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Eastern Equine Encephalitis: An Assessment of Vermont's Treatment Plan and the Lack of Preventative Treatment

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Abstract

When an avian host and the *Culiseta melanura* mosquito meet in fresh water hardwood swamps, the Eastern Equine Encephalitis virus (EEE) is spread to the bird community. When that same bird is bitten by a mosquito that feeds on humans, such as the *Aedes*, *Coquillettidia*, and *Culex* species, the EEE virus has found its bridge vector. EEE is a rare disease in humans; the Centers for Disease Control and Prevention (CDC) reported in 2010 that the virus affects an average of 6 people per year (Epidemiology & Geographic Distribution section, para 2). In 2010, blood collected from deer and moose tested positive for the disease. In 2011, several emus in a large flock were affected. Last summer, two people in Rutland county died from complications of EEE, an 87 year-old man and a 49 year-old man. Vermont chose to address the problem with an aerial spraying of pesticides and reported a 50% reduction in the *Culiseta melanura* mosquito. Many Vermont residents, however, have expressed a concern over the extensive pesticide exposure.

The Vermont Department of Health (VDH) issued a statement in September of 2012 in hopes of educating the public about the selected pesticides they would use to treat the community. They stated, "There are no studies examining whether the use of Anvil to control mosquitoes has caused any long-term health effects in humans" (VDH, 2012, p. 1). Most Vermont residents were not satisfied with this report and began doing research on their own. The demand for a vaccine has become much more prevalent. This paper will look at the rates and effects of the Eastern Equine Encephalitis virus on humans, the health affects of aerial pesticide spraying, and the lack of an acceptable vaccine or antiviral treatment medication.

Background

The *Culiseta melanura* mosquito is found primarily around the Atlantic and Gulf coasts, and the Great Lakes Region. It is responsible for maintaining the EEE virus among the wild bird population. The *Cs. melanura* mosquito feeds almost exclusively on birds and does not bite humans. Therefore it is important to note that the transmission of the EEE virus to humans requires a bridge vector- a mosquito that bites both birds and humans, such as the *Aedes*, *Coquillettidia*, and *Culex* species. "Human EEEV cases occur relatively infrequently, largely because the primary transmission cycle takes place in and around swampy areas where human populations tend to be limited" (CDC, 2010, Epidemiology & Geographic Distribution, para 1).

The EEE virus can produce two types of illness. Those with a systemic illness may have a fever, chills, joint pain, or other flu-like symptoms. This illness may last for 1-2 weeks and recovery will be complete when there is no nervous system involvement. Those with the encephalitic illness (EEE) will manifest symptoms several days after the systemic illness. Symptoms may include vomiting, diarrhea, convulsions, restlessness, drowsiness, and coma. The CDC (2010) reports that one third of those infected with EEE will die. Many of those who survive will suffer from permanent neurologic damage, including minimal brain dysfunction, paralysis, personality disorders, seizures and severe intellectual impairment. Many of those survivors will die within a few years. There is no treatment for EEE. Once the virus enters the nervous system, health care personal can only offer supportive care.

Vermont's Plan of Attack

Source Reduction

The state of Vermont has decided to attack EEE with several different methods, including aerial spraying of pesticides, larviciding, and source reduction. Source reduction is a preventative method that involves the removal of mosquito breeding grounds. Vermont is encouraging its residents to change the water frequently in bird baths, drill holes in tire swings,

dump containers that collect water, even drain swamps and dig ditches to prevent free-standing water from collecting on ones property. "Source reduction often minimizes, and in many cases eliminates, the need for mosquito larviciding in the affected habitat with the added benefit of a reduction in adulticiding [the application of insecticides to kill adult mosquitoes by ground or aerial applications] in nearby residential areas" (American Mosquito Control Association, 2011).

Larvicide

Larviciding involves a ground application or aerial spraying of pesticides to kill mosquito larvae. The Vermont Public Interest Research Group (VPIRG) wrote a guide in 2001 to educate the public on Vermont's treatment plan for the West Nile Virus, an arbovirus similar to EEE that is prevented in the same manner. At this time, Vermont had proposed the use of three larvicides: *Bti*, Bacillus sphaericus, and monomolecular oil. *Bti* and Bacillus sphaeicus both have to be ingested to be affective. The chemicals will grow in the gut of larvae, releasing toxins and breaking down the gut wall of the mosquito. Monomolecular oil is spread on the surface of water. It lowers the surface tension of the water, inhibiting the orientation of larvae. It also acts by "wetting tracheal structures and causing anoxia. Larvae normally use surface tension to suspend for long periods when breathing and resting. Emerging and egg-laying adults cannot be supported on the water surface when oil is present and drown" (VPIRG, 2001, p. 11).

Integrated Vector Management (IVM) uses evidence-based decision making, combining chemical and non-chemical vector control in an effort to "make a significant contribution to the prevention and control of vector-borne diseases" (IVM, n.d.). In a review of larvicides, IVM states, "A primary requirement of any larvicide is that it has to be degradable and have minimal toxicity, especially on non-target organisms" (IVM, n.d.). There have been numerous studies done on the health effects of larvicides on humans, including *Bti*, Bacillus sphaericus, and

monomolecular oil. Based on these studies, the EPA (2013) finds that there are minimal effects on humans when the larvicides are applied according to label directions.

There are, however, potential negative ecological effects of larviciding. Larvicide is not specific to mosquito larvae, it affects fly larvae as well. Adult flies and fly larvae are important food sources for many insects, reptiles, birds, amphibians and mammals in Vermont. The application of larvicide will invariably disrupt the food chain for many species.

Adulticide

The American Mosquito Control Association (2011) stated, "Adulticiding (the application of insecticides to kill adult mosquitoes by ground or aerial applications) is usually the least efficient mosquito control technique" (section D). In 2012, the Vermont Department of Health (VDH) released a statement in an attempt to educate the public about the types of pesticides that would be applied over several communities via aerial spraying. Vermont would be treating the communities with Anvil 10+10, a combination treatment containing sumithrin and piperonyl butoxide. Anvil is an endocrine disruptor, a chemical that interferes with the endocrine system function. Anvil would essentially disrupt growth, development, reproduction, behavior, and normal organ function of the insects that came into contact with it.

Anvil 10+10

Anvil 10+10 is a combination of two chemicals, sumithrin and piperonyl butoxide. In 2008, the Environmental Protection Agency (EPA) reassessed many older chemicals to ensure that they met current standards for chemical registration. Sumithrin (generic name: phenothrin) and piperonyl butoxide were two of the chemicals to go through this reregistration process. The toxicity profile for sumithrin states, "Phenothrin is not known to be acutely toxic at high exposure levels to humans or mammals. Phenothrin exhibits low acute toxicity by oral (Category

III), dermal (Category III), and inhalation (Category IV) routes of exposure. Phenothrin is a mild eye irritant (Category III) but is not a skin irritant or a skin sensitizer" (EPA, 2008, p.14).

Piperonyl butoxide has a similar review; the acute toxicity profile states, "PBO has a low acute toxicity by oral, inhalation and dermal routes. It has been assigned toxicity Category III by oral and dermal and Category IV by inhalation exposure routes. In the acute studies, PBO has been identified as minimally irritating to eyes and skin, and is a dermal sensitizer" (EPA, 2008, p. 16). While both seem to have minimal effects, both have been shown to cause hepatocellular changes at high doses, including increased liver weight, liver adenomas and liver carcinomas. As far as their carcinogenic effects, the Material Safety Data Sheet does not list any of the ingredients in Anvil as a carcinogen "at concentrations equal to or great than 0.1%" (Vermont Agency of Agriculture Food and Market, n.d.).

Literature Review

The National Institute of Environmental Health Sciences (NIEHS) describe endocrine disruptors as "chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife" (NIEHS, 2013, para 1). The NIEHS reports that endocrine disruptors may pose the greatest risk prenatally and in the early postnatal period when the development of organ and neural systems are forming. Environmentally, the effects of endocrine disrupting chemicals (EDCs) have been largely noted in invertebrates, reptiles, fish, birds and mammals (Mnif, Hassine, Bouaziz, Bartegi, Thomas and Roig, 2011, section 2, para 3). As far as the effects on humans, Mnif et al. (2011) report that "endocrine disruptor pesticides have also been shown to disrupt reproductive and sexual development" (section 2, para 4).

In their 2011 article entitled *Effect of Endocrine Disruptor Pesticides: A Review*, Mnif et al. discuss the long-term effects of EDCs on fetuses, infants and children, stating that this

population shows greater susceptibility than any other. "Infants are extremely vulnerable to pre and postnatal exposure to endocrine disruptor pesticides, resulting in a wide range of adverse health effects including possible long-term impacts on intellectual function and delayed effects on the central nervous system functioning" (section 2, para 5). In terms of the carcinogenic effect of EDCs, Mnif et al. discuss numerous studies that have found links between pesticide exposure and breast and prostate cancer, however the authors suggest more research should be done as some of the data is inconsistent.

In the 2012 article, *Endocrine-Disrupting Chemicals: Associated Disorders and Mechanisms of Action*, authors De Coster and van Larebeke cite pesticides as one of the many causes for a rise in health problems. "Epidemiological data show increases in incidence and prevalence of diseases associated with endocrine-disrupting chemicals, such as breast, prostate, and testis cancer, diabetes, obesity, and decreased fertility over the last 50 years" (section 2, para 1). The authors found that diabetes has shown a more than 6-fold increase since 1958. Cancer rates in Great Britain have increased by 25% overall since 1978, with a 14% increase in men and a 32% increase in women. Obesity rates in U.S. adults increased from 13.4% in 1960 to 35.1% in 2005. While these numbers are shocking, and certainly could be related to the increase of EDCs in the environment, DeCoster and Larebeke advise that "Time trends and ecological studies are not well suited to study a possible association between exposure to endocrine disrupting chemicals and risk of disease, as assessment of exposure is extremely difficult" (section 2, para 1).

Finally, Environmental Health published a study in 2012, linking EDCs with the risk of breast cancer. Authors Brophy, Keith, Watterson, Park, Gilbertson, Maticka-Tyndale, Beck, Abu-Zahra, Schneider, Reinhartz, DeMatteo & Luginaah studied 1005 breast cancer cases from a regional cancer center. The study looked at the occupational and reproductive histories of the

participants and found that "Across all sectors, women in jobs with potentially high exposures to carcinogens and endocrine disruptors had elevated breast cancer risk" (Abstract, para 3). The authors also found that there were specific sectors with which the risk was even higher, agriculture included. Brophy et al. cite an "under-representation of potentially highly exposed migrant farm and greenhouse laborers" (Limitations, para 5), due to the fact that they were not treated at the regional cancer center. This exclusion, the authors state, may have underestimated the risk estimate. Another limitation to this study is that the authors were unable to identify exposure to specific chemicals, however they do state that associations were observed between breast cancer carcinogens and EDCs.

Though none of the articles cite sumithrin or piperonyl butoxide specifically, it is important to remember that the long-term effects of Anvil on humans has been a neglected topic. The New York Department of Health (n.d.) put a statement on their website stating,

> Short-term exposures to very high levels of pyrethroid pesticides similar to sumithrin can affect the nervous system, causing such effects as loss of coordination, tremors or tingling and numbness in areas of skin contact. Short-term exposure to high levels of petroleum solvents can cause irritation of the eye, skin, nose, throat or lung. Vomiting or central nervous system depression may occur if very high levels of petroleum solvents are ingested. There are no studies examining whether the use of Anvil to control mosquitoes has caused any long-term health effects in humans (section 2, para 1).

Community Disadvantages

Spraying Mishaps

The label on a container of Anvil 10+10 states, "Harmful if absorbed through the skin" (Vermont Agency of Agriculture Food and Market, n.d.). The state of Vermont has addressed

this issue by telling its residents to "Stay inside or avoid the area when spraying takes place and for about 30 minutes after spraying" (VDH, 2012, p.3). There have been several documented cases, however, of people accidentally coming into contact with aerial pesticide spraying. Audubon magazine ran a story in 2000 on the West Nile Virus and the pesticide spraying that took place in New York that year. Author Robert Boyle quotes Josh Kaufman, a 24 year-old Whitestone resident who stated, "I was playing catch with a friend when the helicopter came over. It was so low I could see the guy's face, and then the spray hit me." Boyle goes on to write, "Kaufman says that he felt sick for weeks, with aching muscles and a headache. Others reported that they and their children had been sprayed while in a park, and fans watching a Mets game at Shea Stadium also got doused" (Boyle, 2000, para 19).

VIRG (2012) also documents the problems with the pesticide spraying in New York with the West Nile outbreak in 2000:

> Typical of inadvertent exposures, a Manhattan woman was accidentally doused with a synthetic pyrethroid when spray crews had difficulty maintaining advertised schedules and sprayed two hours earlier than announced. In another incident, a group of Manhattan residents ventured out on an evening when no spraying had been announced, only to be blanketed by mist when passing spray trucks caught them in the open (p. 18).

New York had taken precautions in 2000, just as Vermont has, to inform and educate the public about their pesticide treatments. While one would hope that state agencies involved in aerial spraying have since learned from mistakes such as these, human error must be taken into consideration.

Not Just for Mosquitoes

Vermont is scattered with bodies of water; streams, lakes, rivers and ponds fill the beautiful landscape between New York's Adirondack mountain range and New Hampshire's

White Mountains. These sources of water serve as breeding grounds for the mosquitos that spread the EEE virus. It would be impossible to guarantee the avoidance of contamination of these waters with the pesticides used in aerial spraying. The Vermont Agency of Agriculture Food and Markets (VAAFM) posted the Anvil 10+10 label on their website last year before the aerial spraying. The label states, "This product is toxic to aquatic organisms, including fish and aquatic invertebrates" (VAAFM, n.d.). Fishing is a big part of the culture and the commerce in Vermont. If aerial spraying is to continue, there is no way to guarantee that Vermont's aquatic wildlife will not be affected.

Along with fishing, hunting, and maple syrup producing, many Vermonter's pride themselves in their honey. Anvil's label also states, "This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment area" (VAAFM, n.d.). Once again, there is no way to guarantee that Anvil will not be sprayed on bees or blooming crops. There will be many lives affected by the reduction of bees if Vermont continues to use aerial spraying as a treatment option for the EEE virus.

The Community Nurse Dilemma

The community nurse is faced with several problems at this point. For starters, the Vermont communities being affected by the EEE virus need education. The residents have questions about the disease, its symptoms and available treatment. There are also many questions to be answered about the use of pesticides and the possible effects on humans. Along with educating the public, the community nurse needs to advocate for them. With enough people that have expressed concerns over aerial spraying, the community nurse needs to begin researching another solution. In this case, the state of Vermont is faced with a highly fatal

disease, yet this disease lacks any preventable treatment. As the rate of neuroinvasive illness from EEE rises, the need for a vaccine becomes great.

The solution to the EEE threat is a suitable human vaccine. The pesticides used for treating for mosquitos have many documented affects on humans and other species. Vermont residents are having to choose between the lesser or two evils: blanketing the community in poisonous chemicals that may wipe out other species that are vital to Vermont's ecosystem, or facing an outbreak of a virulent, fatal virus. The community nurse has the opportunity to educate the public, ensuring that everyone has the best information available. The nurse can make certain that enough is being done in the community to reduce the amount of pesticide being used while the public waits for a vaccine. The nurse can mobilize volunteers to go into the community and assist with source reduction. There is also the need for public forums to educate citizens on steps they can take around their homes to reduce the chance of being bitten.

At the same time, the nurse has the opportunity to act as a bridge between the public and the state, advocating for their residents and making sure their concerns are heard. The state needs education as well, and the nurse is a valuable source of information. Public health nurses need to make sure that the voices of their community do not go silent, and that the state is doing everything in their power to help protect their citizens.

The Vaccine Trial

The need for an EEE vaccine has been recognized, and there are studies underway at this time. The U.S. Army Medical Research and Materiel Command began a clinical trial in December of 2007 that was expected to finish by February of 2013. Participants would receive a 0.5ml injection on day 0 and day 28, and then a 0.1ml injection at 6 months. Those involved would follow up routinely for check-ups and any EEE illness would be recorded for the duration of the study. The results of this study have not yet been posted (ClinicalTrials.gov, 2013).

In another study, funded by the National Institute of Allergy and Infectious Disease and the National Institutes of Health, a live-attenuated recombinant EEE virus was engineered. The virus was capable of replicating only in vertebrate cells, meaning that a mosquito could not be re-infected by a vaccinated mammal, which would give the virus the ability to morph. Authors Pandya, Gorchakov, Wang, Leal and Weaver state, "EEEV is considered the most deadly of all the alphaviruses due to the high case fatality rates associated with infections, reaching as high as 90% in horses. In humans, the estimated case fatality rate approaches 80% and many survivors exhibit crippling sequelae such as mental retardation, convulsions, and paralysis that require life-long institutionalized care" (section 1, para 1).

In the study, 3 to 4 week-old mice were immunized with the EEE vaccine. One hundred percent of the vaccinated mice survived the study. There were no significant temperatures or weight changes throughout the course of the 25 days. "In contrast, all sham-vaccinated mice developed clinical signs of infection including ruffled hair, vomiting, lethargy, hunched posture and paralysis, and all died by day 6 post-challenge" (section 3.3, para 3). The authors conclude by stating, "Our EEEV vaccine candidate appears to be safe and efficacious in mice and is incapable of infecting mosquitoes. Further testing of this vaccine strain is needed to assess its suitability for human use" (section 4, para 5).

Conclusion

It has been difficult to take a stand on either side of this subject. The EEE virus is quite fatal and new to my community. As a concerned Vermont citizen, I feel that the state should be doing everything in its power to keep this virus from reaching the human population. There should be task forces in and around the community working on source reduction. Until there is a safe vaccine available for the public, I believe that larvicide and aerial spraying are necessary actions. Throughout all my research, I have found that the pesticides being used for the aerial

spraying seem to be mildly irritating as opposed to carcinogenic like other EDCs including Bisphenol A (BPA) and dichloro-diphenyl-trichloroethane (DDT). However, given that there haven't been any studies looking at the long-term effects of Anvil 10+10, I am weary of such a blanketing use. It will be impossible to keep these chemicals off Vermont's food sources and out of its waters and soil, and given the toxicity of Anvil to aquatic wildlife and bees, it seems that for the time being, we are left to decide between the lesser of two evils.

A vaccine for EEE must be engineered. Health care needs to go in the direction of prevention. It makes more sense to spend money preventing EEE than to spend money dealing with the catastrophes it leaves behind. It's uncertain what the long-term effects of all the pesticides will bring. The pesticides wouldn't be necessary if there was a vaccine available to prevent the disease in the first place. As another mosquito season creeps up, the EEE vaccine needs to become a priority.

The role of the community health nurse has become increasingly evident as I researched this topic. There are so many different needs throughout the community when it comes to this seasons' threat of EEE. Community health encompasses so many different aspects of health: physical, mental, preventative, even educational; and it's not just the residents that require the assistance of the nurse. There are tests to be done on dead birds, swamp areas that need to be drained, even governments that need to be educated. The role of the community health nurse is one that requires many different, and very important hats. The presence of EEE in Vermont is unnerving for such an outdoorsy community. The VDH has a long season ahead of them.

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