

Avoiding the bite: update on DEET

Safe and effective against West Nile virus when properly used

By Penny Miller, BSc(Pharm), MA(Ed)

Concerns about the prevention of life-threatening infections from the mosquito-borne West Nile virus have raised interest in the use of insect repellents. Pharmacists are in a key position to assess and recommend insect repellents, as well as to provide patient advice on the safe and effective use of these agents.

DEET (N,N-diethyl-m-toluamide, more recently known as N,N-diethyl-3-methylbenzamide) is a chemical pesticide useful as a synthetic insect repellent against biting and sucking insects, namely mosquitoes, ticks, and flies. It is not effective against stinging insects such as bees and wasps. With over 40 years of worldwide use, DEET is still the most effective and best-studied insect repellent on the market. DEET should be worn where mosquitoes are active and when skin is exposed.

West Nile virus

The first Canadian case infected with West Nile virus was reported in August 2002 during an outbreak in southern Ontario.¹ Because this is an emerging disease spread by mosquitoes, adequate prevention is needed. Female mosquitoes become infected with the West Nile virus after feeding on the blood of infected birds, and the virus can then be injected into humans during blood feeding. Only 1% of mosquitoes in affected areas carry the virus.

Illness typically occurs two to 14 days later. It is estimated that 80% of infected people are asymptomatic, while approximately 20% have mild, flu-like symptoms such as fever, fatigue, headache, and body aches. Occasionally, a mild rash or swollen lymph glands occur. The duration of this illness, referred to as West Nile fever, is usually three to six days.²⁻⁴

Severe infection with encephalitis or meningitis can occur in 1/150 to 1/200 cases. Presenting symptoms can include rapid onset of severe headache, stiff neck, high fever, nausea, vomiting, confusion, unconsciousness, muscle weakness, and flaccid paralysis. Over the course of

serious infections, seizures, myocarditis, hepatitis, pancreatitis, and ocular manifestations have been reported.^{2,3} Presently, the risk factors for severe disease and death are advanced age (mean age of 56), diabetes mellitus, and immunosuppression. Long-term sequelae of this neurological infection include memory loss, cognitive dysfunction, depression, muscle weakness, and fatigue.⁴ The fatality rate of hospitalized cases in recent outbreaks has been 4% to 14%.

Pharmacology

Under normal conditions, humans release carbon dioxide and lactic acid that serve as attractants to insects. DEET most likely blocks chemoreceptors on mosquito antennae that sense these substances, so that the insect cannot locate its prey.⁵ Insects are not killed, they are simply repelled.⁶

Product strengths

A higher concentration of DEET produces a longer-lasting effect, but not better protection.⁷ Products containing 30% provide six hours of protection, 15% provide five hours, 10% provide three hours, and 5% provide two hours⁸ (see Tables 1 and 2). Although some preparations contain 100% DEET, the effectiveness of DEET plateaus at 50%, so there is little additional benefit at higher concentrations. Health Canada will be phasing out insect repellents containing more than 30% by December 2004.⁷

One approach to selecting the concentration of DEET is to base it on the amount of time spent outdoors. Sweating and swimming may reduce the duration of effect.^{6,9} Under most circumstances, products containing 30% will be effective for adults.

*In affected areas of Canada
just 1% of mosquitoes are infected
with West Nile virus*

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TABLE 1 — Ingredients found in registered insect repellents in Canada^{8,13}

Insect repellent	Duration of protection (hours)	Age restrictions (years)*	Frequency of application daily	Comments
P-methane 3,8-diol 10%	1.5–2	>3	2	Data lacking in children
Soybean oil 2%	1.5	>2	NA	Potential aspiration pneumonia with oral ingestion
Citronella 5%–15%	0.5–2	>2	NA	Sensitizing; potential risk of aspiration pneumonia with oral ingestion
Lavender 6%	0.5	>2	NA	Potential risk of aspiration pneumonia with oral ingestion
DEET 30%	6		3 or more when effects are wearing off	
DEET 15%	5	>12	3 or more when effects are wearing off	
DEET 10%	3	2–12	3	Avoid prolonged use
DEET 5%–10% or less	2–3	0.5–2	1	Avoid prolonged use; avoid applying to hands and face

*Remember that use of DEET is not advised for children under six months of age.

Combined DEET and sunscreen preparations

When applying separate preparations, the repellent may reduce the effectiveness of the sunscreen by about 33%.¹⁰ However, the efficacy of DEET may not be influenced by the use of sunscreens.¹¹ Combination products of DEET and sunscreens also present difficulties with application instructions. Sunscreens should be applied liberally, while DEET should be applied sparingly and infrequently. These conflicting instructions for use have resulted in Health Canada prohibiting combination products as of December 2003.⁷

Use in children

Health Canada and the Canadian Paediatric Society recommendations for use in children have recently been changed. They advise using DEET formulations of 10% or less for infants and children under age 12 and advise against use for children under six months of age. To reduce systemic absorption, children aged six months to two years should limit application frequency to once daily and avoid applying DEET to the hands or face. Older children aged two to 12 years should limit applications to three times daily.^{7,12}

However, these recommendations will only provide about three hours of protection and there are concerns of a greater risk of infection if a child is outdoors for longer. Given the lack of evidence of increased toxicity of DEET in low concentrations, a second application may be warranted in a young child spending extended hours outdoors.¹³

Safety data

The National Pesticide Information Center (NPIC) confirms that DEET is safe when used according to the manufacturer's directions.¹⁴ Worldwide usage of DEET for over 40 years has confirmed that human use toxicity is

very low. Adverse effects occur rarely and are associated with excessive or chronic use rather than the actual concentration of the preparation. Skin reactions such as contact dermatitis, generalized pruritus, and angioedema may occur rarely. Applications to the eye and mucous membranes can be irritating.¹⁵

Serious reactions have been related to misuse of the product, such as applying to broken skin, using for multiple days without washing skin between applications, or swallowing the product. Toxic encephalopathy, seizures, and death have been reported after accidental ingestion, inhalation, excessive skin application, or eye contamination.

A recent study of 20,764 DEET exposures (as reported to Poison Control Centers in the USA) revealed that 70% of cases had no symptoms, 2% had a moderate effect, 0.1% had a major effect, and two deaths occurred.¹⁶ A moderate effect included fever, disorientation, hypotension, or brief seizures requiring treatment. A major effect was considered to be one that was life-threatening or resulted in permanent disability, e.g., status epilepticus, respiratory intubation, ventricular tachycardia, and cardiac or respiratory arrest. Ocular exposures accounted for 84.9% of symptoms, inhalation for 43.9%, dermal for 14.2%, and ingestion for 9.6%.

To date, there is no direct relationship between DEET use and birth defects or cancer. Health Canada states there is no evidence that use of DEET by pregnant or lactating women poses a health hazard to unborn babies or breast-fed children.^{13,17}

DEET may damage rayon, spandex, leather, plastics such as eyeglass frames and watch crystals, and painted or varnished surfaces. It does not affect cotton, wool, or nylon.⁴

Cont'd on p. 46

PREVENTION STRATEGIES

- Avoid situations that will lessen the duration of DEET effectiveness, such as water exposure (rain), sweating, and mixing DEET products with sunscreen products.
- Avoid wearing insect-attracting scents such as floral-scented perfumes and dryer-sheet-scented clothes.
- Use enough repellent to cover exposed skin or clothing. Do not apply to skin under clothing.
- Apply DEET repellent to clothes when possible.
- Apply DEET in well-ventilated areas. Do not inhale repellents.
- Do not apply sprays or foams directly to the face, but rather apply to the hands and then rub carefully on face, avoiding the eyes and mouth.
- Avoid applying DEET to any cuts, wounds, or irritated areas.
- Upon returning indoors, wash DEET off skin and clothes using warm, soapy water.
- Do not allow young children to apply repellents themselves, especially on their hands, as children tend to put their hands in their mouths and risk ingestion.
- Reduce mosquito populations by removing receptacles of standing water where mosquitoes breed.
- Reduce mosquito exposure by limiting outdoor activities during mosquito feeding times at dawn and dusk.
- Use barriers such as mosquito nets and protective clothing (such as light-coloured pants and long-sleeved shirts).

Pharmacokinetic properties

After topical application, about 8% of the applied dose may be absorbed.¹⁸ Ethanol formulations increase the dermal absorption. If DEET is ingested, concentrations achieved within one hour can be hundreds of times

higher, and serum concentrations of 1 mmol/L have been associated with seizures (neurotoxicity) and death.¹⁹ It is metabolized by hepatic P450 enzymes.

The two major pathways involve oxidation via CYP2B6 and CYP1A2 enzymes and dealkylation via CYP2C19 and CYP3A4 enzymes.¹⁸ Potential drug interactions have not been studied. DEET is renally cleared within 12 hours, where 10% to 14% is unchanged in the urine.⁵ The half-life is 2.5 hours. This rapid elimination should prevent any accumulation in the body.¹³

TABLE 2 — Selected commercial products containing DEET

Product	% of DEET
Off Skintastic	Spray 5% and 7%; lotions 7.5%
Off Insect Repellent	Foam 10%; aerosol 15%
Deep Woods Off	Pump spray 25%; aerosol 25%
Deep Woods Off for Sportsmen	Aerosol 30%
Repel	Gel 7%; pump spray 18%; lotion 20%; aerosol 23%
Muskol	Lotion 28.5%
Cutter	Aerosol 10%, 23%, 30%; lotion, stick 30%
Ben's 30 Wilderness	Aerosol spray 30%
Ben's Backyard	Lotion, pump spray 24%
Sawyer	Lotion, 10%, 20%, 30%; pump spray 17.5%
Skedaddle	Lotion 6.5%, 10%
Ultrathon (3M)	Aerosol spray 8%, 24%, 31.6%

Alternative insect repellents

DEET is the only repellent that provides long-lasting protection after a single application. One study revealed that DEET 23.8% provided protection for 301.5 minutes, compared to soybean oil for 94.6 minutes, IR3535 (ethyl butylacetylaminopropionate) for 22.9 minutes, citronella 10% for 20 minutes, and Skin-So-Soft Bath Oil for 9.6 minutes. Wearing repellent-impregnated wristbands or devices that emit sounds, or ingesting vitamin B₁ (thiamine) or garlic are ineffective at repelling insects.²⁰

Conclusion

Despite widespread concern about the safety of DEET, evidence shows that it is both safe and effective in adults, children, and pregnant and lactating women. It is the most long-lasting of all insect repellents available in Canada. Other effective alternatives are available, but their duration of action is so short that they are of questionable value. When used properly, DEET-based repellents provide long-lasting, safe, and reliable protection against mosquito-borne infections. ■

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