys will not be sufficiently detailed. The mainstay of epidemiological data collection will be routine health information systems that report passively detected cases.

Monitoring imported versus local malaria infections (and, if local, the most plausible source of infection) is essential for the design of effective interventions. This is because many malaria infections reported in urban areas are likely to have been acquired in rural areas. Travel may be seasonal, or associated with specific social events such as school holidays, harvest patterns or religious activities. Monitoring the impact of travel will require a shift from routine aggregate case surveillance to case-based surveillance, including information on travel history, occupation, age, residence and other relevant individual-level variables. In elimination settings, full case investigations may be required.

Fig. 7. Schematic for identification of core data needs to tailor the response to malaria in urban areas



EIR = entomological inoculation rate. It is an estimate of the number of infective bites from malaria mosquitoes received by an average person during a malaria season or year

Although essential in the classification of cases, travel history data must be interpreted with care. A high level of certainty in case classification requires an understanding of the parasite species and its biology (including incubation periods), the presence of malaria mosquitoes in the vicinity of the patient's residence (in the urban area) and malaria epidemiology at the patient's destination. Under some conditions, active case detection may be used to identify hotspots of malaria transmission, especially where data from the routine surveillance systems is inadequate.

Technology can be harnessed in urban areas, which generally have better access to electricity, computer hardware and software, and the internet than rural areas. Registers should be transferred from a paper-based system to an electronic one, to capture a greater quantity of patient data. This is necessary in all urban areas across the transmission continuum, although previous guidance has recommended detailed case-based surveillance only in elimination settings. Technology can also be used to enhance community participation in surveillance. For example, in some towns and cities, people can report fever and patterns of day- or night-biting mosquitoes using mobile phone applications. Global positioning systems (GPS) in mobile devices can be used to map local breeding sites, the location of health facilities, residence of cases, destinations of those who have travelled and other relevant information. These can then be analysed using geographic information systems (GIS) and other methods.

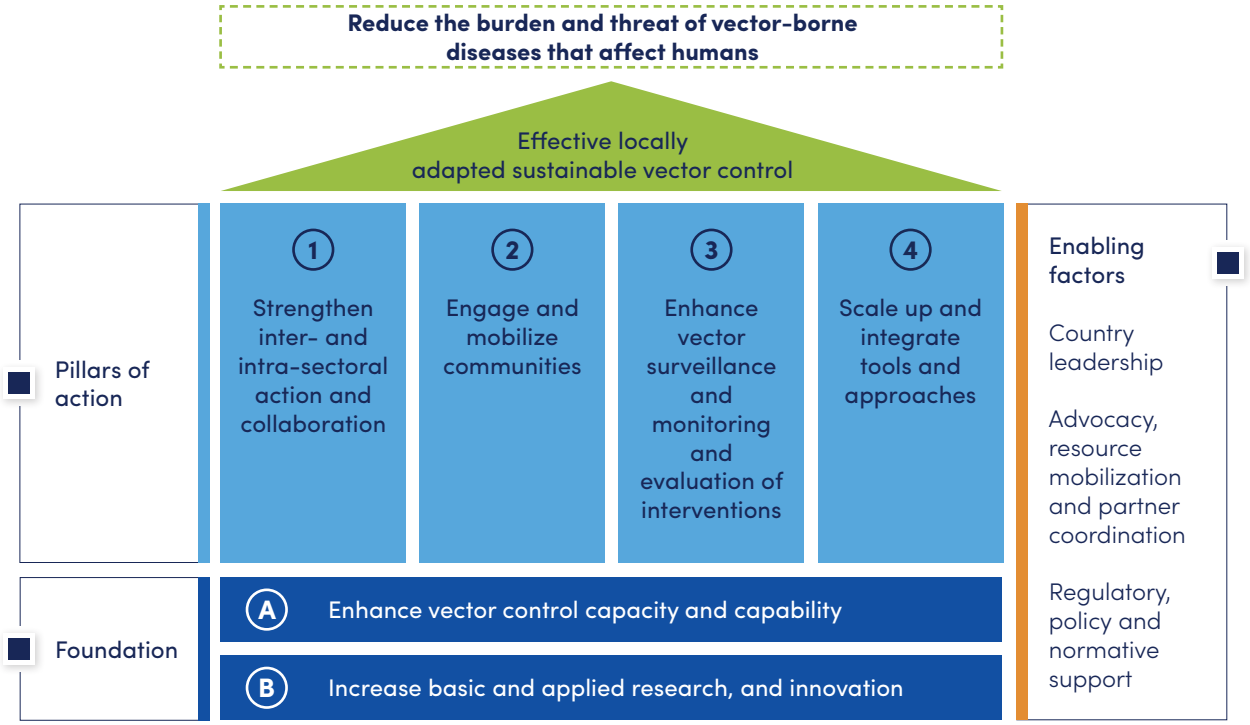
In some urban settings, the private sector is a major source of malaria diagnosis and treatment. However, data from the private sector are often poorly integrated into the surveillance system. Therefore, it is important that the private sector is engaged closely and incentivized to report to the main surveillance system. In some instances, regulatory changes may be required to facilitate reporting by this sector and ensure data quality. Malaria surveillance in urban areas should also take advantage of epidemic disease surveillance systems that have been established to track and respond to emerging or re-emerging diseases that are considered high-priority public health threats. These systems rely on disease data and other sources of information on fever outbreaks that could be used to locate disease outbreaks in real time.

Establishing city-wide surveillance systems via a network of health facilities will require collaboration between city health agencies, the private sector and national governments.

5.2 Entomological surveillance

The diversity of vector ecology in urban areas presents an opportunity to apply the integrated vector surveillance and control approaches outlined in the WHO Global Vector Control Response 2017–2030 *(5)* (**Fig. 8**). Integration may provide a means to significantly expand entomological surveillance for vector-borne diseases in urban settings, within a limited budget.

Fig. 8. WHO Global Vector Control Response Framework



Source: WHO *(5)*.

Vectors such as *Aedes aegypti* and *Culex quinquefasciatus* are highly adaptable to urban settings, as are, increasingly, some of the malaria vectors such as *Anopheles gambiae* s.l. *(52)*. With the current high levels of human mobility, *An. stephensi*, a highly efficient malaria vector, has also invaded several cities in Africa and is seemingly increasing its range, and in some cases has been implicated in malaria outbreaks *(13, 53, 54)*. Before 2012, this vector was not reported in Africa. Following the emergence of *An. stephensi* in the Horn of Africa, the WHO Global Malaria Programme launched an initiative in 2022 to stop further spread, focusing on collaboration, surveillance, data sharing, guidance and research *(55)*.

Additional guidance on the requirements for entomological surveillance across the transmission continuum can be found in the WHO reference manual on surveillance, monitoring and evaluation *(49)* and the WHO *A toolkit for integrated vector management in sub-Saharan Africa (45)*. In summary, core entomological surveillance activities include:

- identifying the mosquito vector species;
- measuring species-specific vector abundance (house and container and human feeding indices) and ascertaining vector composition;
- assessing vector behaviour – such as biting rates, biting preferences (humans or other animals), biting times (day or night) and biting and resting locations (indoor or outdoor);
- monitoring the vector's susceptibility to insecticides (including frequency, levels and mechanisms of resistance);

- measuring rates of infection of the vector with the malaria parasite (sporozoite rate, oocyst rate) and calculating human exposure to infectious bites (entomological inoculation rate); and

- identifying the habitats of immature stages of vectors and habitat characteristics.

5.3 Intervention surveillance

Information systems for malaria interventions fall into three broad categories:

- routine supply chains for diagnostics, medicines, vaccines and ITNs delivered through clinics;

- interventions delivered as campaigns (e.g. mass ITN distributions, IRS, larviciding, seasonal malaria chemoprevention); and

- interventions outside the health system, such as infrastructure projects (e.g. drainage, house screening).

Logistic management information systems (LMIS) should be in place to monitor the distribution, coverage and consumption of interventions, and stock on hand. This will require effective and sustainable digitization of systems. Across the various levels of the system, LMIS should be used to track trends in commodities, monitor patterns of use, monitor expiration of stock and address stock-outs.

For interventions delivered through campaigns, digital campaign platforms are essential to quantify need, track distribution and coverage, identify inefficiencies and gaps, and effectively address these gaps.

Another important aspect of intervention surveillance is efficacy monitoring. This includes monitoring vector resistance to insecticides, durability of ITNs, quality of IRS, resistance to artemisinin and partner medicines, and deletion of histidine-rich proteins by the *P. falciparum* parasite that allows it to evade detection. WHO has developed detailed guidance on insecticide *(56)*, drug *(57)* and diagnostic *(58)* resistance that countries can use to establish relevant surveillance and monitoring systems. The design and selection of surveillance sites may require specific consideration for urban areas.

Household surveys, including those undertaken during foci investigations or during active case detections, are essential to understand population-level access to, coverage by, and use of, interventions. In urban areas where transmission is focal, data collection methods and sample sizes may need to be adapted for standard household survey design.

5.4 Surveillance of demographics and human population movement

Over time, demographic patterns, such as family sizes, age structures and social dependencies, have changed, with distinct differences emerging between rural and urban areas. These differences have implications for urban health policies. Detailed and granular demographic information is needed to help with the broad urban health response, as well as malaria, for which travel, income levels and occupation are important risk factors.

As discussed in section 4.1, imported malaria contributes to a considerable proportion of the burden in urban areas because of extensive human movement into and out of urban areas. Understanding the mobility continuum – that is, the pathway of population movement at points of origin, transit, destination and return – is essential to measure the risks posed by malaria importation. Patient travel histories are the most common source of such information. However, patient travel histories are unavailable in most areas with moderate and high malaria transmission risk; they also are of limited use for predicting overall human population movements required for the malaria response.

Combined with travel histories, large-scale data that describe the mobility continuum can be useful in assessing the health (and malaria) risks associated with mobility *(59, 60)*. These risks are dependent on the volume of mobility, spatial and temporal scales of mobility, interactions between mobile populations and communities, and the underlying potential for public health risks. Sources of large-scale mobility data include research studies, surveys, micro-censuses, and inventories of refugees and internally displaced populations *(60)*. With the rapidly increasing coverage of location-enabled mobile phones, anonymized call data records (CDRs) have been used to define large-scale movement patterns *(61)*. Some studies have combined CDR data with information on local malaria transmission to estimate the risks associated with human population movement and identify areas of high vulnerability. City planners and national malaria programmes can work with mobile phone companies to explore the utility of CDR data to help understand human mobility patterns at scale and investigate relationships with malaria risk.

5.5 Climatic and environmental surveillance

Geospatial surveillance can be used to collect information and analyse climatic and environmental risk factors for malaria. This can range from basic mapping of health facilities *(62, 63)*, settlements and other features using devices that have GPS to use of high-resolution satellite imagery to inform microstratification of malaria risk *(64, 65)*. Environmental surveillance can also be used to map the availability of safe water supplies, communities' practices of water storage, and the presence of stagnant water in domestic and peri-domestic areas. Aerial technology such as unmanned aerial vehicles may be used to rapidly identify potential risk factors for exposure to mosquitoes, such as substandard housing.

Remotely sensed data and existing spatial databases are now freely available online that can provide high-resolution data on temperature, rainfall, humidity, green space, population density, housing types and other infrastructure. This information can be used to map potential larval habitats and areas at higher risk of local transmission. Remotely sensed imagery from satellites or drones can also provide information on changes – for example, changes in the size of urban centres or mosquito habitats. Ground surveys are also useful to locate potential larval habitats. Data with geographic coordinates can be displayed within widely available GIS packages to support decision-making.

5.6 Surveillance of social determinants

An understanding of the key social determinants of health is essential in the response to malaria in urban settings *(66)*. The disease is often concentrated in lower socioeconomic groups, informal and low-income settlements, people with high-risk occupations (e.g. night workers, small-scale traders who get their produce from rural areas), people living near poorly maintained construction sites and highly mobile populations. To understand the social determinants of health and access to health care, and identify high-risk populations that are not reached with services, some of the information needed is:

- place of residence (e.g. urban, peri-urban, slum);
- education and literacy levels;
- race, gender, ethnicity and age – to identify high-risk and marginalized groups;
- legal immigration status;
- cultural, religious and linguistic diversity – to be considered in sensitization and behaviour change campaigns;
- key economic activities and occupations in urban areas, including seasonal agricultural calendars and types of agriculture – to inform exposure risks and understand socioeconomic status;
- socioeconomic status – based on information on income and expenditures, or proxies such as wealth assets index;
- types of dwellings and sleeping habits – to inform risk of exposure to mosquitoes and contribute to analysis of socioeconomic status;
- ownership of mobile phones and access to mass media coverage (e.g. phone, radio, TV) – to inform connectivity and access to information;
- behaviour in seeking medical care, home treatment, and personal protective habits against vectors;
- acceptance of malaria interventions; and
- perceptions and beliefs about malaria in the local population or subpopulations.

5.7 Capacity for analysis and use of data

Monitoring and evaluation are important to assess the impact of interventions on health and on mosquito populations. This enables regular assessment of the effectiveness of the programme, so that interventions can be changed to be most effectively deployed, as well as providing information on the cost–benefit ratio. Urban health departments, in collaboration with national malaria programmes, require the following core capacities to ensure an effective response to malaria and other vector-borne diseases:

- digital information platforms, including integrated databases and GIS capacity;
- epidemiologists with adequate statistical skills;
- entomologists and vector control specialists with strong field experience;
- data managers with the ability to develop and maintain integrated databases;
- health systems experts;
- experts in demography and social determinants of health;
- experts in communication, and social and behavioural change management;
- public health engineering experts;
- experts in advocacy, and community and multisectoral engagement;
- operational research experts.

Part 6. Preventing malaria in urban areas

Mosquito control – using environmental management, insecticides and microbial larvicides *(67)* – is the main method for preventing malaria in urban areas. Given the other vector-borne diseases that are found in urban settings, clear opportunities for integrated vector management present themselves *(45)* to enhance the efficiency of mosquito control in urban settings. These opportunities need to be explored and best practices documented.

The *Anopheles* mosquitoes that transmit malaria breed in a wide range of water bodies, depending on the species. In general, they are found in both clean and polluted water, but generally not heavily polluted, very smelly water (**Table 2**). These species predominantly feed at night, often entering houses to take a blood meal. *Aedes*-transmitted diseases are spread primarily by *Aedes aegypti* and, to a lesser extent, by *Ae. albopictus*. *Aedes* mosquitoes transmit viruses, including those that cause dengue, chikungunya, yellow fever and Zika. The ability of *Aedes* species to transmit a range of viruses suggest that they may be able to transmit other viruses that spill over from animal populations in future. Of immediate concern is the threat of yellow fever virus being introduced into large unvaccinated populations in South-East Asia *(68)*, and causing outbreaks in areas of Africa where vaccination coverage has waned.

Aedes aegypti is well adapted to an urban existence since it is a container breeder. It is found in a multitude of water bodies outside and inside the home, including water storage containers, discarded tyres and plastic waste, flowerpots, underground culverts and guttering. *Ae. albopictus* breeds in the same domestic habitats but also in more natural ones, such as coconut husks, cocoa pods, bamboo stumps, tree holes and rock pools. This diversity of habitats explains the abundance of *Ae. albopictus* in rural and peri-urban areas, and shady city parks. Both *Aedes* species are aggressive biters of people during the day, particularly around dawn and dusk.

In some parts of the world, *Culex* mosquitoes transmit lymphatic filariasis and viruses such as West Nile virus. *Culex* mosquitoes are associated with highly polluted water. They can produce prodigious numbers of adult mosquitoes from latrines and other underground water bodies. They are the most common species of urban mosquito, and are a major nuisance biter indoors and outdoors at night.

Table 2. General characteristics of common urban mosquitoes

MOSQUITO GROUP	DISEASES TRANSMITTED	AQUATIC HABITATS	BITING ACTIVITY
Anopheles spp.	Malaria	Highly varied, including open sunlit pools; shaded, lightly polluted water bodies; and water tanks	Night-time, indoors and outdoors
Aedes aegypti* and *Aedes albopictus	Chikungunya, dengue, yellow fever, Zika	Water storage containers, plastic waste, tyres, guttering, underground sites	Daytime, indoors and outdoors
Culex quinquefasciatus	Lymphatic filariasis, viruses and major nuisance biters	Highly polluted water	Night-time, indoors and outdoors

Detailed information on malaria-specific mosquito control interventions recommended by WHO, based on stringent review of evidence, is available online *(69)*. However, a number of potential approaches to reduce malaria transmission in urban settings go beyond ITNs, IRS or larviciding – interventions for which WHO has reviewed the evidence. They include basic development activities that are aimed at healthy and secure city living, such as improved drainage, sanitation, roads and sidewalks, office or industrial buildings, and management of urban agriculture. Observational evidence suggests that several of these approaches are associated with reductions in malaria infections *(24, 45, 70)*.

Targeted chemoprophylaxis, chemoprevention and vaccination of high-risk groups may also play an important role in specific epidemiological contexts.

Box 3 summarizes some of the approaches and interventions that have been used with the aim of preventing malaria in urban areas. Those that have shown impact against malaria and are therefore recommended by WHO are indicated with an asterisk *(69)*.

BOX 3. APPROACHES AND INTERVENTIONS TO PREVENT MALARIA IN URBAN AREAS

Environmental management

- Improved drainage
- Improved water storage or installation of piped water
- Improved sanitation and waste management
- Improved housing with screens
- Urban agriculture without surface water pooling
- Filling of swamp areas and other stagnant water sources
- Other construction activities that eliminate potential breeding sites

Chemical and microbial control

- Larviciding guided by appropriate ground surveillance of potential larval habitats
- ITNs and IRS in pockets of moderate and high transmission
- Reactive IRS for outbreak response

Chemoprevention

In pockets of moderate and high *P. falciparum* transmission:

- Depending on seasonality, perennial or seasonal chemoprevention where there is a clear indication of high burden of severe disease in children under the age of 5 years
- Intermittent preventive treatment in pregnancy
- In some settings, targeted reactive drug administration

Vaccine

- In pockets of moderate and high *P. falciparum* transmission, use of the RTS,S malaria vaccine to protect children under the age of 5 years. Other vaccines in development may also be applicable to urban settings.

Behavioural change

- Social and behavioural change messages to increase public awareness of malaria and the public's participation in the response, including appropriate use of preventive and case management interventions
- Messages targeting industry and corporations to ensure their engagement and support of the response to malaria in urban areas

6.1 Environmental management

In urban settings, considerable opportunities exist to implement environmental management activities to provide a foundation on which to implement disease-specific interventions. Environmental management approaches are sustainable in the long term. There are numerous examples across the world showing the benefits of environmental management against malaria. Early examples include control measures in Indonesia *(71)* and Malaysia *(72)*. More recently, successful examples include the Khartoum Malaria Free Initiative in Sudan (**Annex 3**) and the Urban Malaria Scheme in India (*73;* **Box 5**). Further guidance on reducing mosquito biting in and around the home is provided by Lindsay et al. *(70)*.

Urban mosquito control is rooted in improvements to the built environment, which is the infrastructure that any modern urban centre will naturally plan for its growing population. Regulations are needed to guide construction and land-use changes by the government, private sector and individuals so that they contribute to "building out" malaria.

6.1.1 Larval control through environmental management

Since malaria mosquitoes breed in stagnant water, mosquito control requires water management through flood prevention, improved drainage and filling of waterbodies and waterlogged areas. Properly constructed and well-maintained drainage channels where pooling of water is prevented can be effective in reducing mosquito larval sites and can last for decades. Flooded areas that are potential sources of mosquitoes can be managed by growing flood-tolerant trees, which also provide shade and cool urban areas. Where urban agriculture is practised, growing crops in flooded land should be managed effectively, including frequent drying. Urban centres should have green centres that do not breed mosquitoes *(45)*.

To garner community support, mosquito control needs to remove all mosquito species that transmit diseases (not just malaria) and nuisance biters. Effective measures include removing solid waste, providing reliable piped water to prevent people storing water in containers, improving the design of pit latrines, and designing mosquito-proof culverts and soakage pits. Many of these interventions not only protect people against mosquitoes and the diseases they transmit but also have co-benefits, all of which improve the quality of life of citizens in the town or city.

6.1.2 House screening

WHO conditionally recommends screening of residential houses to prevent and control malaria in children and adults in areas with ongoing malaria transmission, focusing on screening of windows, ceilings, doors and eave spaces *(69)*.

In combination with larval source reduction and taking into account factors such as structure of houses, screening of homes and other inhabited buildings should be encouraged to reduce disease transmission, while also reducing nuisance mosquito biting and flies, and improving ventilation to help cool houses. Where feasible, house screening should be retrofitted to urban homes, and new homes should incorporate screening into their original design. House screening programmes should be

accompanied by health education to encourage householders to keep screened doors closed. Although generally acceptable to the population, house screening can also be encouraged through legislation, use of demonstration homes, microfinance or insurance policies and through large-scale building developments.

If house screening is deployed or adopted by communities with the aim of preventing malaria, evaluation should be conducted to determine whether this desired impact is achieved, and to contribute towards closing existing knowledge gaps *(69)*.
Close monitoring is needed to assess material durability, use and coverage. This information should guide how regularly screens need to be replaced or repaired and provide information on the sustainability of the intervention.

6.2 Chemical and microbial control of mosquitoes

Where environmental management is unable to completely suppress malaria transmission, additional measures need to be implemented by health departments.

6.2.1 Larviciding

Historically, malaria control in urban centres relied heavily on larviciding, combined with environmental management *(74)*. This combination of interventions is likely to be effective in modern cities too. In Dar es Salaam, United Republic of Tanzania, regular application of the microbial larvicide *Bacillus thuringiensis* var *israeliensis* (Bti) resulted in a 72% reduction in the odds of malaria infection in children under 5 years old compared to no larviciding *(48)*. Larval source management has also been used successfully against *An. stephensi* and *An. culicifacies* in urban centres in India *(67)*.
WHO provides operational guidance larviciding *(67)* and conditionally recommends its use in areas where larval breeding sites are few, fixed and findable – such as in many urban settings. The urban ecosystem is amenable to high-resolution geospatial mapping that allows easier identification and monitoring of such larval sites. Community participation in identification of potential larval habitats and reporting via mobile apps and other channels can considerably reduce the cost of mapping and verification.

6.2.2 ITNs and IRS

In malaria-endemic countries, WHO recommends large-scale deployment of ITNs or IRS for the prevention and control of malaria in children and adults living in areas with ongoing malaria transmission *(69)*. Given the breeding-site preference of African malaria vectors much of the deployment of these interventions is currently focused on rural areas *(8)*. In urban areas, however, there may be some challenges with delivery and uptake of these interventions. Urban residents may be less likely to sleep under a net and more likely to refuse entry during insecticide spraying.

Most urban areas are likely to have focal malaria transmission, and – as for other vector control interventions – the deployment of ITNs or IRS should be considered for targeting known clusters of malaria transmission, such as peri-urban areas and areas close to mosquito larval sites. As a result, universal deployment of ITNs and IRS throughout an urban area is unlikely to be cost-effective in most settings.

In urban areas where malaria transmission is universally very low, use of ITNs and IRS may not yield significant impact even in transmission hotspots. This may change if such areas are invaded by mosquito species such *An. Stephensi*. During outbreaks, reactive, time-limited IRS may be used to reduce transmission *(69)*. The use of space spraying, often implemented in urban areas, is not effective in reducing malaria transmission but may play a role in controlling epidemics of dengue and other vector-borne diseases.

6.3 Chemoprophylaxis and chemoprevention

In many countries, malaria risk is considerably lower in urban areas than in rural areas. Because of travel between urban and rural areas, many cases seen in urban areas are likely to have been acquired outside cities or towns. Depending on the scale of the problem, chemoprophylaxis for urban travellers could be considered to prevent infections. Important considerations are the type of medicines to use, and their cost and sustainability *(69)*.

Various forms of chemoprevention can also be used in urban areas of moderate and high *P. falciparum* transmission. Seasonal malaria chemoprevention and perennial malaria chemoprevention (formerly known as IPTi), and intermittent preventive treatment in pregnancy (IPTp) are effective under certain epidemiological conditions. Before scaling up these interventions, it is essential to carefully consider the potential impact of the intervention in relation to the cost of implementation, as well as the acceptability and expected compliance with them by the urban population.

6.4 Vaccines

In October 2021, WHO recommended "widespread use of the RTS,S/AS01 (RTS,S) malaria vaccine among children in sub-Saharan Africa and in other regions with moderate to high *P. falciparum* malaria transmission" *(75)*. This is the first vaccine for a human parasite to receive a WHO recommendation. The vaccine is to be used within the broad mix of WHO-recommended preventive, diagnostic and treatment measures. Although most of the trial and evaluation data came from predominantly rural settings, in principle the vaccine may be equally effective in focal areas of moderate- and high-transmission intensity in urban settings. However, if most people with malaria infections in urban areas have access to prompt and effective malaria treatment, and the risk of severe disease is low, the use of the vaccine in the urban setting may not be a priority.

Part 7. Delivering quality clinical care in urban areas

7.1 Ensuring quality of care

Between 5.7 and 8.4 million deaths are attributed to poor quality care each year in low-and middle-income countries (LMICs), and inadequate quality of care imposes costs of between $1.4 and $1.6 trillion annually in lost productivity in LMICs *(76)*. Quality of care is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with evidence-based professional knowledge *(77)*. To increase access to quality preventive and curative services for malaria, and improve clinical care outcomes in urban areas, careful attention needs to be given to improving the quality of health services across all levels of the healthcare system – from the community level up.

Quality is multidimensional. Ideal health services for malaria in urban settings should be effective, safe, people centred, timely, equitable, efficient and integrated (**Table 3**). To achieve this, individuals must work collectively within an optimal system. Iterative change is required to improve quality at every level of the health system. The WHO *Quality health services: a planning guide* outlines the actions required at the national, district and facility levels of the health system to improve the quality of health services, providing guidance on implementing key activities at each of these levels *(78)*. It highlights the need for a health systems approach to improve quality of care, with a common understanding among all stakeholders of the activities needed. It is applicable across rural and urban settings, but implementation pathways may vary depending on context, even between urban areas.

Table 3. Examples of how the domains of quality relate to care of malaria patients in urban settings

QUALITY DOMAIN	IMPLICATIONS FOR MALARIA CARE
Effective	Appropriate knowledge and skills of health workforce in delivering preventive and curative services in urban settings. Adherence to best-practice treatment guidance and protocols. Optimal training and supportive supervision.
Safe	Ensuring safety when preventive and clinical care is provided. Existence of appropriate safety protocols and standards.
People centred	Close engagement with communities to develop locally contextualized and people-centred strategies, and foster community ownership of interventions. Special attention paid to being accountable to the urban poor, whose voices are often not heard.
Timely	Responding to urgent population needs in a timely manner, including potentially large numbers of malaria cases imported to urban areas.
Equitable	Improving access and providing quality services, irrespective of socioeconomic status or urban community, thereby ensuring access by poor and marginalized groups, which suffer the greatest malaria burden.
Efficient	Efficient use of scarce resources – training of community health workers in assessment and treatment of uncomplicated malaria.
Integrated	Integrated management of malaria and other health services (e.g. pneumonia; maternal, newborn and child health; HIV), moving towards integrated health services.

Source: WHO *(78)*.

Managing and improving quality of care must be integral to efforts to combat malaria in urban areas. This will require:

- a motivated health workforce that is supported to provide quality care;
- accessible and adequately equipped health facilities;
- safe and appropriately designed interventions, devices and technologies;
- information systems that support continuous monitoring and response;
- financing mechanisms that enhance quality of care; and
- patients and communities that demand a high quality of care.

Another key component required to deliver high-quality malaria services to urban populations is "managing for quality" *(78)*. Patients will not use services that they mistrust and that they consider to be of little benefit to them. Thus, robust mechanisms to ensure, monitor and continually improve quality must be built into the foundations of healthcare systems. These include health worker and patient interactions, and readiness of facilities to deliver services.

7.2 Prompt diagnosis and effective treatment of malaria

Healthcare delivery in urban areas is often uneven in spread and quality, so development of strategies for improvement should be based on a thorough understanding of the local context. **Box 4** summarizes the key aspects of delivery of quality care to malaria patients in urban settings, which are broadly similar to approaches in rural settings, and are anchored in universal health coverage *(1)*.

Compared with rural settings, the healthcare system in urban areas is typically characterized by:

- a higher concentration of public and private healthcare facilities, and a higher number of healthcare professionals per unit population;
- specialized referral facilities and teaching hospitals (in larger urban centres);
- a relatively high number of care providers, private laboratories and medicine retailers in both the licensed and unlicensed private sectors, who are attracted by high population densities and a predominantly cash-for-service economy;
- an uneven distribution of healthcare facilities that leaves some areas, including informal settlements, underserved;
- limited regulations on importation, trade and advertising, and a poor capacity for quality control testing and enforcement; this can lead to the existence of substandard and falsified products and services that leave the urban population, particularly those in informal settlements, vulnerable to suboptimal health care; and

- the blending of "boundaries" between public and private health services, with many health professionals operating in both the public and private sectors. This multiplicity of care delivery points and sources of information for the public, along with an often multicultural, mobile and socioeconomically diverse population, makes communication and action around treatment-seeking behaviour and healthcare delivery in urban areas complex and dynamic.

A higher concentration of wage earners and opportunities for affiliation of private clinics and pharmacies that makes implementation of health insurance schemes relatively feasible in urban areas. This provides an opportunity to improve access to quality malaria diagnostics and medicines, however, these schemes must have the necessary safety nets for the poor.

In some countries certified by WHO as malaria-free, antimalarial medicines are not available in pharmacies. Instead, confirmed cases are immediately referred to specific public health facilities for free malaria treatment and rapidly reported to ensure documentation and appropriate classification of cases. Travellers who are rarely exposed to malaria in their countries or places of residence should be informed about the malaria risks at their destination, the best approaches to prevent malaria infection during their travels, how to report any symptoms when they return, and the importance of seeking early diagnosis and treatment.

BOX 4. PROVISION OF PROMPT, HIGH-QUALITY DIAGNOSIS AND EFFECTIVE TREATMENT

Diagnosis

- Rapid diagnostic tests available in all primary healthcare facilities, including in the private sector where access remains limited
- Quality microscopy available at relevant levels of the health system, especially in inpatient facilities, including in the private sector or for confirmatory purposes in elimination settings

Treatment

- First- and second-line treatment available at all appropriate levels of health service facilities
- Appropriate management of severe malaria cases in all inpatient facilities

Delivery

- Strong public health system with adequate and motivated health workforce
- Universal health coverage – all residents have access to quality, affordable care
- Strong engagement of the private sector to provide quality, affordable care
- Exploration of delivery of quality service through community health workers and the private sector to serve marginalized and/or underserved populations in urban areas
- Investigation of the presence of substandard and counterfeit products, and implementation of legal codes to mitigate these risks

7.2.1 Ensuring access to prompt diagnosis, effective treatment and referral

Quality malaria diagnostics and medicines should be available and affordable at the point of care. Recommendations on which medicines to use to treat malaria and manage severe disease can be found in the WHO malaria guidelines *(69)*. All people with suspected malaria should have rapid access to parasitological confirmation of diagnosis using rapid diagnostic tests (RDTs) or microscopy, with results available within a short time after patient presentation. Case definitions can vary across the transmission continuum. In moderate- and high-transmission settings, history of exposure and fever form the main basis for suspecting malaria. In elimination settings, information from travel history and other factors may inform case definitions.

Patients with severe febrile illness should be rapidly referred to health facilities for care, as delayed treatment of severe malaria increases the risk of death. People with confirmed diagnosis of uncomplicated malaria should be treated with effective first-line treatments. Antimalarial treatment should be limited to cases with positive tests; patients with negative results should be reassessed for other common causes of fever and treated appropriately. For patients with *P. vivax* infection, radical cure with appropriate medication is recommended.

Legal codes against the distribution of substandard and counterfeit products should be strictly implemented.

Inpatient facilities should be equipped with blood transfusion services, and sufficient supplies of oxygen, ventilators and other requirements for the management severe illness.

7.2.2 Identifying and reaching vulnerable and marginalized populations

Poverty and social marginalization reduce access to prompt and effective diagnosis and treatment. They are concentrated in informal settlements, where marginalized ethnic and religious groups, illegal immigrants and minorities reside and tend to be exploited for low-paid labour. In these populations, children, pregnant women and immunocompromised individuals are the most vulnerable to malaria mortality. Government policies tend to promote free access to treatment, but public health facilities are often limited and overburdened in urban informal settlements. Universal health coverage demands special initiatives to ensure equitable access to care for vulnerable and marginalized populations in urban informal settlements, including social and behaviour change communication materials tailored to reach these groups to encourage healthcare-seeking behaviour. In addition, provision of community services and engagement of private medicine retailers through accreditation, franchising and subsidy schemes may be needed.

7.2.3 Engaging the private sector

Access to quality-assured RDTs and microscopy is limited in many malaria-endemic settings, particularly in the private sector. A recent study in Nigeria found that malaria rapid diagnostic tests were available in only about 20% of private pharmacies and vendors *(79)*. However, studies have also shown that staff (including non-medical staff) in a variety of private healthcare settings can administer a malaria RDT and

adhere to the test, provided they have been well trained and receive appropriate supervision *(80)*. Testing in the private sector, however, is hampered by policies and regulations that restrict where RDTs can be sold and performed, as well as by the lack of financial and non-financial incentives to support malaria testing before treatment.

The demand for, and supply of, artemisinin combination therapy (ACT) in both the public and private sectors is promoted and well established in provider and consumer behaviour. However, market forces, poor regulation and limited out-of-pocket money often crowd out quality-assured ACT in the private sector. Consequently, poor-quality and inappropriate products are often accessed. Special initiatives are needed to promote appropriate case management in the private sector – for example, tax and tariff exemptions, subsidy schemes, accreditation of medicine retailers, and other measures that increase the affordability of testing and treatment to the patient or caregiver. As noted above, prompt and complete reporting of confirmed cases through established surveillance systems is crucial.

7.2.4 Strengthening referral systems

The rapid transfer of patients to referral facilities for intensive care is easier in urban areas than in remote rural areas. However, the multiplicity of healthcare delivery points and the widespread availability of substandard care in some settings are persistent causes of delayed referral and appropriate care. Also, tertiary facilities in urban areas may be crowded with outpatients seeking care for mild illness, as a result of challenges in the city-wide primary healthcare systems or referrals from outside the urban setting. WHO has developed guidance on strengthening referral systems in low- and middle-income countries *(81)*.

Ensuring access to prompt, effective care for mild malaria is the most efficient way to ensure that referral facilities are not overburdened with severe malaria cases *(69)*. This requires expanding access to quality primary health care. The basic requirements for efficient referral systems include establishment of referral criteria, clear communication channels between different levels of the system, availability of transportation services, and adequate affordable inpatient facilities to avoid overcrowding and poor patient management. Marginalized and poor urban communities, who are at the highest risk of malaria, often have difficulty accessing the referral system. City governments should pay attention to social protection approaches to help them, including free transport and admission to referral facilities for the very sick.

Part 8. Developing a response plan for malaria in urban areas

Planning for infectious disease control, including for mosquito-transmitted diseases, is essential to secure the health and resilience of future urban populations alongside rapid urban growth. Planning of the malaria response in urban areas should be aligned with established processes for urban health planning and priority setting. The process should address the unique challenges and opportunities in urban settings, engage stakeholders at all levels, and use appropriate data and analysis to inform tailoring of interventions and strategic approaches.

Planning and response will be led by urban or municipality governments, with strong technical support from national malaria programmes, and close links to central authorities, partners, the private sector and communities.

As described in detail in previous sections, the response to malaria in urban areas revolves around:

- an effective town- or city-wide surveillance, and monitoring and evaluation system to detect malaria and other infectious febrile diseases, mosquito larval sites, adult mosquito species, their abundance and behaviour and tailor interventions to need; and evaluate their impact
- prevention of malaria in urban areas, targeted based on surveillance data and consisting of mosquito control; and
- access to equitable, quality health care, with prompt diagnosis and effective treatment for all those in need.

There are five main enabling factors to consider in the malaria response in urban areas:

- linking policy planning, budgeting and response at the national and local urban government levels to ensure resource mobilization across multiple sectors, including funds earmarked for infrastructure development;
- intersectoral collaboration between the municipality's malaria control unit, national malaria programmes, other sections in the local health department, other municipal departments (e.g. finance, planning, housing, waste removal, water, education, agriculture and the environment) and nongovernmental organizations;
- inclusion of, and engagement with, all parts of the local community to ensure their support and involvement;
- targeted social and behavioural change communication; and
- ongoing research to generate innovative solutions to respond to malaria in urban settings.

A summary of the India Urban Malaria Scheme, established in 1971, provides a case study example in **Box 5**.

BOX 5. THE URBAN MALARIA SCHEME IN INDIA

Rationale

The Madhok Committee was set up in 1969 to advise the country and the Indian National Vector Borne Disease Control Programme on a comprehensive plan for the control of malaria in both rural and urban areas. By 1970, 10–12% of malaria cases in India per year were from urban areas. A modified plan of operation, which included the Urban Malaria Scheme (UMS), was developed and submitted to the Indian Cabinet. The scheme was approved in 1971.

Objective

The objective of the scheme was reduction of transmission, disease and deaths due to malaria to a tolerable level at which the human population can be protected from malaria transmission with the available means.

Urban areas covered by the UMS

The criteria used to select areas for inclusion in the UMS were towns with at least 50 000 people; annual parasite incidence of 2 (cases per 1000 population); and willingness of towns to establish and implement civic by-laws to prevent or eliminate domestic and peri-domestic mosquito breeding places.

Currently, the UMS protects nearly 143 million people from malaria and other mosquito-borne diseases in 131 towns in 19 states and union territories.

Interventions and strategies[a]

Parasite control

- Provision of quality diagnosis and treatment in hospitals and dispensaries in both the public and private sectors.
- Establishment of malaria clinics or malaria control agencies in megacities, via municipal corporations, railways, defence services and so on.

Vector control

- Source reduction through environmental methods to control mosquito breeding, such as engineering works; filling of ditches, pits and low-lying areas; lining of streams, canalizing; desilting; deweeding; trimming of drains; safe water disposal and sanitation; emptying water containers once a week; and observing weekly dry days *(82)*.
- Larval control, including use of larvicides and larvivorous fish.
- Space spraying using pyrethrum extract (2%) in 50 houses around every malaria and dengue positive case to kill infective mosquitoes.
- Minor engineering works.

Legislation

- Establishment or strengthening of legislation and by-laws to support the control of malaria and other mosquito-borne diseases. These focused on preventing mosquito breeding in domestic and peri-domestic areas, residential blocks, government and commercial buildings, and construction sites.

BOX 5. THE URBAN MALARIA SCHEME IN INDIA (continued)

Staffing

Each municipal area was staffed with an entomologist/biologist and a surveillance officer; each ward was staffed with an inspector and insect collector; and each sector was staffed with five field workers. A driver and a car were provided to towns with up to 40 sectors (two drivers and two cars for those with more than 40 sectors).

Funding

Expenditure for this scheme is included in the centrally sponsored sector plan. A matched equivalent, in kind, was provided by state governments.

[a] *See the WHO guidelines for malaria (69)* for recommendations on various strategies and interventions.

Source: National Center for Vector Borne Diseases Control *(73)*.

8.1 Key steps in the development of the response plan for malaria in urban areas

There is no single pathway applicable to all countries to develop a robust response plan for malaria in urban areas. This is because the governance structures vary across different countries and urban areas, from highly centralized to highly devolved decision-making. As well, resources needed for urban health may be controlled by central governments or urban governments. Therefore, the steps described in **Fig. 9** are illustrative and should be adapted to each urban context. The underpinning commonality is a holistic response that achieves the best returns on investment while ensuring equity and social protection.

Fig. 9. Steps for development of the malaria response in urban settings

NMP = national malaria programme; SBBC = social and behavioural change communication

[a] Refer to previous sections of this document for details on interventions, activities and data needs for the response to malaria in the urban setting.

[b] Refer to section 7.2 for more details on tailoring of malaria interventions and activities.

8.2 Tailoring the response: microstratification and multi-criteria decision-making

WHO consolidated malaria guidelines have recommendations across all interventions and strategies that can be accessed in an easy-to-use online platform *(69)*. Countries should refer to these recommendations when making decisions on malaria interventions in urban areas. However, many factors, such as adequate housing, reliable piped water and clean environments, that reduce malaria in urban areas are also basic human rights, as described in Part 6. Therefore, countries should incorporate these into their malaria response strategies, and mobilize resources for them as appropriate.

To effectively tailor the malaria response across urban settings, relevant data and contextual information should be collected and used to determine the appropriate mixes of interventions and approaches for optimum impact on transmission and burden of disease. To do this effectively, data should be geocoded to the relevant units of decision-making. In urban areas, enumeration zones, neighbourhoods or equivalent are sufficiently granular geographies for decision-making. Where cases are imported, it is important to link data to possible places of infection.

Microstratification (stratification of risk and its determinants at a granular and operationally relevant level) will help with geographically (and temporally) classifying malaria risk and its determinants into meaningful categories to inform the tailoring of interventions to geographic units of interest (malaria hotspots). Layering different microstratified indicators allows multi-criteria decision-making to determine which interventions and approaches to implement. WHO is developing an operational manual on subnational tailoring of malaria interventions that will provide further guidance to countries. In brief, the following steps are key to this process.

Step 1: Map the malaria risk

Malaria risk in urban settings can be defined using epidemiological and entomological metrics. Risk may also be defined based on the determinants of transmission. These include environmental factors, such as distribution of potential suitable breeding places for local vectors, level of urbanization (urban, surburban, peri-urban, rural fringe), housing and infrastructure (informal settlements), ground coverage, climate and seasonality. Often, there is no single type of data to adequately define malaria risk, and triangulating across different sources of information is helpful in the process of risk microstratification.

Epidemiological information from routine surveillance systems, even at the aggregated level, can be a good signal of the distribution of malaria in urban settings. There are, however, a number of important issues to pay attention to when using aggregated routine data.

- Data from health facilities are often not linked to patient residence, and there could be a mismatch between the burden measured at point of care and the origin of cases. This is especially the case in areas with large health centres and hospitals.
- Where data are reported, it is sometimes uncertain whether diagnosis of treated cases was through a parasitological test or solely based on symptoms.

- Information from health facilities may not be complete, as a result of inconsistent reporting.
- Information on the underlying population at risk over time, which is required to calculate measures such as parasite prevalence and malaria incidence, may be inaccurate or unavailable.
- Many patients are likely to seek care in the private formal sector. In many settings, this sector is not connected to the surveillance system, adding to the incompleteness of routine data.
- In some cases, patients may self-treat at home using medicines purchased from shops or drug stores, often without a clear understanding of their malaria status.
- Even with complete data, most cases in urban areas are likely to be imported in some settings. Information on travel history may not be available for countries that do not have surveillance systems that are used in elimination settings.

Some countries may have community data on parasite prevalence, but these are often from only very few locations and collected every 3–5 years. More frequent small-scale household surveys may be done in targeted areas within urban settings, but these could be expensive. Countries are therefore encouraged to establish the required surveillance systems to collect epidemiological data that can adequately inform the response to malaria in urban areas, as described in Part 5.

Meanwhile, countries can combine aggregate health facility data with targeted extraction of retrospective patient-level information from health facilities, focusing on cases that received care during the peak transmission seasons. This will help provide information on residence and case distribution across the urban setting, as well as on gender and age patterns. These data can then be matched with available entomological data and data on other determinants related to the environment, infrastruture, socioeconomic status and climatic factors to develop a context-specific risk matrix. In areas where risk is considered to be moderate or high, and there is uncertainty about the extent of importation, health facilities can conduct rapid patient surveys of travel history to clarify the current level of risk.

Step 2: Define appropriate interventions and approaches

As described in previous sections, the most sustainable approach to reducing malaria transmission and burden of disease in urban settings is by environmental management to reduce mosquitoes at source through urban planning, carefully planned socioeconomic and infrastructure development and maintenance and improvements to socioeconomic conditions. This should be the fundamental aspect component of the response to malaria in urban areas.

Additional preventive interventions such as house screening, larviciding, ITNs, IRS, chemoprevention and vaccines can be implemented in targeted ways, focusing on areas at high risk of malaria. Access to quality clinical care should be available across the urban setting; special consideration will be needed to reach marginalized and socioeconomically vulnerable communities.

Tailoring interventions to clusters of malaria transmission will require defining, at the response unit level, criteria based on:

- the baseline and current risk of malaria;
- the type of interventions that have been implemented in the past and their impact;
- socioeconomic and developmental changes between baseline and the current period, and their potential role in modifying risk; and
- the interventions currently available, and their efficacy and effectiveness (individually and in combination), community acceptability and delivery mechanisms.

For example, the general criteria for targeting ITNs, as provided in the WHO malaria guidelines *(69)*, are as follows:

- ITNs are most effective where the principal malaria vectors bite predominantly at night after people have retired under their nets.
- ITNs can be used both indoors and outdoors, wherever they can be suitably hung (hanging nets in direct sunlight should be avoided).
- Continuous distribution through antenatal care and Expanded Program on Immunization channels should remain functional before, during and after mass distribution campaigns. Other distribution channels may include schools, faith-based and community-based networks, and occupation-related channels (e.g. farm workers, miners, the private sector).
- If pyrethroid resistance is detected, pyrethroid–piperonyl butoxide (PBO) nets should be considered for distribution, instead of pyrethroid-only nets.

Adaptation of these criteria to urban settings will require consideration of the following:

- Based on the level of clustering of malaria risk, the strategy may be to move away from universal mass distribution across the whole urban setting to targeting clusters of ongoing transmission.
- Where all clusters in an urban setting have very low transmission, ITN distribution may not have a significant public health impact in the urban area. In some areas, transmission is very low (equivalent to less than 1% parasite prevalence) at baseline, or incidence is less than 100 cases per 1000 population at risk per year.
- A suitable transmission threshold might be defined, given that, even in clusters where there is some level of transmission, this may be too low for ITNs to have a significant impact on malaria.
- In very low transmission areas, environmental management is likely to be more effective – for example, targeted larviciding and combined with expanded access to case management and case-based surveillance (including outbreak detection systems), and IRS for outbreak response.

- Digital microplanning and delivery platforms can be efficient tools for targeting and distributing nets in urban areas, as in rural areas.

- Household survey data may not be sufficient to track access, coverage and use of ITNs in urban settings. However, they may be necessary initially to establish baseline transmission in some settings, if sampling is appropriately adapted. Programmatic data, together with updated digital microplanning databases, may be operationally more feasible in the long term..

Across all interventions, countries can use the practical information provided in the WHO malaria guidelines *(69)*, as well the operational manual for subnational tailoring of malaria interventions *(83)* and other WHO implementation guidance to tailor interventions and approaches optimally.

Step 3: Project the impact of intervention and strategy combinations

Countries are likely to decide on several implementation scenarios in their response plans for malaria in urban areas. To help countries decide on the optimum scenarios, mathematical models may help with projections of impact *(84)*. The current transmission dynamic models that have been used to analyse intervention effects will require important adaptations to the urban context because vector–human dynamics and care-seeking pathways are likely to be different from those in rural areas. Furthermore, with mosquito control through environmental management likely to be an essential basis for the response, data are needed to accurately parametrize models.

By identifying which interventions and strategies have the greatest impact, mathematical models offer ideal pathways to understand the impact of the various scenarios, and help with decisions on resource prioritization.

Step 4: Prioritize within limited resources

Priority setting is an important, although often challenging, process of governance, budgeting and implementation. Broadly, health priority setting aims to select the best possible options for addressing the most important health needs, in the best way within available resources *(85)*.

Health priority setting is inherently political and, as such, must be inclusive, reflect societal values and goals, and be based on compromise among stakeholders. However, it must also be informed by the evidence. The core of prioritization must be need, impact and equity. The process of tailoring malaria interventions and strategies should be part of, and aligned with, priority setting for the broader national health sector. In addition, priority setting for the response to malaria in urban areas should incorporate the contribution of the wider non-health sector as part of the broader urban health and development agenda, including input from affected communities. Modelling, cost-benefit and cost-effectiveness analysis may be useful in supporting priority setting.

Part 9. Innovation, research and development

The *Global technical strategy for malaria 2016–2030* clearly outlines that innovation, research and development are essential to continuously improve and transform the global response to malaria *(4)*. In support of the three pillars of the strategy, countries where malaria is endemic and the global malaria community are advised to harness innovation and increasingly engage in basic, clinical and implementation research. The New Urban Agenda also highlights the need to harness research and technology for sustainable, healthy cities *(7)*. Although not exhaustive, nor in order of importance, some general areas of focus for innovation and research related to malaria in urban areas include the following.

- **Transmission dynamics and determinants of malaria in urban areas.** Understanding the epidemiological, entomological, climatic, environmental and socioeconomic determinants of malaria in urban areas will be essential to improving the response to malaria in urban areas. Social determinants include acceptability of interventions, household wealth and poverty, gender, education, employment, social connectivity and marginalization, migration and inequities that result from these determinants. Environmental determinants include the extent and distribution of malaria mosquito habitats, the type of habitats used and the porosity of houses to adult mosquitoes. Some of these determinants can be mitigated through malaria-specific prevention and treatment interventions, whereas others will require socioeconomic development, improved governance, social inclusion and other approaches.

- **Impact of malaria in urban areas on children, pregnant women and other high-risk groups.** Few studies have been conducted on malaria importation rates, and their contribution to malaria transmission and severe malaria phenotypes (including *P. vivax* relapses) in urban areas. There are also limited studies of the consequences of malaria in pregnancy in urban areas, where transmission is often below the WHO recommended thresholds for use of intermittent preventive treatment in pregnancy. Given the consequences of seasonality of movements on acquisition of malaria and importation into urban areas, another information gap is the role of importation of malaria on school attendance, the labour force and overall productivity in urban areas.

- **Impact of current malaria control interventions.** Most malaria control interventions, including mosquito control tools, treatments and chemoprophylaxis, have been evaluated only in rural situations. They also need to be evaluated in urban environments, where malaria mosquito densities are often lower, breeding grounds can be better identified, human population movements play a greater role in transmission and there is a wider range of socioeconomic status. Lower vector densities, malaria infection rates and malaria incidence lead to the need for very large sample sizes in intervention trials. More studies are needed on the impact of interventions on urban *P. vivax* transmission and burden. Therefore, methodologically innovative study designs, including pragmatic trials, are required to provide useful information on impacts of malaria interventions in urban settings.

- **Effectiveness of environmental interventions.** Case studies of environmental interventions such as management of drainage, filling of ditches and removal of solid waste are needed to share successes and failures. The supply chain for building interventions, including house screening, needs to be described

to remove bottlenecks and facilitate introduction of these interventions. The importance of mosquito-free urban green spaces for health and well-being should be studied in malaria-endemic countries.

- **Scaling up of environmental interventions.** Evaluation is needed of the product supply chain for relevant, quality building commodities (for house screens and other modifications), from factories to the consumer, including identification of barriers to supply and access. This goes beyond malaria-specific needs and will contribute to overall provision of affordable housing, with direct implications for overall social well-being, malaria and other vector-borne diseases. Collaborations with engineering departments in local universities and with private industry are needed to address these issues.

- **Evaluation of new technologies for surveillance.** Technology offers massive opportunities in disease and entomological surveillance, delivery of malaria interventions (e.g. digital campaign platforms), epidemic preparedness and response, mapping of land-use changes, tracking climatic factors through remote sensing and tracking human population movements through GPS-enabled devices. The switch to technological solutions may be easier in urban settings than in rural settings because of better availability of electricity, the internet and a trained workforce. Urban areas, however, also have islands of technological exclusion, often among marginalized and lower socioeconomic groups. Research and innovation in the broad areas of surveillance of health and malaria-related factors are likely to yield major improvements in the response to malaria in urban areas.

- **Development of novel interventions.** Appropriate and novel interventions, including environmental interventions, need to be developed for the control and elimination of malaria in urban areas. Innovation is urgently needed to develop solutions for removing solid waste and sewage, important sources of urban mosquitoes and domestic flies, from the environment, including recycling to produce new products such as building substitutes, fertilizer and biogas. Research needs to be encouraged into innovation in microfinance products, easy access to house screening products and development of new financial products for supporting entrepreneurs. Industry-quality, accessible house screens are required.

- **Adaptation of risk mapping and mathematical models of malaria transmission.** Current geospatial and mathematic modelling frameworks have been parametrized primarily using data from rural malaria-endemic settings. They are not well adapted to mapping and modelling small-scale (geographic and temporal), highly clustered transmission dynamics in urban settings. However, the data to inform these studies are limited. There is a need to collect data relevant to mapping and modelling of malaria transmission dynamics in epidemiological, entomological and other urban research studies and routine systems. There is also a need to develop geospatial and mathematical models that effectively address the dynamics of malaria transmission in urban areas.

- **Case studies of best practices for effective multisectoral approaches.** Although often advocated, good practices in operating intersectoral committees for control of malaria in urban areas need to be developed and shared. Studies of the interactions between actors involved in multidisciplinary research need to be undertaken to record both successes and failures, to guide other malaria programmes in urban areas. This requires a transdisciplinary approach. Examples of malaria elimination in urban settings also need to be described and shared.

- **Community engagement.** Engagement of local communities in implementation research is important. Community engagement processes in malaria programmes in urban areas, health services and local government services are complex, dynamic and adaptive. Examples of good and bad practices should be captured in case studies to help guide future plans, as well as to consider investments in the necessary staffing to ensure success. Engagement of communities with both the health sector and other sectors, and the synergies that arise from this engagement are essential to understanding sustainable community engagement approaches.

- **Health education.** Research is required on public health messaging to encourage community activities for malaria control and behavioural changes (e.g. shutting doors at dusk, avoiding littering). Development of school curricula that provide instruction on malaria and other relevant mosquito-transmitted diseases should be encouraged. Studies into effective advocacy approaches are essential.

- **Economic impacts.** The economic impacts of malaria and other urban mosquito-transmitted diseases such as dengue should be estimated to understand the loss of income and tax revenue – from individuals and businesses – due to days lost to ill health and lower productivity. Special consideration needs to be given to the economic role of women, who have a disproportionate role as carers of sick children and relatives. These assessments provide compelling evidence that can be used to make the case for investment in the control of malaria and other vector-borne diseases.

- **Impacts of climate change and urbanization.** Rapid urbanization increases climate risks because most of the greenhouse gas emissions that lead to climate change are produced in urban settings. In addition, urbanization leads to increased temperatures of several degrees because of the large quantity of cement and tarmac (materials with a high thermal mass); this can increase malaria risk by increasing the development of mosquitoes and parasites. Drought and floods, often exacerbated by climate change, will make risks associated with water storage and flooding more common, increasing the risk of malaria and dengue in many urban settlements. Climate change leads to loss of rural livelihoods, population displacement and rapid urbanization in ways that are hard to predict and plan for. These changes are already having disruptive economic and social influences in both rural and urban areas. Over the long term, climate change could modify malaria transmission patterns. Therefore, research is needed to provide insights into the link between urbanization, climate change and the risks of malaria and other vector-borne diseases.

- **Legislation and enforcement.** Enforceable laws to reduce the threat of malaria and other mosquito-transmitted diseases in urban areas should be considered. This can be through housing regulations; standards for the construction of roads, drainage and other features; management of urban agriculture; waste disposal; protection of urban water systems; maintenance of urban parks; and other environmental factors related to malaria in urban areas. Regulations may also be needed in diagnosis, treatment and reporting of malaria cases from the private sector. Laws that discourage the importation or development of substandard diagnostics, medicines, insecticides, nets and other malaria tools are essential.

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Annex 1. Development process and members of the thematic groups

This publication was developed by WHO (the Global Malaria Programme and the department Social Determinants of Health) and UN-Habitat following the launch, in September 2021, of a global consultation on a framework for malaria control in urban environments. The consultation involved Member States and stakeholders, including organizations of the United Nations, scientific and research groups, nongovernmental organizations and implementation partners. The launch was led by the Honourable Yvonne Aki-Sawyerr, Mayor of Freetown, Sierra Leone, and Pedro Alonso, former Director of the Global Malaria Programme. The process was supported by five specialized thematic area working groups consisting of leading experts in their fields, as well as scientists and other stakeholders. The full list of is provided below:

Thematic group on prevention

Co-chairs:

Paola Marchesini, National Malaria Control Programme, Brazil

Fredros Okumu, Ifakara Health Research Institute, United Republic of Tanzania

Members:

Jen Armistead, President's Malaria Initiative, United States of America

Jude Bigoga, University of Yaounde, Cameroon

Fiona Cameron Shenton, Durham University, United Kingdom of Great Britain and Northern Ireland

Prosper Chaki, PAMCA Organization, United Republic of Tanzania

Alex Eapen, ICMR - National Institute of Malaria Research, India

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Annex 2. Ecology of malaria in urban areas

Sub-Saharan Africa

In sub-Saharan Africa, malaria prevalence in urban areas is generally than in rural areas, because mosquitoes are less numerous per person in towns and cities than in peri-urban and rural areas. This is largely due to the lower abundance and extent of mosquito breeding sites in urban environments (**Fig. A1**). Lower mosquito biting rates in urban areas is also a consequence of high human population density, the presence of well-screened houses, the fear of theft that results in buildings with few external openings, and a high density of metal-roofed houses that have extremely high indoor temperatures during the day, which can reduce the survival of malaria mosquitoes resting indoors *(1)*. In marked contrast, in rural areas, water bodies are more extensive, and housing is often less dense, with cooler thatch-roofed houses. In rural areas, most malaria transmission occurs in or near the home, whereas, in urban areas, a large proportion of infections and cases may be acquired when travelling for business or pleasure to rural areas. In towns and cities, transmission is focal, with a few areas accounting for most cases; transmission rates are often higher in peri-urban areas and informal settlements.

Although well-planned urban growth in sub-Saharan Africa reduces malaria risk, of increasing concern is the recent colonization of African cities by the highly efficient urban mosquito *Anopheles stephensi*. This species is the main malaria mosquito vector in urban settlements in India and Pakistan. It has recently invaded Sudan, Ethiopia, Djibouti and Somalia, and is likely to have spread across many African cities *(2)*. *An. stephensi* thrives in cities, where it occurs in human-made water containers such as household water storage containers and garden reservoirs (typical *Aedes aegypti* mosquito habitats), as well as open, sunlit pools. Sub-Saharan Africa has not previously had a malaria mosquito such as *An. stephensi* that has adapted to urban centres, and the reported establishment of this species in the Horn of Africa poses a potential health risk of unprecedented size.

Since transmission rates are lower in urban areas than in rural areas, levels of immunity are also lower in towns and cities, making urban populations susceptible to epidemics of malaria if malaria mosquito populations rise sharply. Whereas people in rural communities are infected at home, urban residents travelling to rural areas become infected far from home, becoming ill when returning to their urban home. In rural areas, people sick with malaria are treated by the public health sector, whereas, in town, people often seek treatment from the private sector, at small clinics or at shops or market stalls.

South-East Asia

Malaria in urban areas is restricted to the Indian subcontinent, from Karachi in the west to Kolkata in the east. The disease is well established in urban areas as a result of the adaptation of *An. stephensi* and, to some extent, *An. culicifacies* to breeding in artificial containers. Malaria is particularly associated with rapid peri-urban expansion and poor socioeconomic conditions in cities such as Mumbai, New Delhi and Chennai *(3)*. Since urban control of malaria is not a new public health concern in Asia, there are opportunities for control programmes elsewhere to learn from the continent's control strategies.

Latin America and the Caribbean

In Latin America, malaria is traditionally a rural disease. However, there have been increases in the incidence of urban malaria over the past decade, despite an overall reduction in national malaria burdens, including in Colombia, Brazil, Peru and Ecuador *(4, 5)*. This trend has been driven by rapid and unplanned urbanization, fuelled by population growth and migration of people from rural malaria-endemic areas to areas with malaria mosquitoes. These migrants often reside in areas with poor socioeconomic conditions, inadequate housing, and lack of sanitation and drainage. Political instability is a driving force behind population displacement – for example, in Colombia and Venezuela. There is also evidence that some mosquito species have adapted readily to the urban environment and new larval habitats such as water containers, enabling local malaria transmission within urban areas *(4)*. Urban malaria is of concern because of the rapid expansion of populations and urban areas in this region.

Fig. A1. Examples of common aquatic habitats for African urban malaria mosquitoes

A: urban flooding; B: urban garden; C: brick pits; D: pit for rubbish; E: concrete water storage used during house construction; F: flooded yams.

Source: photos courtesy of S Lindsay.

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Annex 3. Multidisciplinary malaria control in Khartoum

Malaria was the major cause of outpatient attendances, admissions and deaths in Khartoum, Sudan, in the 1980s and 1990s. This led to the launch of the Khartoum Malaria Free Initiative (MFI) in 2002 by the State and Federal Ministry of Health. The MFI targets a total population of 2 million people in urban areas, 3 million people in peri-urban areas and 0.6 million people in rural areas *(1-4)*. Since implementation of the programme, total malaria deaths (confirmed and unconfirmed) have declined by almost 75%, from 1070 in 1999 to 274 in 2004, and parasite prevalence has declined from 0.8% to 0.04% (1995–2008) *(1, 5, 6)*.

Integral to the success and sustainability of the programme has been strong political support at both the state and federal levels, together with close coordination with the ministries of health, education, and agriculture and animal resources, and the Urban Water Corporation (UWC). This delegation of responsibilities has also helped maintain the total annual cost, which is covered largely by the government, at the relatively low level of US$ 600 000 or around US$ 0.10 per person protected per year. The robust structure of the programme is particularly important, given that funding is so difficult to maintain, new agricultural schemes and new construction sites continually create more breeding sites, and the health system has been weakened by two decades of conflict.

The MFI has three main components: diagnosis and treatment, prevention and epidemic surveillance. However, its mainstay is control of the population of the primary malaria mosquito *Anopheles arabiensis*, which largely breeds in irrigation canals, and pools created from broken water pipes, water basins and storage tanks. To achieve this, the removal of water basins and storage tanks is enforceable by law, and the Ministry of Health collaborates with the UWC to repair broken water pipes. The MFI is responsible for surveillance, reporting and transportation, while the UWC provides engineers and equipment. By 2004, just under 4 km of water pipes had been replaced, and more than 6 km had been repaired.

The regular drying of irrigated fields (intermittent irrigation), which reduces mosquito breeding, is compulsory in both government and private irrigation schemes. This initiative is supported by the Farmers Union and the Ministry of Agriculture and Animal Resources. In 2011, 98% of irrigation schemes were dried for at least 24 hours. Leakages from irrigation canals are also repaired, and vegetation around canals is cleared in conjunction with the Ministry of Agriculture and Animal Resources. The MFI employs 14 trained medical entomologists, 60 public health officers, 180 sanitary overseers, 360 assistant sanitary overseers and 1170 spraying personnel, who are responsible for routine larviciding and environmental management to reduce mosquito breeding *(3)*.

One factor contributing to the sustainability of the MFI is strong community support, generated through the distribution of information leaflets, regular radio broadcasts and television coverage, health education in schools in collaboration with the Ministry of Education, the organization of an annual Khartoum State Malaria Day, public meetings, and the establishment of malaria control committees and societies. A total of 405 schools and 287 000 pupils are involved in mosquito larval control activities. IRS and distribution of long-lasting insecticidal nets (LLINs) are not currently undertaken in Khartoum; however, LLINs are exempt from import tax to encourage

private sector sales. The MFI also seeks to strengthen case management through the improvement of microscopy, staff training and provision of antimalarial drugs through the "revolving drugs fund".

The experience of Khartoum State has shown the effectiveness of an integrated approach to malaria control, involving social stability, widespread health education and strong programme administration. The programme also succeeded in mobilizing local resources and related sectors for malaria control through training of local staff, continuous evaluation of local models by national health authorities, and the designation of local leaders based on ability rather than personal or political relations. Long-term solutions to ensure sustainability require proper urban planning, reinforcing the drainage and sanitary facilities, and improving the performance of the health services, including diagnostic capacity.

Recent setbacks in the fight against malaria in Khartoum also demonstrate the fragility of the progress when faced with political instability, biological threats and funding limitations.

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