ATSDR Agency for Toxic Substances & Disease Registry

Division of Toxicology and Human Health Sciences (DTHHS)

Health Effects in Humans

DEET (N,N-Diethyl-meta-toluamide)
Chemical Technical Summary for Public Health and Public Safety Professionals

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The U.S. EPA estimates that 30% of the U.S. population applies DEET every year. In the more than 45 years that DEET has been used in the U.S., reports of adverse effects in humans associated with the dermal application of DEET have been relatively rare, given the billions of applications of the repellent. Case reports of toxicity from DEET exposure have been documented in the medical literature, and range in severity from mild skin irritation to death.

Intentional Ingestion of DEET

Rarely, people have ingested DEET intentionally to commit suicide, or because of psychological problems (Tenenbein 1987; Fraser et al. 1995). The effects resulting from intentional ingestion are variable, due to the different scenarios in which they occurred. Of the six reported cases of deliberate DEET ingestion, three led to death. In these cases, the amount ingested was 15-50 mL of 47.5% to 95% DEET in bottles. In two cases, bottles of DEET were drunk along with unspecified amounts of alcohol. Health effects included coma, unresponsiveness to pain and other stimuli, and death (Tenenbein 1987). In another case, a woman with a history of unipolar-depressive illness ingested a number of pills along with 50 mL of 95% DEET. She arrived at the hospital comatose and pulseless. She had a generalized seizure and died from a generalized bowel infarction (Tenenbein 1987). In another case, a woman with a history of psychological disorders ingested 15-25 mL of 95% DEET. She had a right and left atrial enlargement and diffuse ST-T abnormalities, but returned to normal within 24 hours with no further cardiac abnormalities (Fraser et al. 1995).

Fatalities Due to Dermal Exposures to DEET

From 1961 to 2002, eight deaths were reported related to DEET exposure. Three of these deaths resulted from deliberate ingestion of DEET (Tenenbein 1987) (see above). Two deaths were reported in adults following dermal exposure to DEET (Bell et al. 2002). The remaining three cases were all female children, with ages of 17 months, 5 years, and 6 years (Zadikoff 1979; Osimitz and Murphy 1997). All three children had been described as having "heavy, "frequent" or "nightly" applications of DEET. The 6-year-old had congenital ornithine carbamoyl transferase (OCT) deficiency, a potential lethal hyperammonemic condition, which may have contributed to her death. DEET did not inhibit human OCT in vitro (Rej et al. 1990)

Psychological Effects in Adults

The two recorded cases of dermal DEET exposure resulting in psychological effects involve males 27 and 30 years old. In one case the 27-year-old applied Deep Woods Off! (20% DEET) while fishing on a humid afternoon. The man experienced an altered mental state and paresthesias, which progressed to auditory hallucinations and severe agitation. He was heavily sedated when he arrived at the hospital and required mechanical ventilation. After 24 hours, his condition had improved and he was discharged after 3 days with no recurring symptoms (Hampers et al. 1999).

In the other case, a 30-year-old man applied DEET daily to a rash as a means of self-medication. After application to half of his body, he would enter a home-made sauna for up to 90 minutes. He would exit and apply the repellent to the other side of his body and repeat. These treatments continued for a week, and he was noted to be lethargic and incoherent following the treatments. After his final treatment, he developed grandiose delusions and became verbally aggressive, irritable and belligerent. He was treated in the hospital with various drugs and his condition improved by the 6th day. He was discharged on the 10th day and did not have recurrence of symptoms (Snyder et al. 1986).

Exposures of Military Personnel-Dermal Effects

Unique cutaneous side effects have been reported in fewer than 15 soldiers who applied military-issued DEET repellents. A 19-year-old soldier applied a 33% DEET repellent to his skin, and then slept with the repellent still on his skin. He developed a vesiculobullous eruption of his left antecubital fossa, which cleared after 14 days (McKinlay et al. 1998). A 20-year-old soldier noticed a burning sensation and skin eruption in his antecubital fossa area after sleeping with repellent on his skin for 8 hours. The man was treated with corticosteroids for 10 days, and the lesions disappeared without sequelae (Amichai et al. 1994). Reuveni and Yagupsky (1982) reported an additional 10 soldiers who developed a burning sensation and erythema in the antecubital fossa after applying a 50% DEET solution before sleeping. Four of the soldiers were referred to a dermatologist, and only three soldiers received medical treatment. In two of the soldiers, a permanent scar remained in the location of the erythema. Once of the cases required corrective surgery after scar tissue formation.

In a controlled test following the initial reactions, 63 soldiers volunteered for testing. They were treated with a gauze pad soaked in DEET that was applied to the antecubital fossa. Of the 63 soldiers tested, 46% of them developed a reaction to the treatment. The reactions varied in intensity, but all had epidermal changes. However, when the men were also patch-tested on their upper arms in a similar manner, none had a reaction, suggesting that the antecubital fossa was uniquely sensitive to the irritant effects of DEET. A second control group was tested at the U.S. Naval Hospital in Oakland, CA to confirm DEET as the cause of the symptoms, and the results were consistent with the cases that occurred in Vietnam (Lamberg and Mulrennan 1969). These cases would suggest that it is prudent to wash DEET from the skin surface before sleeping.

Multiple-Case Studies

AA study was done involving 143 National Park Service employees at Everglades National Park to determine the effects of DEET on varying use groups. Exposure groups were classified as low (non-users), medium (0.01-0.52 g/day) and high (0.71-69.38g/day) use of DEET. It was found that 36 of the workers (25%) reported health effects that they attributed to DEET. These effects included rashes, skin or mucous membrane irritation, transient numb or burning lips, dizziness, disorientation, and difficulty concentrating. Headache and nausea were also reported. A statistically significant difference was not found between reported effects from high-exposure and medium-exposure workers, although the incidences were significantly higher than in the non-users (McConnell et al. 1987).

A retrospective analysis of calls to poison control centers provided additional data of the effects of exposure to DEET in the general U.S. population. From 1985 to 1989, 71 poison control centers reported over 6 million human exposures to a variety of chemicals. Of these, 9,086 calls were related to DEET exposure. Of the DEET calls, 54% had no symptoms at all at the time of the call, and only 40% had symptoms that were thought to be related to DEET exposure. Symptoms were most likely to occur if the patient sprayed the repellent in the eyes, or inhaled the product. Symptoms were least likely to occur if the patient ingested small quantities of the repellent. Of all exposures, 88% did not require medical attention; 35% had minor side effects (skin irritation); 1% experienced moderate symptoms (including disorientation or brief seizures, all of which resolved without sequelae; and five had major effects (which were life-threatening or result in residual disability or disfigurement). One reported death was from deliberate ingestion of an 8-ounce bottle of DEET. No relationship was found between age, sex, or concentration of DEET and the severity of reported side effects. Children were not more likely to develop side effects from DEET exposure when compared to an adult population (Veltri et al. 1994).

A similar analysis published by Bell at al. (2002), analyzed an additional 20,764 reports to poison control centers from 1993-1997. Of all reported cases, 96% were determined to have no effect or a minor effect. Once again, the highest rate of side effects was from inadvertent ocular exposure (21% of all calls). Skin symptoms (irritation or rash) were reported in 10.5% of calls. Neurological symptoms were reported in 1.4% of all cases (including dizziness, headache, and drowsiness). Seizure was reported for 20 cases. Two deaths were reported in a 26 year-old male and a 34 year-old female following dermal exposure. No clear relationship was seen correlating seriousness of the side effects and concentration of DEET products used, and children were no more sensitive than adults.

Case Reports of Children's Exposures

Of 17 cases of reported significant toxicity from DEET exposure during the period of 1961 to 2002, 14 were in children under the age of 8. The most frequently reported symptoms of DEET toxicity in children were lethargy, headaches, tremors, involuntary movements, seizures, and convulsions (Braissoulis et al. 2001; Osimitz and Grothaus 1995; Osimitz and Murphy 1997; Pronczuk de Garbino et al. 1983).

In children's exposures the route of intentional exposure is most often dermal, and accidental exposures most often are by ingestion of DEET solutions. In cases of significant DEET ingestion in children, impairment of gait, loss of muscle control, loss of consciousness, hypertonia, tremors and seizure (generalized) have been reported (Zadikoff 1979; Tenenbein 1987; Petrucci and Sardini 2000; Edwards and Johnson 1987). After an 18-month-old girl ingested an unknown quantity of Mylol® (10% DEET), she was admitted to the hospital. She was irritable and in an opisthotonic posture, suffering from periods of shaking and crying. Her muscle stretch reflexes were depressed, and her head control was poor. She was in the hospital for 6 weeks, in which her condition improved slowly. She was discharged to a local hospital for further recovery (Zadikoff 1979). The girl's symptoms are fairly typical of ingestion exposure in children; however the duration of her recovery process is much more prolonged than in any other case study reviewed.

An 18.5-month-old female who was sprayed with Deep Woods Off!® (20% DEET) daily for 3 months developed weakness, ataxia, uncontrollable tremors and increased drooling. DEET was found in the child's urine, and her white blood cell count was elevated. She improved after treatment with corticotrophin 3 times a day, and her condition improved to full recovery within 3 months (Edwards and Johnson 1987).

A 6-year old girl was admitted to the hospital with periumbilical tenderness, ataxia, and brisk

reflexes of the ankle and knee. She had been exposed to a spray containing 15% DEET over extensive areas of the skin on more than 10 occasions. On the fourth day of her hospitalization, she became agitated, combative, and increasingly disoriented, with increased serum ammonia levels. Her condition deteriorated and she died 8 days after admission. Autopsy revealed that the child was a carrier for congenital OCT deficiency, which could have predisposed her to toxicity as a result of extensive exposure to DEET (Heick et al.1980; Pronczuk de Garbino et al. 1983; Osimitz and Murphy 1997).

Between June and August 1989, five cases (four boys aged 3-7 years and a 29-year-old man) of generalized seizures temporally associated with the dermal application of DEET occurred in the states of New York and Connecticut (CDC 1989). The patients had been exposed to varying concentrations of topically applied DEET, with generally fewer than three applications. The onset of seizures ranged from 8 to 48 hours after the last application. All patients quickly recovered. None of these cases clearly established that DEET was the toxic agent responsible for the seizures (CDC 1989).

A recent review regarding the safety of DEET-based insect repellents for children and pregnant and lactating women was presented by Koren et al. (2003).These authors concluded that the available evidence does not confirm that children are especially susceptible to the toxic effects of DEET and the etiology of adverse neurological outcomes associated with the DEET in children and adults has still not been determined. These conclusions are also supported by a review by Sudakin and Trevathan (2003) on the safety of DEET in the general population

Reproductive/Developmental Effects

A 34-year-old expectant mother, while working in Africa, applied a lotion containing 25% DEET daily to her arms and legs apparently throughout her pregnancy in addition to taking chloroquine. She did not suffer complications during pregnancy. When the child was born, however, an antimongoloid slant of the palpebral fissures, hypertelorism, thin lips, poorly developed philtrum and a broad nasal bridge were observed. The child developed statomotor retardation, muscular hypotonia, central hearing loss and strabismus in the first months of its life. It was concluded that the use of DEET might have played a role in the occurrence of the reproductive effects (Schaefer and Peters 1992).

In another study of DEET use during pregnancy, two mothers who were sisters gave birth to two male infants within 2 weeks of each other. About 8 weeks into their pregnancies, the women went on a camping trip with their spouses. The group used large amounts of insecticides and the insect repellent Off!® to control flies and mosquitoes. Both children had heart problems which led to congestive failure and diagnoses of coarctation of the aorta. One of the boys died after 38 days, and the other survived (Hall et al. 1975). Of note is the fact that the sisters were not together during their pregnancy except during the camping trip, and that there was a family history of heart problems on the father's side of the boy who survived.

McGready et al. (2001) studied the effects of DEET applied in the second and third trimesters of pregnant women (449 DEET treated; 448 controls) as part of a double-blind trial of insect repellents in the prevention of malaria. DEET was found in 8% of cord blood samples, indicating that it crossed the placenta. However, no adverse effects were seen on survival, growth, or development at birth or at 1 year of age.

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