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Advice to Travelers on Topical Insect Repellent Use Against Dengue Mosquitoes in Far North Queensland, Australia

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Dengue outbreaks occur annually in Far North Queensland, Australia. Advice on topical insect repellents provided by health authorities rarely addresses the wide range of formulations and active ingredients currently registered for use in Australia. Recommendations on the use of registered products require review.

Mosquito-borne disease in Australia is a major concern.[1] Since the early 1990s, there has been almost annual activity of dengue recorded from Far North Queensland, where the only species of mosquito currently present in Australia capable of transmitting dengue, *Aedes aegypti* (L.), is present, and culminating in one of the largest epidemics of dengue in 50 years reported during 2008 to 2009.[1,2] Advice is provided to residents and tourists regarding the need to protect themselves through the use of repellents. However, there are some important differences in the personal protection advice provided by health authorities in areas of dengue risk compared to elsewhere in the country.

Australia supports a diverse mosquito fauna, but of the more than 300 species known to exist in the country relatively few pose a serious threat to public health either through nuisance-biting or transmission of disease-causing pathogens.[1] The vast majority of these species are most active in host seeking at dusk and dawn with varying activity levels during the night or in the late afternoon.[1] However, the two mosquitoes capable of transmitting dengue in Australia, *Ae aegypti* and *Aedes albopictus* (Skuse) (recently introduced to the Torres Strait and may potentially spread to mainland Australia[3,4]), are severe nuisance-biting pests that predominantly bite humans during the day.

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Personal protection advice provided by local and state health authorities on websites, fact sheets, and press releases typically includes the recommended use of insect repellents, in combination with behavioral practices and physical barriers, to prevent bites by mosquitoes. Topical repellents containing the active ingredients diethyltoluamide (DEET) and picaridin are widely recommended, represent low risk to human health, and have been demonstrated to provide effective protection from biting mosquitoes.[5–7] However, the advice provided by local health authorities, with regard to both active ingredients and formulations, does not reflect the wide range of commercially available repellents currently registered with the Australian Pesticides and Veterinary Medicines Authority (APVMA). While DEET and picaridin are the most common active ingredients, botanical products containing extracts from *Melaleuca* spp. or *Eucalyptus* spp. are also widely available, but products containing botanical active ingredients and the extracts from a range of Australian native plants have been shown to provide only limited protection again *A aegypti*.[5,8]

While these botanical repellents may only offer limited protection times, a product registered in Australia as "extract of lemon eucalyptus, being acid-modified oil of lemon eucalyptus (*Corymbia citriodora*)" has been shown to provide effective protection against a range of biting insects.[5] This product is not actually the extract from the plant but a by-product of the hydrodistillation process known as p-menthane-3, 8-diol (PMD). This is the first plant-derived repellent to be included in public health messages issued by the Centers for Disease Control (CDC) in North

America following the recent outbreaks of West Nile virus.[5] However, despite the potential effectiveness of this product, it is currently not included in personal protection advice provided by health authorities.

The concentration of active ingredients is directly related to the period of time an individual is protected from biting mosquitoes, not necessarily the proportion of mosquitoes repelled. While formulations containing approximately 10% DEET have been shown to provide protection against *A aegypti* for over 100 minutes, formulations containing 80% provide protection for over 800 minutes in laboratory tests.[9] While low-dose (eg, <10% DEET or picardin) repellents may provide effective protection, they must be reapplied more frequently than formulations containing >20% DEET or picaridin. Products containing botanical extracts, due to their lower mean protection times,[8] will generally need to be reapplied twice as often as the low-dose DEET or picaridin formulations.

One of the recent advancements in commercial insect repellents is the availability of formulations that combine topical repellents with cosmetics including sunscreen and skin moisturizers. Laboratory testing of combined sunscreen and mosquito repellent formulations found that there was no reduction in mean protection times when tested against *A aegypti*.[9] However, when there was concurrent use of sunscreen, reapplied at 2-hour intervals on top of a 17% DEET-based topical repellent, mean protection times were significantly reduced following subsequent applications, possibly due to disturbance of the layer of repellent.[9] Some questions regarding long-term use of these formulations have been raised considering the different application rates recommended for sunscreen and insect repellents. Where a combined sunscreen and insect repellent formulation are required against day-biting mosquitoes, regular reapplication of a repellent/sunscreen formulation with a low DEET concentration (<20%) is recommended to minimize any risk of overexposure to DEET.[9]

A range of non-topical products that purport to repel mosquitoes are widely available. Wrist bands and patches impregnated with botanical-based repellents are currently registered in Australia, but these products have been shown to be ineffective at providing protection.[7] Similarly, electronic devices that emit sound have also been shown to be ineffective at repelling mosquitoes.[10]

While management activities are in place to reduce the incidence of dengue through disease surveillance, mosquito control and surveillance, and public education,[11] the need to reduce nuisance-biting impacts through personal protection strategies will remain. It is important that the advice provided by health authorities to travelers, as well as residents, in the region reflects both the availability of registered products and published laboratory and field-based efficacy testing.

Declaration of Interests

The authors state that they have no conflicts of interest to declare.

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