Mosquito-borne viral infections in Southern Africa: a public health perspective

Of the six mosquito-borne viral infections of interest in Southern Africa, four can cause a haemorrhagic state.

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Six mosquito-borne viral infections are of interest in Southern Africa, four of which have the potential to result in a haemorrhagic state. Numerically speaking, the viral haemorrhagic fevers of Africa are not important in the public health sense, but these conditions tend to create panic and media interest beyond the true risk to health. Health workers are at potential risk of acquiring these diseases in the occupational setting, which further compounds the problem. Mosquito-borne viral infections therefore become of public health interest in the following circumstances:

- a potential epidemic
- a potential fatal, untreatable disease; and
- a potential risk to health personnel of contracting the disease from a patient.

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Clarification of terms

For a better understanding of this article, one should revisit some of the terms that are frequently used in communicable disease epidemiology.

Vector. Any arthropod that transmits the infectious agent, either by simple mechanical carriage or biologically via the infected non-vertebrate.[1]

Zoonosis. An infection or infectious disease transmissible under natural conditions from vertebrate animals to man.[1]

Arbovirus. Viruses that are transmitted by arthropod bites and therefore fall under the generic name of arboviruses (arthropod-borne viruses).[2]

Reservoir. Any person, animal, arthropod, plant, soil or substance (or a combination of these) in which an infectious agent normally lives and multiplies, on which it depends primarily for survival and where it reproduces itself in such a manner that it can be transmitted to a susceptible host.[1]

Host. A person or other living animal, including birds and arthropods, that affords subsistence or lodgement to an infectious agent under natural (as opposed to experimental) conditions.[1]

Communicable disease. An illness caused by a specific infectious agent through transmission of that agent from an infected person, animal, or inanimate reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector, or the inanimate environment.[1]

Epidemiological approach to communicable diseases

The key to understanding the epidemiology of any communicable disease is in terms of agent, transmission, host and environment.[3]

The agent in communicable disease is the organism, e.g. the yellow fever virus. Arbovirus transmission occurs via the arthropod vector (e.g. a tick or mosquito). The host is either a person or another living animal that affords lodgement to the infectious agent. The transmission cycle used by the agent to reach the host takes place within an environment that determines the success or severity of the infection. Environmental factors are subtle and diffuse, such as climate, seasonality, resources and even education.[3]

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The usefulness of looking at a communicable disease in terms of the epidemiological approach lies in the fact that understanding the epidemiology of the disease, in most cases, will give an indication of the intervention strategies available for dealing with an outbreak of the disease.

Epidemiology of medically important mosquito-borne viruses in Southern Africa

Table I summarises the epidemiology of the six important mosquito-borne viruses in Southern Africa.[4,5]

Of interest in the epidemiology is that all the viruses are actually zoonoses and they all pose a potential occupational health hazard in the health care and laboratory setting. Therefore, they have been classified as group 2 and 3 hazardous biological agents in the Hazardous Biological Agent Regulations published in terms of the Occupational Health and Safety Act, Act 85 of 1993.[5]

Group 2 agents may cause human disease and be hazardous to an exposed person, but are unlikely to spread in the community.[5]

Group 3 agents may cause severe human disease, which presents a serious hazard to the exposed person and may present a risk of spreading to the community.[5]

The regulations also dictate how these organisms should be dealt with in the occupational setting.

Intervention strategies

The sequence of actions that are followed with any communicable disease outbreak are outlined in the box below.[6]

Control of a communicable disease can be directed at the agent, transmission route, host or environment.

- Identification of the agent (diagnosis)
- Notification of the disease
- Treatment of cases
- Interruption of transmission
- Prevention of recurrence
- Analysis of the outbreak and report
- Surveillance

Table I. Epidemiology of medically important mosquito-borne viruses in Southern Africa

Agent	Distribution in Africa	Transmission	Reservoir	Occurrence in Southern Africa
Viruses *not* resulting in a haemorrhagic state				
West Nile virus (Flaviviridae) HBA group 3	Widespread in Africa	*Culex* mosquito in Southern Africa *No* human-to-human transmission (can be tranferred via blood transfusion and percutaneous exposure)	Birds	Occurs in South Africa
Sindbis virus (Togaviridae) HBA group 2	Africa and widespread in sub-Saharan Africa	*Culex* mosquito Human-to-human transmission does not occur	Birds – especially water birds	Infections can be seen in the wetter parts of the South African Highveld where the *Culex* mosquito breeds Irregular epidemics occur in South Africa
Viruses that have the potential to result in a haemorrhagic state				
Yellow fever virus (Flaviviridae) HBA group 3	West and Central Africa	*Aedes aegypti* mosquito Human-to-human transmission does not occur	Monkeys Humans during epidemics	Does not occur in Zimbabwe, South Africa, Mozambique, Namibia, Botswana, Malawi or Angola south of Luanda. The vector for the disease is present in South Africa
Dengue virus (Flaviviridae) HBA group 3	Tropical areas of Africa	*Aedes aegypti* mosquito Human-to-human transfer does not take place	Monkeys Humans during epidemics	For decades not evident in South Africa, Namibia or areas immediately bordering South Africa Outbreaks have been reported on the east coast from Ethiopia to Mozambique and the Comores and Seychelles
Chikungunya virus (Togaviridae) HBA group 3	Southern, Tropical East and West Africa	*Aede* species of mosquito (*Aedes furcifer-taylori* in South Africa) Human-to-human transmission does not take place	Monkeys (vervets and baboons)	Restricted to the tropical corridor in South Africa
Rift Valley fever virus (Bunyaviridae) HBA group 3	Sub-Saharan Africa, Egypt and Sudan	*Aedes caballus* and *Culex theileri* mainly among livestock, possibly also humans but usual route of infection in humans is via infected carcasses	Sheep and cattle	Occurs in all provinces of South Africa and neighbouring countries Very common in Zimbabwe

The agent

No specific treatment (to kill the organism) is available for any of the above-mentioned arboviruses.

The most important vector is* Aedes aegypti, *which lives in collections of water close to houses.

Transmission route (vector and environmental control)[7]

The main method of control is the destruction of the vector mosquitoes and their breeding places. The most important vector is *Aedes aegypti,* which lives in collections of water close to houses. The larvae are searched for and all the breeding places destroyed. One technique that has been used with success in Asia is to ask schoolchildren to search for breeding places of mosquitoes. This is even more effective if some reward is coupled to the finding of sites.

Large breeding areas (such as water tanks) need to be covered, screened or treated with insecticides. In large open water areas natural predators may be introduced, e.g. fish or dragonfly larvae that feed on the mosquito larvae.

When there is an epidemic in a small area, e.g. a small town, the quickest and simplest way to deal with the vector mosquitoes is to use fogging or ultra-low volume (ULV) area spraying. This option is, however, expensive.

The host

Specific protection for the human host

The only two arbovirus infections for which a human vaccine is available are yellow fever and Rift Valley fever. The yellow fever vaccine is highly effective and, in terms of the International Health Regulations, travellers from areas deemed by the World Health Organization to be endemic for yellow fever must be vaccinated against the disease.[8,9]

A traveller from an endemic yellow fever area without a valid vaccination certificate can be quarantined for up to 6 days, depending on the last risk of exposure.[9] An inactivated Rift Valley fever vaccine has been developed for human use but is not licenced or commercially available. Its use remains experimental and it has been used in certain categories of persons at significant risk for acquiring the disease.

Other measures for use with the human host

Another protective measure for use with the human host is to limit the exposure of

Table II. Notifiable medical conditions in terms of the Health Act, 1977 (Act No. 63 of 1977)*

- Acute flaccid paralysis (for estimating polio-associated paralysis)
- Anthrax
- Brucellosis
- Cholera
- Congenital syphilis
- Crimean-Congo haemorrhagic fever
- Other haemorrhagic fevers of Africa
- Diphtheria
- Food poisoning
- *Haemophilus influenzae* type B
- Lead poisoning
- Legionellosis
- Leprosy
- Malaria
- Maternal death
- Measles
- Meningococcal infection
- Paratyphoid fever
- Plague
- Poisoning with agricultural stock remedies
- Poliomyelitis
- Rabies
- Rheumatic fever (acute)
- Tetanus
- Tetanus neonatorum
- Trachoma
- Tuberculosis (primary)
- Tuberculosis (pulmonary)
- Tuberculosis of other respiratory organs
- Tuberculosis of meninges
- Tuberculosis of intestines, peritoneum
- Tuberculosis of bones and joints
- Tuberculosis of genito-urinary system
- Tuberculosis of other organs
- Tuberculosis (miliary)
- Tuberculosis (total)
- Typhoid fever
- Typhus fever (lice-borne)
- Typhus fever (rat flea-borne)
- Viral hepatitis type A
- Viral hepatitis type B
- Viral hepatitis non-A non-B
- Viral hepatitis unspecified
- Viral hepatitis total
- Whooping cough
- Yellow fever

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the host to the vector mosquito whenever possible, e.g. by using protective clothing, bed nets, repellents, by screening homes and using knockdown sprays.

Specific protection for animals

An effective Rift Valley fever vaccine is available for use in animals. Vaccination needs to be implemented *before* an outbreak if an epizootic is to be prevented. Once an outbreak has occurred animal vaccination should *not* be used in that area as infection may be spread by re-use of needles and the multi-dose vials.

Other measures for use with animals

Restricting or limiting the movement of animals may be effective in slowing the spread of the virus from infected to uninfected areas.[2]

Surveillance and notification

The purpose of surveillance is to try to obtain an early warning of a potential outbreak so that effective and timely control measures may be implemented. The International Health Regulations require that certain diseases be notified. The mosquito-borne arboviruses that are potentially notifiable are yellow fever virus, West Nile virus, Rift Valley fever virus and Dengue virus. Notification is a form of passive surveillance. Active surveillance may also be done, e.g. surveillance for West Nile virus by testing mosquitoes for the virus or using sentinel birds such as chickens.[2,6,9]

Notifiable medical conditions in South Africa

Yellow fever, Dengue fever and Rift Valley fever (haemorrhagic fevers of Africa) are notifiable in terms of the Regulations Relating to Communicable Diseases and Notification of Medical Conditions. The requirement for notification is often neglected or forgotten by health practitioners. Notification failure results in failure of the surveillance system of health authorities. For convenience and future reference Table II lists medical conditions that need to be notified. Communicable diseases are notified to the local authority.

References available at www.cmej.org.za

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- Understanding the epidemiology of an arbovirus gives an indication as to which intervention strategy to follow to combat the disease.
- Vector control remains the mainstay in the prevention of arbovirus infection.
- Of the mosquito-borne viral infections only yellow fever currently has a human vaccine available and is mandatory for travellers from endemic countries.
- The only animal vaccine available for arboviruses is for Rift Valley fever, but it needs to be used before outbreaks.
- Yellow fever and potentially West Nile fever, Dengue fever and Rift Valley fever are notifiable in terms of the International Health Regulations.
- Yellow fever, Dengue fever and Rift Valley fever are notifiable diseases in South Africa.