Zika Virus Risk Assessment in the WHO African region

A Technical Report

February 2016

World Health Organization
REGIONAL OFFICE FOR Africa

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Cover photo: *Aedes aegypti* mosquito biting a person

Acknowledgements
The authors would like to thank Peter Macharia, Paul Ouma, Stephen Oloo, Ezekiel Gogo and Joseph Maina of the KEMRI/WTRP for their help in data assemblies and mapping. The authors thank Raymond Bruce J Aylward, Sylvie Brand, Philippe Barbosa of WHO Geneva and Amadou Sall Institut Pasteur, Senegal, for comments on earlier drafts of this report.

CONTENTS

BACKGROUND

Zika viral disease is transmitted through the bite of an infected mosquito, primarily *Aedes aegypti*. The virus was first identified in 1947[1] in rhesus monkeys in the Zika forest of Uganda, and human disease was first identified in 1952 in Uganda and the United Republic of Tanzania. Zika virus disease outbreaks were reported for the first time from the Pacific in 2007 and 2013 in Yap and French Polynesia, respectively. The geographical spread of Zika virus has since been steadily increasing.

Zika virus disease has similar clinical presentation as chikungunya and dengue, although it generally causes a milder illness. Symptoms of Zika virus disease include fever, skin rashes, conjunctivitis, muscle and joint pain, malaise, and headache, which normally last for 2 to 7 days. There is no specific treatment for Zika virus disease, but symptoms are normally mild and can be treated with common pain and fever medicines, rest and drinking plenty of water.

Neurological complications have been reported in Polynesia and in Brazil in 2014 and 2015 respectively. More recently increased number of microcephaly cases has been reported in Brazil since October 2015. Although these microcephaly cases are spatially and temporally associated with the Zika outbreak, more robust investigation and research is needed to better understand a causal link. Other countries with current outbreaks such as Colombia, El Salvador, Cape Verde and Panama have not reported an increase in microcephaly.

For many years, despite lack of systematic surveillance mechanism for Zika virus disease, sporadic human cases were detected in Africa. Since 2007 the spread of the virus has been confirmed in 8 Pacific islands, 25 countries and territories of the Americas, and a few Asian countries. In the African region, Cape Verde has reported outbreak with over 7000 cases from October 2015 to January 2016. However, the number of cases has been on the decline since December 2015 according to available data.

ASSESSING THE POTENTIAL RISK OF ZIKA VIRUS OUTBREAK IN THE WHO AFRICAN REGION

To assess the risk of a Zika outbreak in the countries of the WHO African region, consideration must be given to a number of ecological, epidemiological, structural and system factors that contribute to the likelihood and magnitude of an outbreak.

There is limited data on the epidemiology and transmission cycle of the Zika virus. The main transmitting vector for Zika virus is *Aedes aegypti* mosquito, although *Ae. Albopictus* and other mosquitoes of the *Aedes* genus are thought to have adapted to the virus and in some cases have been shown to transmit it. *Ae aegypti* is also the main mosquito that transmits Yellow fever, chikungunya and dengue viruses. Considering the wide distribution of the vector and its efficiency in transmitting several arboviruses on the continent, all the countries in the African Region are at risk of Zika virus transmission.

Historically, the sylvatic (forest) form of the virus was the main one reported in the few studies in Africa. As urbanization increased, however, the *Ae aegypti* mosquito has adapted to and flourished in the urban environment breeding in open water containers and other collections of stagnant water. In many African cities, there is also a high proportion of the population who reside in slum

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[1] Dick GW, Kitchen SF, Haddow AJ (1952). Zika virus. I. Isolations and serological specificity. Trans R Soc Trop Med Hyg, 46, 509-20.

areas where shelter, water storage, drainage and overall sanitation is poor, potentially increasing the availability of breeding sites for the urban mosquitoes.

Over time, African countries have become more connected with each other through land, water and air transportation increasing the risk of disease spread. They have also increasingly become connected with other countries outside Africa, mainly through air transportation but also through shipping. The potential risk of importation of infections such as Zika virus from other countries is therefore high.

In the event that Zika transmission starts, variations in access to health care and their use for the treatment of acute conditions also contribute the early detection, management and eventual prevention of the spread of infections. The effectiveness of other government systems to respond to a potential outbreak is critical.

Countries with strong health systems, efficient Integrated Disease Surveillance and Response (IDSR) and are implementing the International Health Regulations (IHR 2005) requirements are likely to cope better with a Zika outbreak. Countries in the WHO African region are therefore advised to strengthen: i) vector surveillance and control, ii) disease surveillance and laboratory detection, iii) monitoring the occurrence of neurological complications, and iv) increasing public awareness.

OBJECTIVES

The main objective of this analysis was to assess the risk of Zika virus outbreak by country in the WHO African region and their capacity to contain it from becoming an epidemic. The specific objectives are:

i. Map the epidemiological likelihood of Zika virus transmission using information on the current and past reports of clinical cases, serological evidence of exposure in humans, evidence of the transmission by *Ae aegypti* of other arboviruses, specifically dengue, yellow fever and chikungunya and information on the general presence of the *Ae aegypti* or other Zika transmitting vectors.

ii. Assemble indicators on demography, urbanization, access to health care, surveillance, laboratory capacity and other systems of health system strengths to define exposures, vulnerabilities and country coping capacity

iii. Develop a Zika virus risk assessment framework that includes indicators of main hazards, exposures, vulnerabilities and lack of coping capacities by country.

iv. Implement a Zika virus risk ranking by country in the WHO African region.

ZIKA VIRUS OUTBREAK RISK ASSESSMENT AND MAPPING

As an entry point, the ecological and epidemiological evidence may be sufficient to understand the risk of transmission of Zika virus in a country. However, to go beyond simple epidemiological classification and undertake a comprehensive risk assessment that will provide insight into the potential magnitude of an outbreak, it is essential to understand the major potential hazards, vulnerabilities and country capacity to cope with a Zika outbreak.

Therefore, to assess the risk of Zika virus outbreak in the countries of the WHO African region a vulnerability analysis framework was used. Risk was computed as the product of the hazards, exposures, vulnerabilities and lack of coping capacity.

Indicators of hazards and exposures included were: the potential for Zika virus transmission, population density, proportion urban population, proportion of urban population that reside in slum areas and air and/or shipping connectivity (See **Table 1** for more details). The Zika virus transmission risk was developed from data on reported cases, serological evidence of exposure in humans[2], confirmed transmission of dengue and/or chikungunya and confirmed presence of the *Ae.aegypti* and/or *Ae albopictus*[3]. Evidence of infection in humans through local transmission was weighted highest followed by the serological data and reported transmission of dengue and chikungunya. Data on only the presence of the vector was given the lowest weight. The confirmed transmission of the two arboviruses was used as a proxy of sufficient vector density and/or efficiency.

To compute vulnerability to Zika virus outbreak, only two indicators were used. These were the proportion of children under the age of five years who seek advice or treatment for fever as recorded through national household surveys and the government effectiveness index as measured by the World Bank using several metrics. For each country data on treatment seeking for fever from the most recent national survey was used as used as a proxy of general access to and use of services for treatment of acute episodes. For Algeria, estimates from Egypt were used, as no recent national household survey was available.

The country capacity to cope was measured using the status of implementation of IDSR 2010, the implementation of Emerging and Dangerous Pathogens Laboratory Network (EDPLN) as of the first quarter of 2015[4] and the per capita government US dollars investment in health in 2014 or 2013 where more recent data was not available. It was considered here that other variables such as health worker or health facility to population ratio would be correlated with per capita health expenditure and was not included in this analysis. Implementation of EPDLN was specifically for country readiness to diagnose viral haemorrhagic fevers (VHF) but was used here as a proxy for general national laboratory capacity. Data on national laboratory capacity to perform PCR and ELISA analysis of the Zika virus may be a more sensitive indicator. Even better would be a comprehensive assessment of national laboratory strengths, including infrastructure and personnel, but such data are as yet unavailable.

All indicators were categorised into a maximum of five classes, mainly using natural break in the data for continuous forms and informed ranking for other and the average measures of hazard/exposure, vulnerability and coping capacity were measured from these indicators (**Figure 1**). A composite risk index was generated and used to rank countries by the potential risk of a Zika virus outbreak (**Table 2 and Figure 2**).

Maps of the input indicators used in this analysis are presented in **Annex A**.

[2] http://www.cdc.gov/zika/geo/index.html

[3] Kraemer MU, Sinka ME, Duda KA, Mylne AQ, Shearer FM, Barker CM, Moore CG, Carvalho RG, Coelho GE, Van Bortel W, Hendrickx G, Schaffner F, Elyazar IR, Teng HJ, Brady OJ, Messina JP, Pigott DM, Scott TW, Smith DL, Wint GR, Golding N, Hay SI. The global distribution of the arbovirus vectors Aedes aegypti and Ae. Albopictus Elife. 2015 Jun 30;4:e08347. doi: 10.7554/eLife.08347.

[4] WHO AFRO IDSR Quarterly Bulletin 2015. World Health Organization.

Table 1: Description of the indicators used in the Zika virus risk assessment analysis in the WHO African region

Component	Metric	Description	Classification	Data sources
Hazard & Exposures	1) Zika transmission factors	All areas where the presence of the *Aedes aegypti* mosquito has been reported or has high ecological probability of occurrence were considered to be within the Zika transmission zone. Countries were further classified into those with ongoing reports of Zika virus cases, past report of cases, serological evidence of exposure in humans, reports of local cases of dengue and chikungunya and evidence of presence of virus in the Aedes mosquito or zoonotic hosts	5 = Current reports of Zika cases 4 = Previous reports on Zika cases 3= Human serological data only 2= Evidence of local dengue or chikungunya cases 1= Presence of the *Aedes aegypti* mosquito only	Data on countries with Zika virus data were obtained from: http://www.cdc.gov/zika/geo/index.html; Data on *Ae. Aegypti* and *Ae albopictus* presence were obtained from Kraemer et al 2015.
	2) Urbanization	The urban environment has become the dominant habitat for the Aedes aegypti mosquito although the vector remains prevalent in rural Africa as well. We use recent UN World Population Prospectus data to define percentage urban population	Five natural breaks in the data were used. Please see maps in Annex A	UN World Population Prospects: http://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf
	3) Proportion of urban population living in slums	Within urban environments, slum areas have higher probability of open collection of stagnant waters, are more likely to use open containers for water storage and generally have poor drainage systems. For these reasons, they may harbour most of the Aedes aegypti mosquitos in urban areas.	Five natural breaks in the data were used. Please see maps in Annex A	UN HABITAT State of World Cities 2012/13 report: http://mirror.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3387
	4) Population density	The higher the collection of people within an area where the Zika virus is likely to be transmitted the higher the number of cases	Five natural breaks in the data were used. Please see maps in Annex A	UN World Population Prospects: http://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf
	5) Connectivity	The risk of the importation and spread of Zika and the likelihood of severity of epidemic depends on how well a country is connected to other parts of the world where transmission is ongoing. There is limited public domain data on actual traffic flows from South America and Africa. Instead, data on overall shipping and air connectivity was averaged and used as a general metric of connectivity.	Five natural breaks in the data were used. Please see maps in Annex A	http://data.worldbank.org/indicator/IS.SHP.GCNW.XQ https://www.openknowledge.worldbank.org/handle/10986/3486
Vulnerability	6) Treatment seeking for fever	Data on treatment seeking for fevers was obtained from the DHS website. These information is derived from household surveys and given the mild nature of Zika virus fever, treatment seeking for overall fever is a good measure of access and use of health services which is critical to the detection and management of clinical events.	Five natural breaks in the data were used. Please see maps in Annex A	https://dhsprogram.com/pubs/pdf/CR8/CR8.pdf
	7) Government effectiveness index	Government Effectiveness index was developed by the World Bank and captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political	Five natural breaks in the data were used. Please see maps in Annex A	http://info.worldbank.org/governance/wgi/index.aspx#home

		pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.		
Lack of coping capacity	8) IDSR implementation	Although not a direct assessment of country surveillance and response readiness, the extent to which a country has implemented IDSR and IHR strategies and functions may be a good indicator of its capacity to detect and respond to cases in time.	Classifications provided in the IDRS Bulletin were retained. However, category 5 and 6 in the IDST bulletin were merged. Please see maps in Annex A.	WHO-AFRO IDRS Quarterly bulletin January 2016
	9) Laboratory capacity	There is no point-of-care diagnosis for the Zika virus and any suspected infections required confirmation at a reference laboratory. Although not a viral haemorrhagic fever (VHF), the capacity to diagnose a VHF was used as a proxy for laboratory readiness to diagnose Zika virus infections	Classifications provided in the IDRS Bulletin were retained. Please see maps in Annex A.	WHO-AFRO IDRS Quarterly bulletin January 2016
	10) Per capita expenditure on health	These data was obtained from the World Bank and used here as a broad indicator of health system strength.	Five natural breaks in the data were used. Please see maps in Annex A	World Bank, http://data.worldbank.org/indicator/SH.XPD.PCAP

Figure 1 Countries ranked in order of increasing risk of Zika virus outbreak showing the variations of composite measures of hazards, vulnerabilities and lack of coping capacity.

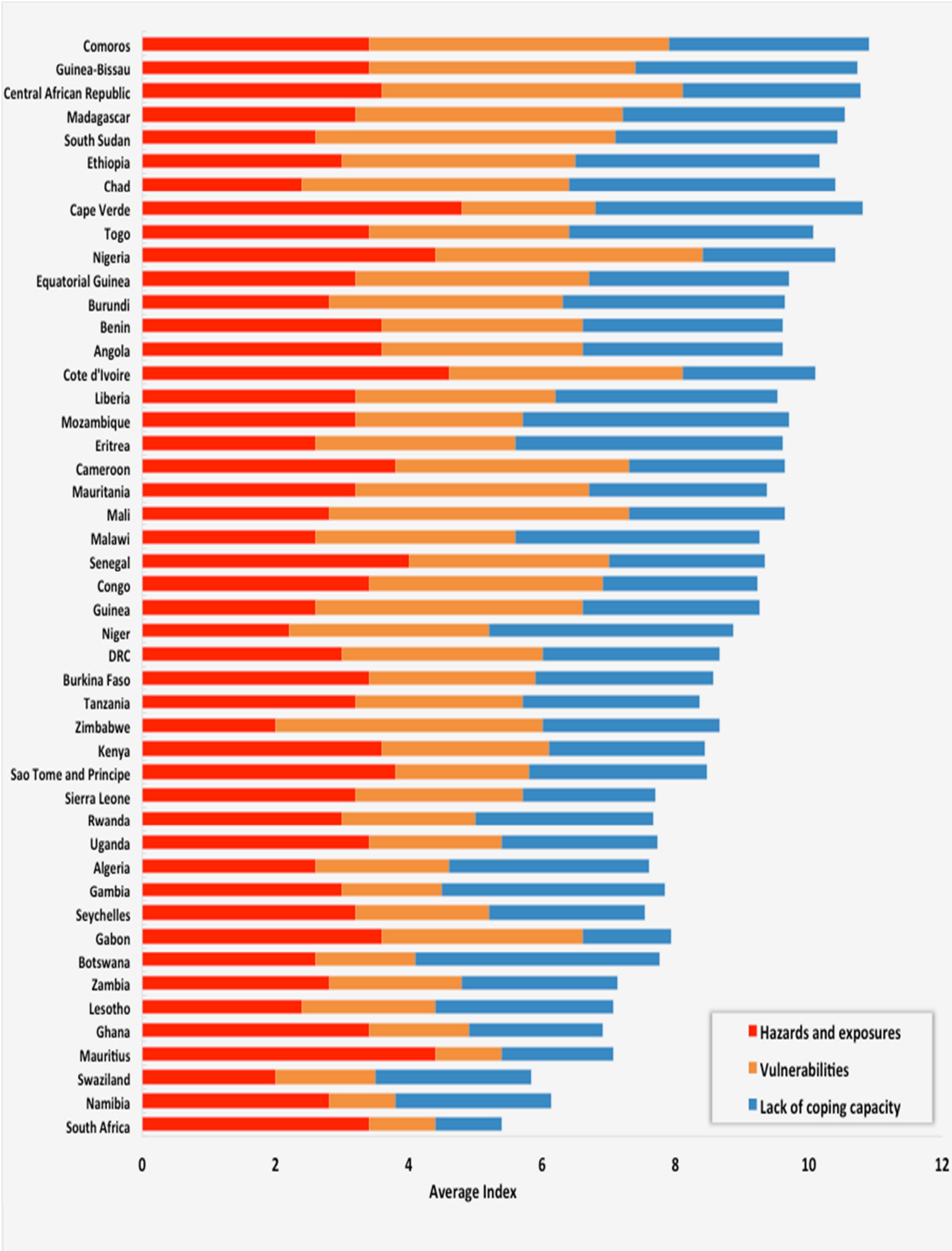
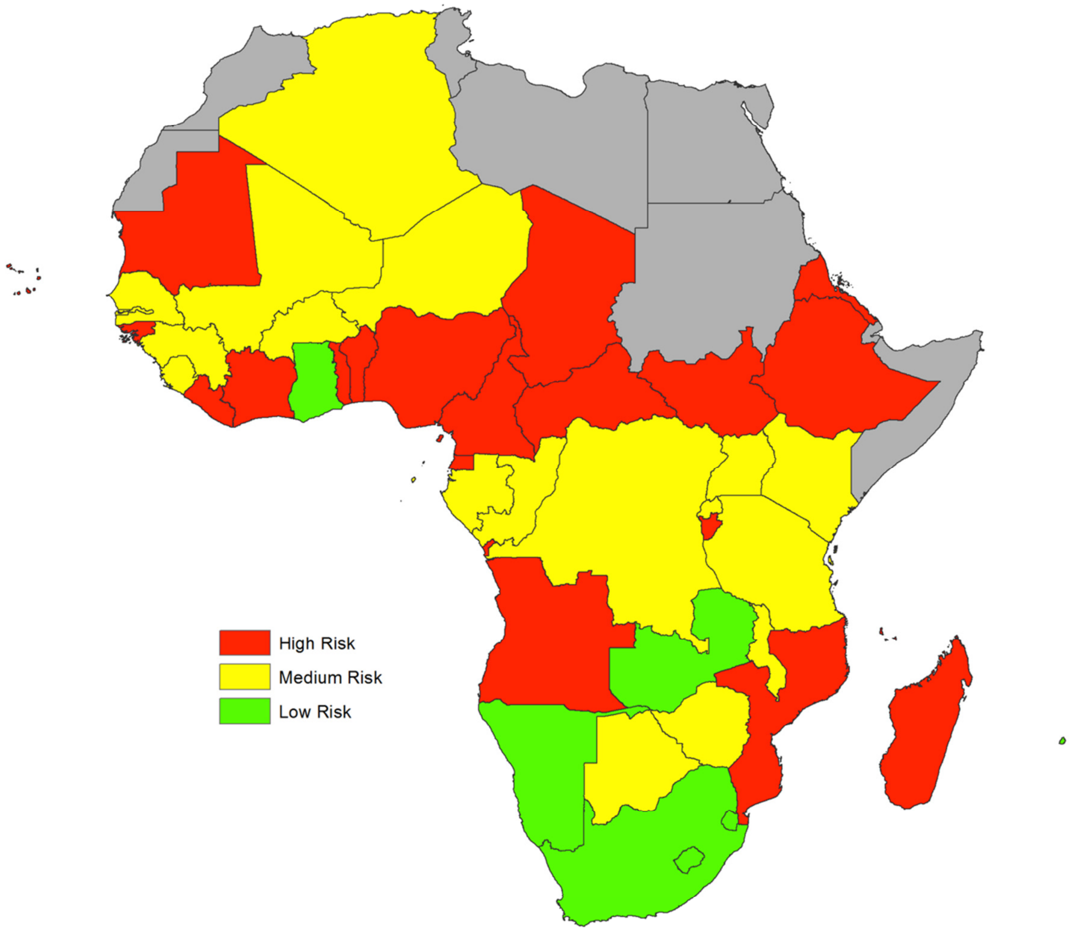


Table 2 List of countries in the WHO African region ranked by Zika virus risk outbreak. Red = High Risk Yellow = Medium Risk; Green = Low Risk. However, all the countries are at risk of Zika virus outbreak and vigilance must be maintained throughout. Risk is defined as the likelihood of Zika virus outbreak and potential of this leading to an epidemic.

Country	Hazards and Exposures	Vulnerabilities	Lack of Coping Capacity	Zika Virus Outbreak Risk	Risk Rank
Comoros	3.4	4.5	3.0	45.9	1
Guinea-Bissau	3.4	4.0	3.3	45.3	2
Central African Republic	3.6	4.5	2.7	43.2	3
Madagascar	3.2	4.0	3.3	42.7	4
South Sudan	2.6	4.5	3.3	39.0	5
Ethiopia	3.0	3.5	3.7	38.5	6
Cape Verde	4.8	2.0	4.0	38.4	7
Chad	2.4	4.0	4.0	38.4	8
Togo	3.4	3.0	3.7	37.4	9
Nigeria	4.4	4.0	2.0	35.2	10
Equatorial Guinea	3.2	3.5	3.0	33.6	11
Burundi	2.8	3.5	3.3	32.7	12
Angola	3.6	3.0	3.0	32.4	13
Benin	3.6	3.0	3.0	32.4	14
Cote d'Ivoire	4.6	3.5	2.0	32.2	15
Liberia	3.2	3.0	3.3	32.0	16
Mozambique	3.2	2.5	4.0	32.0	17
Eritrea	2.6	3.0	4.0	31.2	18
Cameroon	3.8	3.5	2.3	31.0	19
Mauritania	3.2	3.5	2.7	29.9	20
Mali	2.8	4.5	2.3	29.4	21
Malawi	2.6	3.0	3.7	28.6	22
Senegal	4.0	3.0	2.3	28.0	23
Congo	3.4	3.5	2.3	27.8	24
Guinea	2.6	4.0	2.7	27.7	25
Niger	2.2	3.0	3.7	24.2	26
DRC	3.0	3.0	2.7	24.0	27
Burkina Faso	3.4	2.5	2.7	22.7	28
Zimbabwe	2.0	4.0	2.7	21.3	29
Tanzania	3.2	2.5	2.7	21.3	30
Kenya	3.6	2.5	2.3	21.0	31
Sao Tome and Principe	3.8	2.0	2.7	20.3	32
Rwanda	3.0	2.0	2.7	16.0	33
Sierra Leone	3.2	2.5	2.0	16.0	34
Uganda	3.4	2.0	2.3	15.9	35
Algeria	2.6	2.0	3.0	15.6	36
Gambia	3.0	1.5	3.3	15.0	37
Seychelles	3.2	2.0	2.3	14.9	38
Gabon	3.6	3.0	1.3	14.4	39
Botswana	2.6	1.5	3.7	14.3	40
Zambia	2.8	2.0	2.3	13.1	41
Lesotho	2.4	2.0	2.7	12.8	42
Ghana	3.4	1.5	2.0	10.2	43
Mauritius	4.4	1.0	1.7	7.3	44
Swaziland	2.0	1.5	2.3	7.0	45
Namibia	2.8	1.0	2.3	6.5	46
South Africa	3.4	1.0	1.0	3.4	47

Figure 2 Countries ranked in order of increasing risk of Zika virus epidemic based on a composite index of risk derived from the hazards, vulnerabilities and lacking of coping capacities



MAIN MESSAGES

1. All countries in the WHO African region are at some risk of a Zika virus outbreak. Communication of risks, identifying country response teams and putting in place a clear incident management system is required. However, in addition to underlying ecology and epidemiology that may make them more susceptible to Zika virus transmission, the high risk countries also either have additional vulnerabilities or low coping mechanisms in terms of health system and surveillance strengths. These countries should be priority for regional and international systems support and investment in vector control. Detailed analysis by country on the state of infectious disease surveillance systems is urgently required as this is highly critical to the timely detection of and response to infections.

2. For medium risk countries clinical and entomological surveillance should be prioritised. A rapid assessment of the readiness of control, health service and laboratory readiness should be undertaken. National HMIS and IDSR working groups should be established and/or engaged to streamline national surveillance systems.

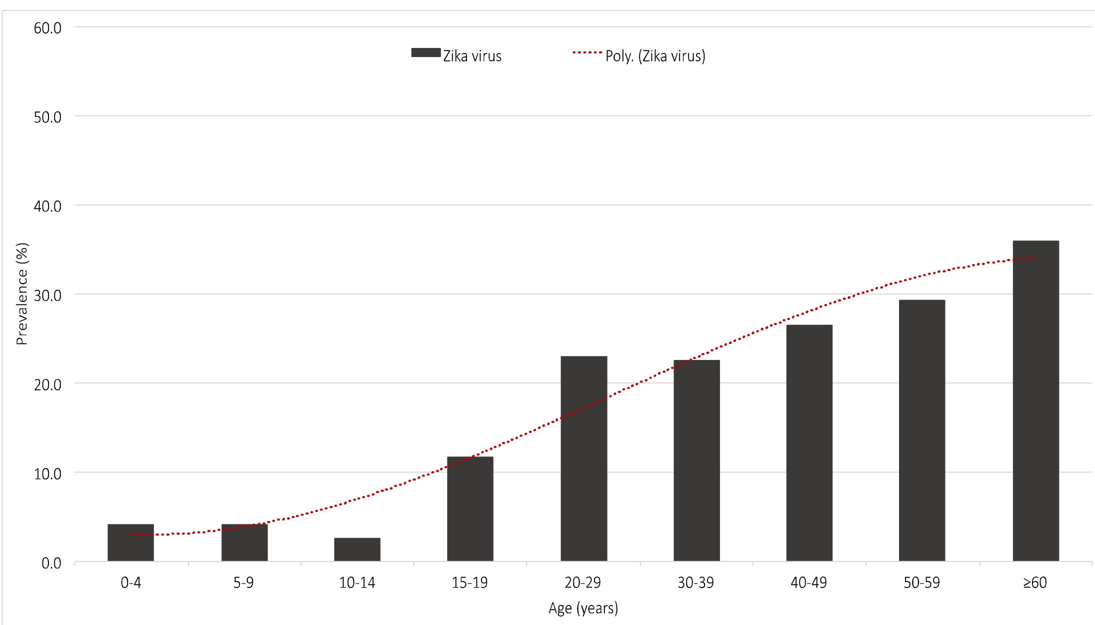
3. Communication and general advisory support should be provided to the low risk countries.

4. Majority of the indicators used in the analysis of the Zika virus risk assessment will vary within country borders. Therefore, while a country's overall risk levels may be low, some areas within the country may have a high risk and national agencies must be vigilant and use local knowledge for sub-national risk assessments.

5. In this analysis only a small set of indicators was used, mainly on epidemiology, governance, ecology, health system and surveillance status to analyse the risk of Zika virus outbreak in countries of the WHO African region to help focus regional and global efforts to prepare for a potential Zika virus outbreak. However, there are other potentially important indicators that have not been included in the analysis of risk such as health worker per capita distribution, poverty and socio-economic inequity, etc. Countries can decide, using the broad framework presented here, to include other indicators they may consider necessary within their context.

6. The Zika virus may be endemic in many parts of Africa where other arboviruses that are transmitted by the *Aedes aegypti* mosquito are prevalent. For example, in a serological study conducted in Kenya between 1966-1968, the distribution of exposure to Zika virus infections show an age pattern that is suggestive of acquisition of immunity in older ages (**Figure 3**). It is therefore possible that countries, which may be regarded as high risk due to past reports of cases and serological evidence, may also be the ones whose populations have immunity and the risk of an outbreak may be lower. It is hard to quantify this across the continent without carefully assembled population level epidemiological data and surveillance systems should be used to collect the right data to provide insight into the age profile of any reported Zika virus cases. Acquired immunity may have however limited impact in averting the consequences of Zika virus infection on pregnant women and foetal health.

Figure 3 Results of a serological survey conducted in Kenya in 1966-1968 showing the age pattern of exposure to Zika virus infections in Kenya. The graphs suggest possible acquisition of immunity in older ages (Source: Geser et al 1970[5]). Caution is required when interpreting this serological data due to cross-reactivity with other arboviruses.



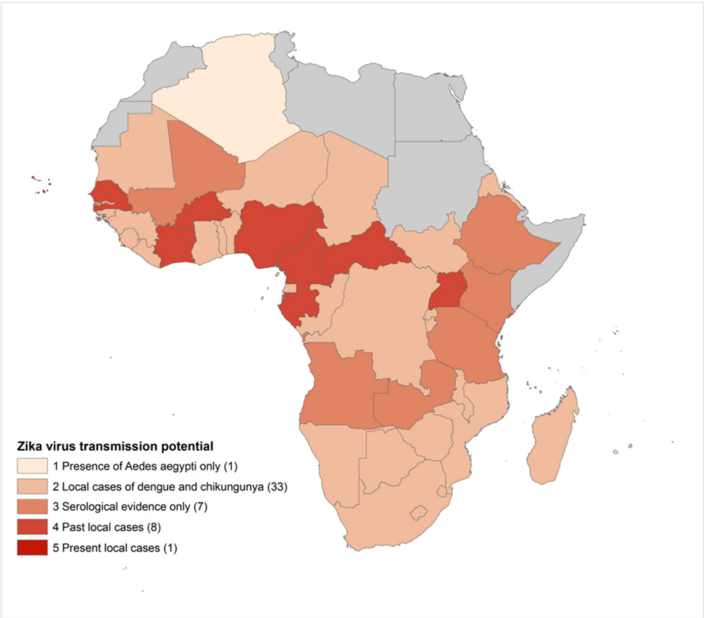
5 Geser A, Henderson BE, Christensen S (1970). A multipurpose serological survey in Kenya 2. Results of arbovirus serological tests. Bull World Health Organ, 43, 539-52.

7. Historically, Zika virus infections have had mild clinical consequences and very few confirmed deaths. Chances are, if evidence from Cape Verde where clinical cases have been reported is used as guide, a Zika virus outbreak in the rest of Africa may also have very low fatality rate. However, it is possible the strain of the virus that has spread very rapidly in the Americas is unknown to African populations and its importation into Africa may lead to a more acute disease and severe sequealea. Vigilance must also be maintained.

8. The association of congenital conditions with Zika virus infection, such as microcephaly and Guillain Barré syndrome, still remains coincidental although on-going studies suggest a strong link. Monitoring of these disorders should be implemented as additional indicators of a possible Zika virus outbreak. However, in Africa, other causes of microcephaly, such as severe fetal malnutrition, rubella, chicken pox and toxoplasmosis are prevalent. Care must be exercised that any increased cases of microcephaly or other disorders are not simply a consequence of changes in surveillance.

ANNEX A: MAPS OF INDICATORS USED TO MEASURE HAZARDS, VULNERABILITIES AND LACK OF COPING CAPACITY IN THE ANALYSIS OF THE ZIKA VIRUS RISK ASSESSMENT IN THE WHO AFRICAN REGION

Figure A1.1



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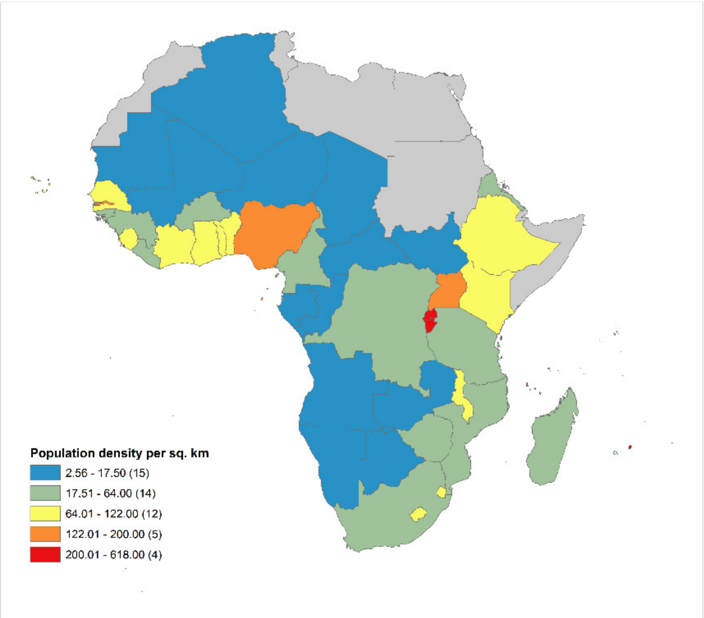

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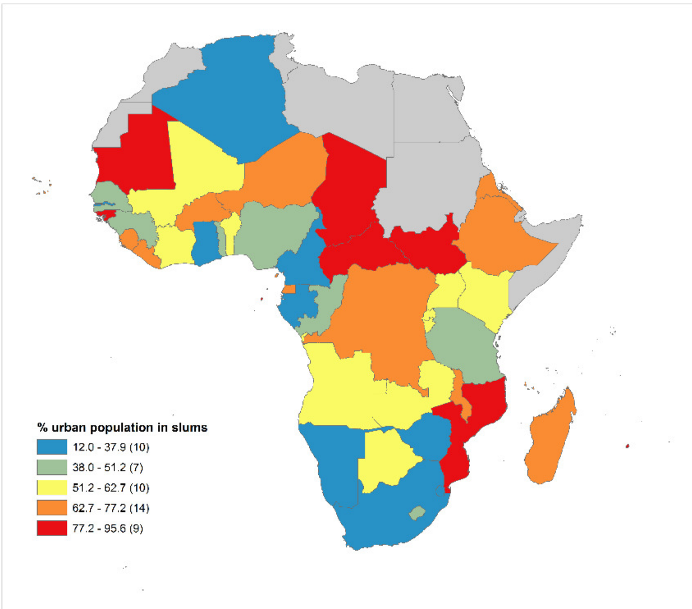

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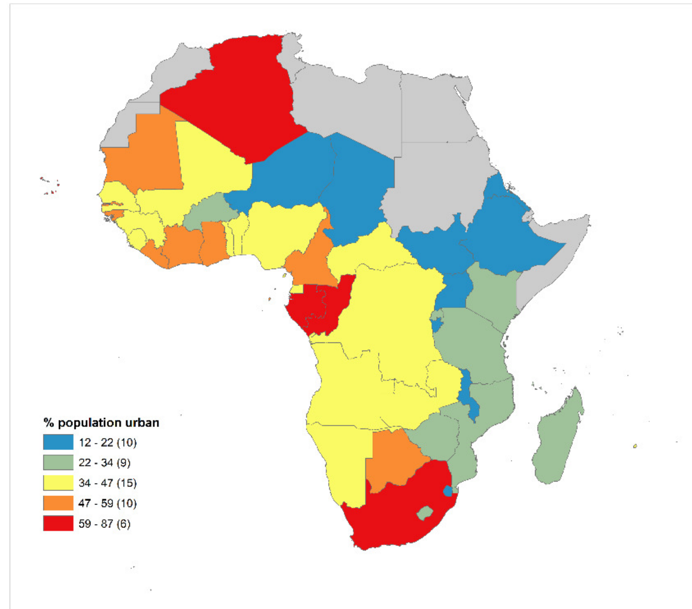
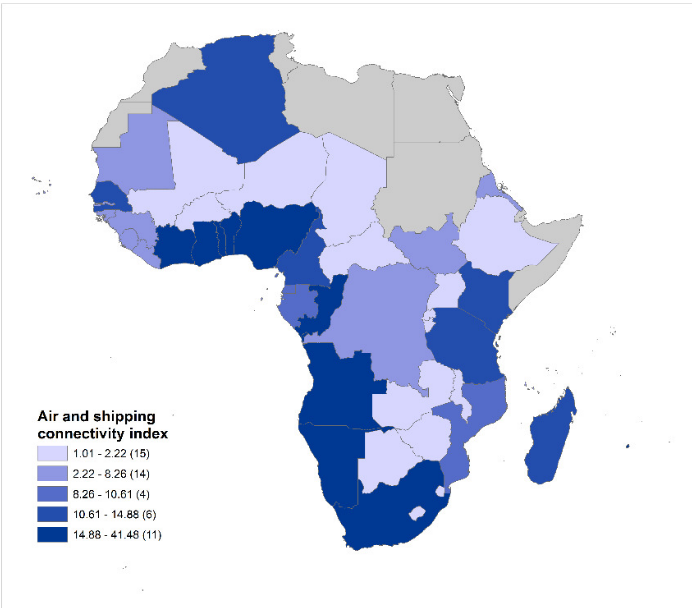


Figure A1.5



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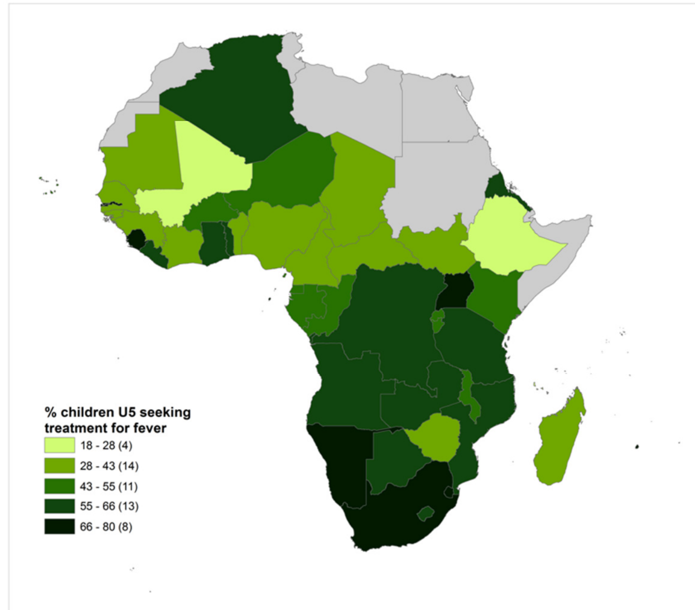

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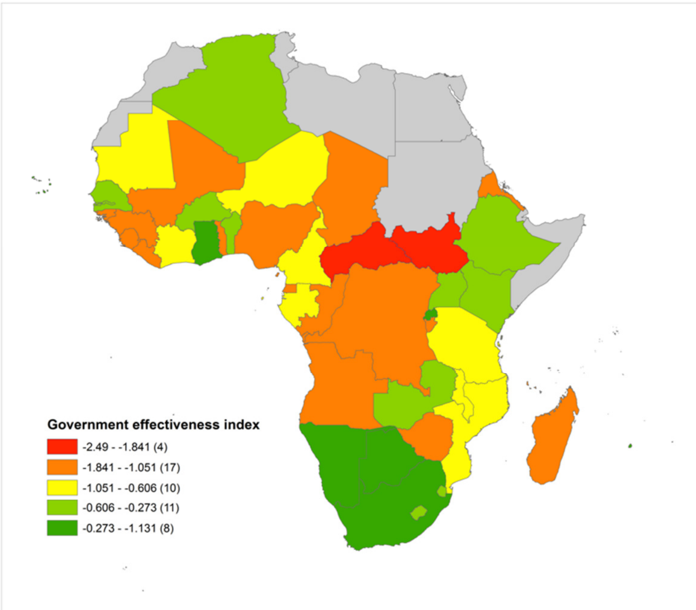

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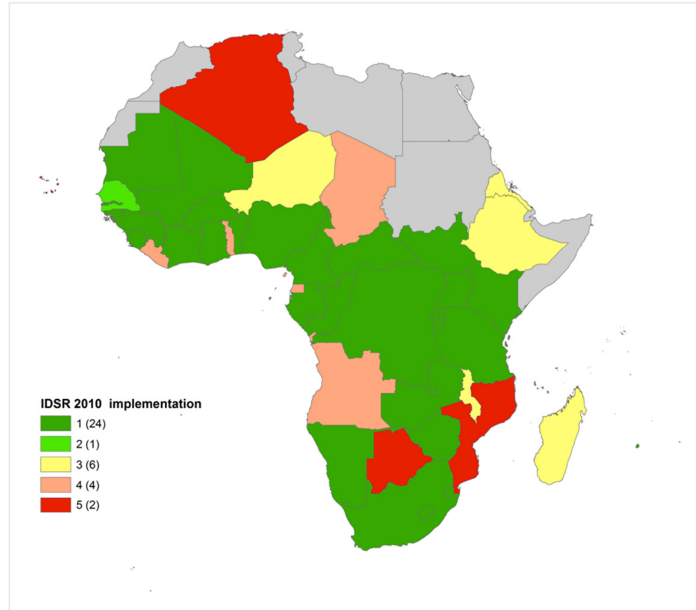

Figure A1.9

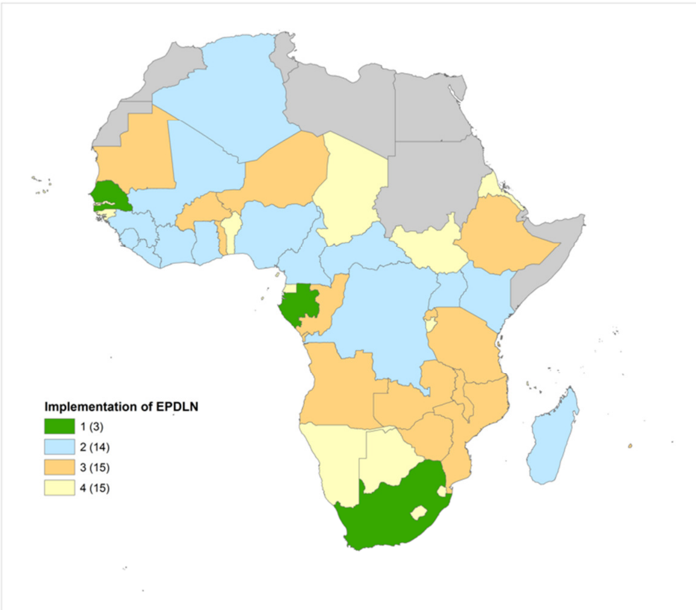

Figure A1.10