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Review Paper

Impact of drought on vector-borne diseases – how does one manage the risk?

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ABSTRACT

Objectives: This article aimed to review all literature on drought and vector-borne disease to enable an assessment of the possible impact of drought on the changing risk of vector-borne diseases in the UK.

Study design: A systematic literature review was performed.

Methods: Using a search strategy developed from a combination of terms for drought and selected outcomes, the authors systematically reviewed all available literature from 1990 to 2012 on the impact of drought on vector-borne diseases. The following databases were searched: PubMed, Web of Science, and EMBASE. After reviewing the abstracts, 38 articles were found to fit the inclusion and exclusion criteria.

Results: Evidence found drought followed by re-wetting can have a substantial effect on water table levels, vegetation, and aquatic predators; all factors which influence mosquito populations. Several studies found an association between a drought during the previous year and West Nile virus incidence. Urban mosquito vectors of dengue virus and chikungunya virus are adaptable by nature and are able to exploit a multitude of additional aquatic habitats created as a response to drought (i.e. water storage containers). Tick populations are likely to be negatively affected by drought as they are dependent upon high levels of humidity and soil moisture.

Conclusions: Further research is needed to identify public health interventions and environmental control measures for an invasive mosquito problem or arthropod-borne disease outbreak in the UK.

Introduction

Since the beginning of the 21st Century, Europe has seen the continued spread and establishment of invasive mosquitoes such as *Aedes albopictus* in most Mediterranean countries,[1] as well as outbreaks of invasive-*Aedes* transmitted chikungunya virus (CHIKV) in Italy and dengue virus (DENV) in Madeira.[2] Large-scale outbreaks of West Nile virus (WNV) have become more common in Eastern Europe, and Usutu virus (USUV) has emerged in Central Europe.[3] The emergence

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of bluetongue virus and Schmallenberg virus in Northern Europe, including the UK, has highlighted vector-borne diseases as an issue for UK public and veterinary health. These events raise questions as to which vectors and pathogens may appear next in the UK and what role a changing climate may have in driving these changes. A report by Public Health England on the health impacts of climate change highlighted key issues for vector-borne diseases, and it was clear that little research had been done on the impact of drought on vector-borne disease risk.[4]

In the UK, summers are predicted to be drier by up to 40% in the southwest, with a general south to north gradient by 2080.[5] Furthermore, there is medium confidence that droughts will become more intense in the 21st Century in Southern Europe and the Mediterranean as well as Central Europe, because of reduced precipitation and/or increased evapo-transpiration.[6] Drought has an effect on all components of the water cycle, from a deficit in soil moisture and groundwater levels to low stream flows and dried up rivers. Droughts are slow-onset phenomena, generally develop over an extended period of time, and can be geographically extensive.[23] Stanke et al.[23] found the lack of standardization in the definition of drought is reflected by over 150 published definitions. Generally and in the context of this review, drought can be defined as a deficit of water from the norm for a given spatial area that is the result of constantly below average precipitation. In some countries, drought can be associated with the El Niño Southern Oscillation (ENSO). ENSO is comprised of changes in sea temperatures in the Pacific Ocean (El Niño) and changes in atmospheric pressure across the Pacific basin (Southern Oscillation).[7,8] The association between ENSO and drought has been established in North-eastern Brazil, south-eastern Africa, South Asia, Indonesia, and Northern Australia.[8] It has been documented that droughts are twice as frequent in the year following the onset of El Niño than during other years.[23]

Precipitation changes are known to affect the reproduction, development, behaviour, and population dynamics of arthropod vectors, their pathogens, and non-human vertebrate reservoirs.[9] Recent research suggests that drought may lead to subsequent increases in mosquito numbers and disease outbreaks.[10,11]

Aims and objectives

There has been growing interest in the UK regarding the potential establishment and spread of invasive mosquito species,[12] the involvement of these species in the transmission of pathogens,[13,14] as well as the possible role of native mosquitoes in transmitting emerging pathogens.[15] This article aims to review literature on drought and vector-borne disease (relevant to the UK) to enable an assessment of the possible impact of drought on the changing risk of vector-borne diseases in the UK by specifically addressing the following topics:

- the impact of drought on aquatic habitats for mosquitoes; specifically the impact of wetland drying then re-wetting in relation to the consequent potential for increase in mosquito numbers;
- the impact of drought in relation to WNV outbreaks in North America and Europe;
- the impact of drought on urban *Aedes* mosquito vectors of CHIKV and DENV;
- the association between ENSO and Rift Valley fever virus (RVFV) outbreaks in Africa and Arabia; and
- the impact of drought on tick populations, particularly *Ixodes ricinus*.

Methods

A literature review was carried out addressing the specific issues regarding drought and its impact on disease vectors and their pathogens. A search strategy was developed using combination of terms for drought and selected outcomes in the title, keywords, or abstract (Table 1).

Databases used

The following databases were searched: PubMed, Web of Science, and EMBASE. Expert advice was sought for further sources of literature, and references from extracted studies were hand-searched.

Inclusion criteria

- Papers published from 1 January 1990 to 1 November 2012.
- Studies conducted in any country. This systematic literature review included globally published literature because Europe experiences a wide range of climate and geographical variation.
- Papers in all languages with English abstracts.

Exclusion criteria

- Papers describing drought alone, with no mention of vectors.
- Drought meaning shortage unrelated to climate; studies on dry/arid climates unless drought was noted as an unusual occurrence in the normal climate variability of the area.
- Papers on unrelated subject areas; such as, biochemistry, molecular biology, and genetics.
- Grey literature.
- Papers regarding ENSO and other vector-borne diseases besides RVFV, unless the paper explicitly mentioned drought.

Table 1 – Search strategy.

Exposure: drought OR El Nino OR ENSO OR El Nino Southern Oscillation OR 'rainfall after drought'
AND
Outcome: aedes albopictus OR aedes aegypti OR arbo* OR arthropod* OR chikungunya OR culex modestus OR culex pipiens OR dengue* OR Ixodes ricinus OR lyme borreliosis OR malaria OR mosquito* OR outbreak OR rickettsiae OR Rift Valley fever virus OR sindbis* OR tahyna* OR tick* OR vector* OR West Nile virus