Knowledge, Perceptions, and Practices: Mosquito-borne Disease Transmission in Southwest Virginia

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ABSTRACT

Virginia's temperate climate is suitable for several mosquito species capable of transmitting pathogens to humans. In southwest Virginia, La Crosse encephalitis and West Nile fever are most prominent. The objective of this research, which uses the Health Belief Model (HBM) as a theoretical framework, is to assess knowledge of mosquito-borne disease in southwest Virginia, as well as perceptions and practices of mosquito prevention. Given that several cases of La Crosse encephalitis have been reported in Wise and Tazewell counties, they were selected as study sites to conduct surveys.

Five demographic and socioeconomic variables (gender, age, income, education level and length of time one has lived in the county) were used as predictor variables in logistic regression analyses. Gender, age, and length of residence time in the county were found to be statistically significant predictors of specific health-related behaviors. Within the framework of the HBM, barriers to removing standing water around the home and wearing insect repellent were highlighted. Knowledge of mosquito-borne diseases within the area was generally low, with only one individual correctly identifying La Crosse encephalitis as a threat in the region. Higher numbers (6%) were aware of West Nile virus, while 4% reported malaria in the region, demonstrating a disconnect between actual and perceived risk.

These results can enhance existing public health programs by increasing knowledge, addressing public uncertainty about insect repellent safety, and addressing ways to make recommended practices more effective with the knowledge of how different aspects are perceived by varying groups within the community.

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Attribution

Dr. Kolivras is my academic advisor and committee chair for this thesis. She helped frame the research aims and design, and assisted with developing the survey questionnaire. Her background in medical geography and infectious disease was an asset in drawing conclusions from the data and suggesting application to public health programs.

Dr. Grossman is a member of my thesis committee. With his experience in human geography and anthropology, he helped to develop the survey questionnaire such that it would capture important demographic information and properly communicate the questions on the document to the target audience.

Dr. Redican is a member of my thesis committee. His background in Public Health was important to ensure that the research was framed within the Health Belief Model, which was used as a theoretical framework.

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1.1 Introduction

Infectious diseases are governed by an array of different forces, ranging from climate to human behaviors, with many other moderators in between. With the rapid change in built and physical environments seen today, it is no longer possible to assume that infectious diseases act within the constraints of natural, biological systems. It has become increasingly important to understand not only the changing nature of physical systems, but also role that human interactions play within these larger systems.

Since the eradication of malaria in the mid-20th century, the United States has been blessed with a relatively low number of cases of mosquito-borne disease. However, this threat is quickly returning as a result of a variety of forces. The spread and emergence of vector-borne diseases in the United States and around the world is a complex interplay among the pathogen, the host, and the environment. Harrus and Baneth (2005) identified several major drivers of disease emergence and spread, including habitat change, deforestation, urbanization, climate, globalization, trade, travel, and movement of vectors by wind and migrating birds.

Of importance to this research is the movement of vectors, such as the Asian tiger mosquito, *Aedes albopictus*. This mosquito was introduced to the southeast US from Asia after World War II via the global tire trade (Reiter & Sprenger, 1987). Since then, the vector has become readily established in the US and poses several threats from a medical entomological standpoint. It is capable of transmitting several forms of encephalitic disease, including La Crosse encephalitis (LAC) (Gerhardt et al., 2001) and West Nile virus (WNV) (Holick et al., 2002), both of which are present in southwest Virginia and are the focus of this research.

While *Ae. albopictus* stands to complicate the existing disease ecology of LAC and WNV, which are predominantly spread in Virginia by *Aedes triseriatus* and *Culex* mosquitoes, respectively, there are components of the existing human environment that must also be considered. Specifically, this includes perceptions of mosquito-borne disease transmission and perceptions of recommended public health guidelines to prevent transmission. In order to appropriately address the threat of mosquito-borne diseases to populations in the United States, it is important to first understand how these diseases and preventative practices are conceptualized within communities, so that public health campaigns can be tailored to meet these needs.

1.2 Statement of Purpose

The spread of mosquito-borne diseases is dependent on the relationship among the pathogen, the vector, and the environment. Thus, each element is of equal importance because each relies on the others. From a health standpoint, mosquito-borne disease is only a problem when there is a population at risk, and Virginia is at risk for the transmission of several mosquito-borne diseases. Therefore, it is important to look at the immediate environment of the population at risk to determine how people and communities can protect themselves. There are many things that can be done at the individual level to protect oneself from mosquito-borne disease. However, many people do not take individual precautions. This not only increases their chance of becoming ill but also increases the chance of the pathogen establishing itself in the community.

This study will examine the disease ecologies of mosquito-borne diseases in southwest Virginia and will specifically investigate the correlation between socio-economic and demographic variables, with awareness of mosquito-borne diseases in the area and preventative actions taken. This research builds on previous studies that indicate individual and community-level prevention can be more effective than large-scale approaches. Individuals can, to a large extent, protect themselves from these diseases by taking simple steps to eradicate mosquito-breeding sites around their homes. However, in order to take effective action, individuals must first understand the risks and the appropriate steps to take.

Much of the research done on mosquito-borne diseases has appropriately been done in tropical regions, which are more vulnerable to these threats. Less work has been conducted in developed areas; however given the possible impacts of climate change and variability coupled with increased vector movement (such as that seen with *Ae. albopictus*), the threat of vector-borne disease is becoming an important concern. This research will add to the knowledge of how mosquito-borne diseases are conceptualized within developed areas and help design effective public health programs in anticipation of this growing threat.

Human interactions with mosquitoes in natural and built environments will be investigated through individual behavior via the application of the Health Belief Model. This model, developed in psychology, will be used as a theoretical framework. This model specifically investigates knowledge of disease, individual perceived risk and seriousness of disease, perceived barriers and perceived benefits of taking action, and cues to action. The model

is ideal for this study because it highlights why individuals may or may not take measures to protect themselves.

Southwest Virginia has been chosen as a study site due to its apparent vulnerability to mosquito-borne disease and financial strain faced by local health departments. Specifically, Wise and Tazewell counties were chosen because almost all of the reported cases of La Crosse encephalitis have occurred in those two counties (VDH, 2008). West Nile virus is also considered endemic in the area (VDH, 2005). Additionally, this region borders West Virginia, which accounted for over half of the La Crosse encephalitis cases reported nationwide in 1999 (Nasci et al, 2000). Given that it is estimated that there may be as many as 300,000 cases of La Crosse encephalitis contracted annually in the US (Rust et. al, 1999), these diseases pose considerable threat to the area. In regions with strained financial health resources, it is important that all public health campaigns be as effective as possible. Therefore, this research has both basic and applied goals.

Basic goals:

(1) To understand how specific demographic and socioeconomic status (SES) variables relate to mosquito-borne disease perception and prevention.

(2) To investigate fine-scale dynamics of infectious disease ecology through an evaluation of human-mosquito interactions.

Applied goals:

(1) To use these findings to understand how to enhance existing public health programs that will properly educate target populations

This thesis document contains two additional chapters, a review of relevant literature and a manuscript in preparation for submission to the journal *Health and Place*.

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Chapter 2: Literature Review

2.1 Introduction

This research is situated within the field of disease ecology, which is a sub-discipline of medical geography. Disease ecology focuses on the evaluation of the multiple factors at play when investigating infectious disease emergence, such as La Crosse encephalitis or West Nile virus. These factors include vector ecology, climate variability and change, urbanization, the movement of goods and people, land-cover, and public health measures, in addition to many others. By focusing on the human ecology of disease, this research focuses on the interactions of humans via their behaviors with their natural environment. Therefore, this literature review begins with a discussion of medical geography and the previously mentioned sub-disciplines and how this study is specifically framed within them. Then a background of mosquito-borne diseases in Virginia is discussed. This is followed by a broader discussion of the habitats of mosquitoes. Finally an in-depth presentation of literature explores human behavior as it relates to mosquito-borne disease, as this present study is most concerned with perceptions of disease related to human behavior.

2.2 Medical Geography

Medical geography is a complex and interdisciplinary sub-field within the greater discipline of geography. It can be defined as the application of geographical concepts and techniques to the investigation of health and disease processes (Gesler, 2004, p. 492). While medical geography is often considered to fall within the realm of human geography, it truly sits at the intersection of human and physical geography. This is particularly true of the tradition of landscape epidemiology within medical geography. Landscape epidemiology, from a geographic approach, examines how physical, biotic, and cultural processes are expressed and related to disease in a place (Meade & Earickson, 2000). Pavlovksy (1966) developed this theory, recognizing that disease does not occur sporadically across the landscape; rather there are physical characteristics of a place such as elevation, temperature, and vegetation that contribute to disease expression (Moore, 2008).

Closely related to landscape epidemiology is the tradition of disease ecology, which seeks to understand how human populations and their behaviors interact with built and physical environments in the production or prevention of disease (Gesler, 2004, p.492). Disease ecology

may operate over a variety of scales, but allows for the incorporation of human variables when studying disease dynamics. A focus on the interactions of human behavior with the environment to produce or prevent disease is referred to as the human ecology of disease (Meade & Earickson, 2000) (figure 2.1).

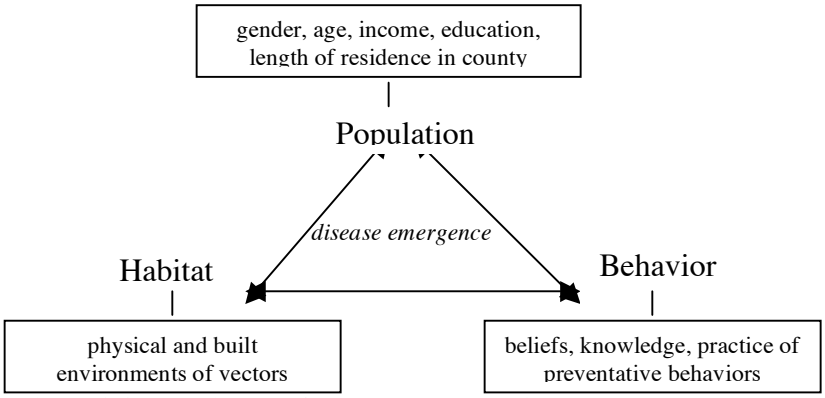

Figure 2.1 The triangle of human ecology as it relates to the current study

Source: Adapted from Meade, M., and Earickson, R. 2000. *Medical Geography*, 2nd ed. Page 35. The Guilford Press, New York, NY.

This research is best situated within this concept of the human ecology of disease. In relation to the triangle of human ecology (figure 2.1), this study seeks to understand the relationships between behavior and habitat and to aggregate these findings within a population in the larger context of disease ecology.

2.3 The Health Belief Model

The Health Belief Model (HBM) was selected as a theoretical framework to allow for the standardized investigation of individual beliefs and behaviors. The HBM is a conceptual model that attempts to understand and predict health related behaviors. Originally, the model was developed by the Public Health Service in the 1950's to understand what factors encouraged or prevented individuals from participating in government-sponsored screening campaigns (Rosenstock, 1966). The specific descriptors of the model are laid out below (Rosenstock, 1966; Becker & Maiman, 1975):

1: **Perceived susceptibility**- The individual's feelings of how likely they are to contract a particular disease.

2: **Perceived seriousness**- The level of impact an individual feels contracting a particular disease would have on his or her own life.

3: **Perceived benefits of taking action**- This refers to how much a person feels that taking action will help in protecting them from contracting a specific disease or condition.

4: **Perceived barriers to taking action**- This refers to reasons an individual may not take recommended preventative or protective action. These can include religious beliefs, personal opinions, and financial restraints.

5: **Cues to action-** Cues to action are external forces that seek to promote a desired behavior.

6: **Self-efficacy/likelihood of taking action**- Self-efficacy refers to the ability of individuals to take positive action to protect themselves. If an individual feels they are susceptible to the disease, that the disease is serious enough and that the benefits of taking action will outweigh the barriers to taking action, they will ultimately take the recommended actions to protect themselves.

Specifically, if individuals feel that they are susceptible to a disease and that the consequences are serious, and that any potential barriers of taking action are outweighed by the potential benefits of taking action, they will ultimately follow recommended suggestions to protect against disease (Rosenstock et al, 1994). However, this model is limited in its application in the sense that although it is conceptually predictive, predictors do not have standard mathematical quantifications, making it hard to quantify their inter-relations (Rosenstock, 1966). Similarly, the operational definitions applied to each of the variables are not constant from study to study (Rosenstock, 1966). Rosenstock (1966) also notes this model may be most applicable to middle-class populations that are more future oriented, as opposed to lower class populations. However, the model is still useful in this study to understand personal protective behaviors to prevent against mosquito-bites and ultimately mosquito-borne diseases.

2.4 Mosquito-borne disease in Virginia

Virginia's summer climate is suitable for mosquitoes; the humidity and warm temperatures make for ideal breeding sites. Thus, mosquito-borne illness is nothing new to the state. Until 1949, malaria was present in large portions of the United States, including Virginia and was considered a major public health problem. The disease was eradicated only through a massive public health effort (CDC, 2004). This past disease history indicates that Virginia's

climate can sustain both the vector and pathogen of what is thought of today as a tropical illness. Consequentially, it is important to ensure public health prevention programs continue to work as planned.

Although not at epidemic levels, small outbreaks of mosquito-borne disease still do occur in Virginia. The most common infections, as reported by the Virginia Department of Health, are eastern equine encephalitis (EEE), La Crosse encephalitis (LAC), West Nile fever (WNV) and St. Louis encephalitis (SLE). On average, case totals of each disease in the state range from several each year to a handful every decade. However, the potential exists for greater impact if public health programs are under funded or not well planned. These forms of encephalitis present symptoms that resemble the flu, but severe cases can result in permanent neurological damage and even death.

La Crosse encephalitis, which is the most common pediatric mosquito-borne disease in the United States (Rust et al., 1999), infects the central nervous system, potentially leaving lifelong damage. Children under the age of 16 are most at risk for contracting the disease and are more prone to suffer long-term complications as a result. Ten to 18 months after infection, infected children may show increases in cognitive and behavioral deficits (Mc Junkin et al., 2001). The disease has typically been confined to the mid-western US and the hardwood forests in the southern regions of the Appalachians where the vector *Aedes triseriatus* resides (Grimstad, 1988). However, over recent years, the vector and virus have slowly expanded into southwest Virginia. According to the Centers for Disease Control and Prevention (2005), only one case was reported between 1975 and 1993 in southwest Virginia. However, between 1993 and 2005, twenty-six cases have been reported in three counties in southwest Virginia. In this area, both *Ae. triseriatus* and *Ae. albopictus* are capable of transmitting LAC, although the virus has only been isolated from *Ae. triseriatus* in southwest Virginia; however, the virus has been found in *Ae. albopictus* in bordering North Carolina (Gerhardt et al., 2001).

The case fatality rate of St. Louis encephalitis (SLE) can reach 35%, depending on the severity of the strain and the age of the affected individual, as elderly populations are at greatest risk for complications (CDC, 2007). SLE arrived in Virginia in 1975, and since then, 13 cases have been reported in the state (VDH, 2008d). Eastern equine encephalitis (EEE) first arrived in Virginia in 2003. Only five cases are on record in the state; however, it has serious consequences. Approximately 35% of those infected with EEE die, and 35% of those who

survive experience permanent neurological damage (VDHb, 2008). Since the arrival of West Nile virus (WNV) only a few years ago, the Virginia Department of Health (2008c) reported 60 human cases between 2000 and 2004. Like other encephalitic diseases, symptoms are often similar to the flu, which has likely led to an under reporting of all of these encephalitic diseases.

Strains of encephalitis are not the only mosquito-borne illnesses of concern in Virginia. Outbreaks of diseases normally thought of as exotic and limited to developing countries have occurred. In 2002, two teenagers were infected with malaria in a Washington, DC suburb. Upon further investigation, public health officials identified two separate pools of *Anopheles* mosquitoes that tested positive for the malaria parasite (CBS, 2002). Neither teenager had reported traveling out of the country; thus it was determined that the infection was acquired locally from one of these pools. With the recent increase of mosquito-borne encephalitis cases along with increased potential for disease emergence, mosquito-borne disease has become a legitimate cause for concern in Virginia.

2.5 Vector habitats

Natural Habitats

Climate is one of many factors that influences vector-borne diseases. Vectors have biological constraints that act within climatological thresholds. Climatological and meteorological shifts can therefore alter disease activity within a given place. Increases in temperature and rainfall correlate directly with an increase in mosquito population because mosquitoes breed in standing water and warmer water temperatures increase the breeding cycle (Leisnham et al., 2006). However, the relationship with climate goes further than this. Outside their areas of origin, African diseases are most likely to thrive in Central and tropical South America, while Middle Eastern diseases are most likely to thrive in the Mediterranean and other like climates (Tatem et al, 2006). Mosquito species from northern, temperate Asia are likely to thrive in climatically similar temperate locations (Tatem et al, 2006), such as Virginia.

Vectors also show specific habitat preferences. For example, at the national scale, LAC is confined to eastern hardwood forests (Moore, 2008). However, at finer scales the vector, *Ae. triseriatus,* shows higher population densities in sugar/red maple habitats than in areas of forest predominated by hemlock or mixed hardwood habitats in West Virginia (Nasci et al., 2000). The climatic and physical forces that influence vector locations within natural systems interact over

varying scales that influence where vector populations can be found. However, vector populations can also be influenced by factors within built environments that are created by humans. These factors are discussed below.

Built Habitats

The built environment, or areas of human settlement, can change the dynamics of natural systems. Mosquitoes may use artificial containers in urban or residential areas as breeding sites (Gubler, 1996) if they are more suitable or accessible than traditional breeding sites. These containers include items such as gutters, water vases, abandoned tires, trash, water storage containers, and any other item that can hold a very small amount of water. It is interesting to note that while *Ae. triseriatus* prefers red/sugar maple habitats over other types of forested areas as mentioned above (Nasci et al., 2000), the vector shows no preference between forested areas and residential areas with open containers (Barker et al., 2003), demonstrating the adaptability of vectors to various settings.

The movement of *Ae. albopictus* provides a good example of the adaptation of this vector to the built environment as a result of human movement. At the end of World War II, a global tire trade developed in Asia due to the number of tires left over from military vehicles, and as companies traded these tires around the world, Asian mosquitoes and pathogens seemed to follow (Kennedy, 1999). The port city of Houston, Texas first saw an abundance of the newly introduced *Ae. albopictus* in 1984. The mosquito then spread along major interstate highways, breeding in tires left along the road (Reiter & Sprenger, 1987). *Ae. albopictus* is now readily established in the United States. This vector is responsible for transmitting dengue fever in tropical regions of the world (CDC, 2005) and poses considerable threat to the US as it is capable of transmitting several forms of encephalitis, including LAC (Gerhardt et al., 2001) and WNV (Holick et al., 2002). Within southwest Virginia, this vector shows ovipositon preference in residential yards over forested areas (Barker et al., 2003).

2.6 Perceptions and mosquito-borne illness

To address the threats of diseases, it is important to look beyond just the behavior of the vector. The behavior of susceptible populations also plays an important role in the ecology of infectious diseases. The way in which diseases are conceptualized by individuals influences how

they respond to this threat. A review of the literature suggests that there are many misconceptions about mosquito-borne diseases. By first understanding these misconceptions, it is then possible to develop solutions to the problem.

The level of knowledge with regards to disease transmission varies, and studies show that people may not understand that mosquitoes spread a number of diseases. According to Kumar et al. (2003), 61% of individuals in India attributed malaria to a mosquito vector; however less than 1% of individuals were familiar with the fact that mosquitoes also transmit dengue. A study in Uganda found that many people believe that in addition to mosquitoes, drinking dirty water, inhaling bad air, witchcraft, and eating fresh fruit can cause malaria (Nuwaha, 2002). In Ghana, while symptoms of lymphatic filariasis are well known, the cause is not (Ahorlu et al., 1999). Explanations of the disease were often related to spiritual and hereditary causes (Ahorlu et al., 1999). It is very apparent within the community that they do not believe mosquitoes transmit the disease. The only reason any measures are taken against mosquitoes by some individuals (using coils, herbs, or insect repellent) is simply because insects are a nuisance (Ahorlu et al., 1999). Additionally, residents in Thailand consider mosquitoes to be an annoyance, but do not perceive disease as a major risk associated with them (Phaunukoonnon, 2006).

Regarding likely breeding sites of *Aedes aegypti*, many people believe that mosquitoes are more likely to breed in dirty water (Phuanukoonnon, 2006). In fact, this particular type of mosquito prefers to breed in clean water (Kumar et al., 2003). In the Philippines, Saul and Lansang (1997) found that most individuals believed malaria was contracted via water with mosquitoes or larvae in it, not through the bite of the mosquito. Residents believe that drinking this water is the ultimate source of infection. Thus, even if people understand that mosquitoes are involved, there is a gap in the knowledge of the transmission cycle involving the bite of an infected mosquito (Nuwaha, 2002). By applying the framework of the HBM to these existing studies, issues related to perceived susceptibility are highlighted. If mosquito-borne diseases are attributed to anything other than the bite of an actual mosquito, then people will not feel they are susceptible to contracting the disease through a mosquito bite. Therefore, if any action is taken to prevent against disease contraction it will be ineffective because it will not be protecting against the actual pathway of transmission.

Among people who understand that mosquito bites transmit illness, there is a hesitation to follow suggested guidelines to protect against mosquitoes. Bed nets can reduce cases of malaria

by 31 percent (Goodman et al., 2001); however it is apparent around the world that people are hesitant to use them. In a community in Nigeria, it is widely believed that mosquito nets are the best way to prevent transmission (Onwujeke et al, 2000). In this same study, the majority of individuals responded that the perceived risk of contracting malaria is high and consider it a serious illness; however, the number of respondents claiming to have bought mosquito nets in the past is very low, illustrating the disconnect between knowledge and practice. Reasons cited in this study for not following suggestions included cost, fears of suffocation, inability to care for them properly, and feeling uncomfortable under them at night (Onwujeke et al, 2000). Similarly, residents in Thailand reported that bed nets were inconvenient because they had to eat dinner and watch TV under them, and trying to get children to do these things under a bed net was noted as an additional struggle (Phuanukoonnon et al., 2006).

House sprayings have been the only form of government intervention for mosquito control in Iran (Zaim, 1997) and the primary form in South Africa (Goodman et al., 2001). In South Africa, house sprayings reduced cases of malaria by 18 percent (Goodman et al., 2001). Many people in Iran reported that they do not allow spraying in their living rooms and bedrooms, if they even allow the spraying of their house at all, because they do not like the fumes (Zaim et al., 1997). Therefore, many people deny the only form of prevention offered by government officials. The application of the HBM in these situations highlights barriers to taking action. The hassle of bednets for a variety of reasons as discussed, and the dislike of fumes in the previous example appear to outweigh the risks associated with having mosquitoes inside the home.

Due to the worries associated with bed nets and house sprayings, people have developed their own remedies to prevent mosquito bites. These include sleeping under fans or air conditioning units in hopes that the mosquito will not be able to fly towards them (Zaim et al., 1997). Additionally, Dulhunty (2000) found that many people in the Solomon Islands reported keeping chloroquine in their homes as self-treatment for malaria, which suggests that people are not finishing their doses when they become ill and hoarding them for future use. These attempts do not fully address the problem, and communities have in some cases abandoned the idea that mosquitoes are to blame. Community members in Ghana reported that they do not believe that mosquitoes cause the disease because they have tried to control the mosquitoes and nevertheless people still fell ill, leading to the belief that they cannot prevent the disease because previous attempts to do so failed (Ahorlu et al., 1999). This reasoning jeopardizes public health programs

because people will not comply if they do not believe in the goals or do not trust the effectiveness of these programs.

Less research on the perception of mosquito-borne disease in developed countries has been conducted because these nations face less of a threat as compared to many developing countries. However, there still appears to be a disconnect in the US about transmission and protection. Anecdotal evidence suggests that many people believe storms bring mosquitoes with them. While there is an increase in mosquitoes after a storm, this is a result of more standing water, not storms bringing mosquitoes with them. However, this connection is not always made. Many also feel that the media plays up the seriousness of the disease for a story (Zielinski-Gutierrez & Hayden, 2006). In Colorado, individuals stated that many people got mosquito bites in the past and never became ill; therefore, it really is not a problem (Zielinski-Gutierrez & Hayden, 2006). While it is understandable that individuals who have spent their whole lives getting bitten while never contracting a disease may feel that the threat is not real, it is important to remember that many of these diseases have been introduced to the United Sates within the last decade. It is important to know if people are aware that new diseases have been introduced to the United States, because in a globalized world, this trend will likely continue.

2.7 Conclusion

This literature suggests that infectious diseases operate over varying scales, ranging from global to the scale of the individual. When discussing human disease, it is important to not only understand disease systems, but also to develop control strategies to reduce the number of cases in a population. It is therefore crucial that public health messages help to educate populations about local health threats. Drawing from frameworks within medical geography, this research will investigate the relationships between human behavior and vectors to understand how to design effective public health programs to ultimately lessen the disease load within populations.

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Chapter 3: Manuscript

Knowledge, Perceptions, and Practices: Mosquito-borne disease transmission in southwest Virginia, USA*

* This chapter is a manuscript in preparation for submission to the journal *Health and Place.*

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Abstract

Mosquito-borne disease can often be prevented at the individual level by taking personal precautions; however, effective preventative action is a result of efficient public health programs that adequately teach the population preventative measures. This study uses the Health Belief Model to examine individual perceptions of mosquito-borne disease in Tazewell and Wise counties in southwest Virginia, USA through the use of surveys. Results suggest that overall knowledge of mosquito-borne disease in the area is low. Additionally, gender, age, and length of time of residence in the county were found to be significant predictors of knowledge, perceived effectiveness of preventative actions, and health seeking behaviors, respectively. The patterns seen within specific groups of the population supports the applicability of the Health Belief Model to examine health issues in a place, including infectious diseases, and aid in tailoring public health programs.

Keywords:
medical geography, disease perception, mosquito-borne disease, Health Belief Model, southwest Virginia

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3.1 Introduction

Over the past decades, Virginia has experienced an increase in mosquito-borne diseases, both in the number of cases and the number of diseases present in the region. One cause of this increase is growth in trade and travel, which have accelerated the movement of vectors and pathogens around the world. Virginia's temperate climate is suitable for many vectors, and thus it is easy for organisms to establish themselves here when introduced. However, the built environment created by individuals and communities in Virginia also plays an important role in disease establishment. Actions taken or avoided by individuals can either encourage or discourage mosquito breeding and the eventual transmission of disease.

This research focuses specifically on the region of southwest Virginia. Despite a higher elevation and a drier, cooler climate, two factors loosely considered to limit mosquito-borne disease transmission, in comparison to coastal Virginia, the region has shown vulnerability to mosquito-borne disease, namely La Crosse encephalitis (LAC) and West Nile virus (WNV). A likely reason for this vulnerability involves the human element of infectious disease transmission. The role of human-mosquito interaction in a place cannot be overlooked. It is this interaction at a very fine scale, which when aggregated over a larger area, produces the disease pattern viewed at a broader scale.

Specifically, there is a link between place-based characteristics, perceptions, and mosquito-borne disease that needs to be examined further to increase the efficiency of public health programs. This need is particularly true in developed nations, as much of the research

done on mosquito-borne disease perception has focused on developing areas. Additionally, increased trade and travel in conjunction with climate variability and change make developed nations more vulnerable to diseases once thought limited to tropical and developing regions.

The Health Belief Model, which is a conceptual model designed to examine and predict personal health behaviors, is used in this study to understand individual perceptions of mosquito-borne disease in local communities. The premise of this research is that controlling mosquito-borne disease is difficult without community involvement. Large-scale mosquito-borne disease eradication campaigns such as the government-run malaria eradication program, which included wetland drainage and over 4,650,000 house sprayings between 1947 and 1949 (CDC,2004), are typically no longer seen in the United States; currently, fogging and area sprayings are generally reserved for emergency situations (CDC, 2008). Additionally, these sprayings are not always the best course of action as there are sizeable concerns related to the impact of insecticides on the safety of other species and the environment (Gaines, 2008). However, mosquito-borne diseases remain a concern in the U.S., and preventative action taken at the community level is most efficient. In order to effectively teach individuals how to protect themselves and reduce the risk of disease transmission, it is first important to understand how community members view mosquito-borne disease. It is then possible to incorporate these beliefs and ideas into a larger plan to control mosquito-borne illnesses. Building on the knowledge of community perceptions allows public health programs to be tailored to work for specific communities. In the context of the Health Belief Model, the research presented here has both basic and applied goals:

Basic goals:

(1) To understand how specific demographic and socioeconomic status (SES) variables relate to mosquito-borne disease perception and prevention.

(2) To investigate fine-scale dynamics of infectious disease ecology through an evaluation of human-mosquito interactions.

Applied goals:

(1) To use these findings to understand how to enhance existing public health programs.

3.2 Background

Previous research demonstrates that communities and individuals around the world approach the control of mosquito-borne illnesses differently. Public health initiatives are often

ineffective in halting the spread of disease without the involvement of the community; however, community involvement requires that individuals are first convinced that it is in their own best interest to control mosquitoes (Gubler, 1989). If they do not believe that the mosquitoes spread disease in their area or that human behaviors play a role in disease transmission, they will likely be very hesitant to change their actions. Consequentially, attempts at controlling the disease will have little impact. Additionally, many individuals feel that disease control is the responsibility of the government and therefore feel that there is either nothing that they can do about mosquito control or that it is not their responsibility to keep their villages and neighborhoods clear of potential mosquito breeding sites (Kumar et al., 2003).

A community-based analysis can show patterns of how knowledge is passed between individuals. An investigation of the SARS outbreak in China found that younger, less educated males were less likely to listen to and adapt safety measures (Leung et al., 2003), suggesting that targeting prevention programs towards the women of the household would be beneficial. The women would perhaps be more likely to take measures to ensure protection within the homes, but would also be able to relay important information to the men in a way that may be more effective than government communication efforts (Leung et al., 2003). Similarly, pilot community education programs in Puerto Rico were successful in increasing knowledge of dengue and preventative behaviors (Winch et al., 2002). The same study also found that these programs were most effective when given to schoolchildren that took the messages home to their families.

In the United States, mosquito control efforts have shifted from insecticide application for mosquito control towards a system of integrated pest management, which incorporates public relations and education (Rose, 2001). Adulticides, which target adult mosquitoes, are typically reserved for instances of extreme flooding, which can cause a drastic increase in the mosquito population (Rose, 2001). Within Virginia, the current focus is on mosquito surveillance and the application of insecticides locally to large pools of mosquitoes if deemed necessary (VDHa, 2005). However, in 1999, large-scale fogging, which cost $500,000, was used in the southeast region of the state through funding from the Federal Emergency Management Agency (FEMA) to control mosquito breeding after large-scale flooding from Hurricane Floyd (FEMA, 2003). It is likely that large sums of money, however, will not be made widely available to control mosquito-borne diseases unless they become much more common.

3.3 Theoretical Approach

This research is grounded in disease ecology and uses the Health Belief Model (HBM) as a theoretical framework. Disease ecology explores the interactions of human populations and behavior with the physical and built environments in the prevention or production of disease (Gesler, 2004, p.294). This study examines the disease ecologies of mosquito-borne diseases in southwest Virginia. Human interactions with mosquitoes in their natural and built environments are investigated through individual behavior via the application of the HBM, which allows for an investigation of differing perceptions of mosquito-borne disease within this region. While originally designed for individual use in psychology, its use has expanded and the HBM is now applied as a tool to aid in the understanding of population perceptions and actions relating to disease. The original model was developed by the Public Health Service in the 1950's to understand why individuals chose not to participate in government-sponsored prevention campaigns (Rosenstock, 1966). The model has since been expanded to incorporate more factors as the health community continues to understand that complex interactions are at play with regards to disease transmission and control (Becker & Maiman, 1975).

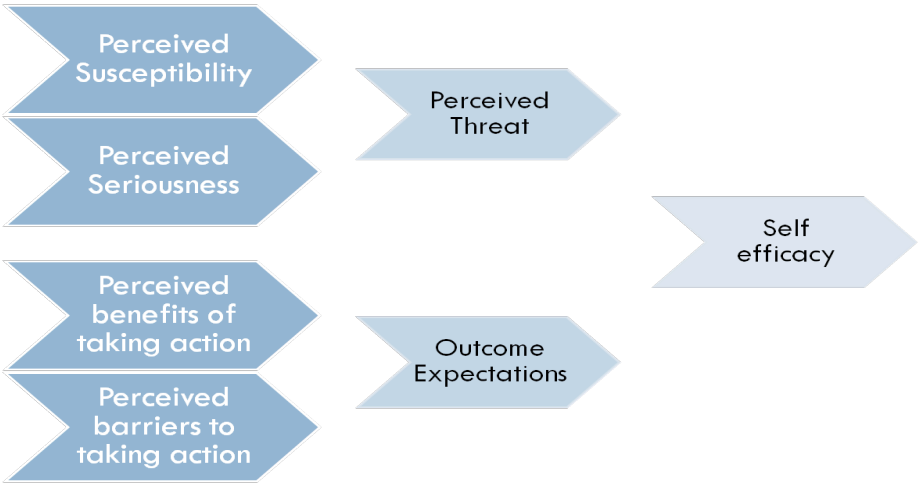

Figure 3.1. The Health Belief Model. Flow diagram of the major predictors
Source: Adapted from http://www.ohprs.ca/hp101/mod4/fig4-1.gif (from Nutbeam and Harris, 1998)

With reference to figure, if individuals feel that they are susceptible to a disease and that the consequences are seriousness, and that any potential barriers of taking action are outweighed by

the potential benefits of taking action, they will ultimately take action to prevent against disease (Rosenstock et al., 1994).

There have been a handful of studies that have specifically applied the Health Belief Model in the United States and Canada to recent outbreaks of mosquito-borne viral encephalitis; these studies have found the model to be a useful tool in highlighting perceptions of risk and barriers to taking actions. The amount of time it takes to clear standing water around the home, as well as the belief that DEET-based mosquito repellents are dangerous to the environment (Aquino et al., 2004) and personal health (Aquino et al., 2004; Herrington, 2003) have been noted as key barriers to taking personal protective action. A Center for Disease Control study (CDC, 2003) found that the younger population (under 65) was more likely than the older population to practice personal protection, despite the elevated risk of WNV to older people. Interestingly, the same study also found that households with lower incomes were more likely to report practicing personal protective barriers around the home. The aforementioned studies suggest that the Health Belief Model is successful in highlighting personal behavior practices. However, these studies were conducted in Connecticut and British Columbia, and the findings may not necessarily be generalizable to the rural Appalachian region of Virginia.

Three general aspects of the HBM have been selected to guide survey development and data analysis in this study. These include (1) the knowledge of mosquito-borne disease in the region, (2) the perceived susceptibility and seriousness to mosquito-borne disease in the area, and (3) the perceived barriers and benefits of following recommended preventative guidelines. Survey questions were selected to fall within these general categories in order to analyze individual perceived responses. Aggregation of these individual responses within the categories allows for the analysis of patterns of responses within the sample population across a broader scale. Therefore, patterns seen within the community related to knowledge or perceptions are examined, rather than simply just evaluating individual knowledge, as it is at this broader scale that public health programs are designed to function. In this way, analyses match the scale of public health programs, which can then be improved based on the results of this study.

3.4 Study Area

This study focused on southwest Virginia, which is denoted as the southern, mountainous portion of the state, and the specific study areas are Wise and Tazewell counties. These counties were chosen because they have seen the greatest mosquito-borne disease activity in southwest Virginia since 2000 (VDHa, 2008) (figure 3.2)

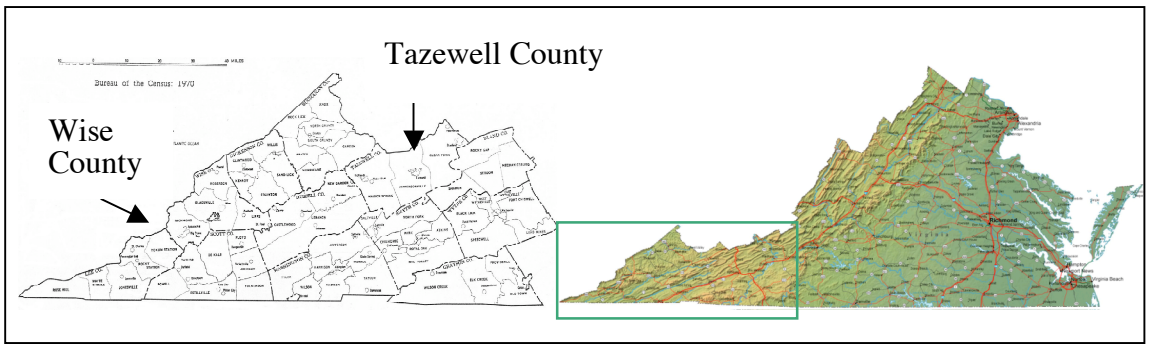

Figure 3.2. Counties selected for inclusion in this study due to past vulnerability to mosquito-borne encephalitis.
State map source: http://www.virginia-map.org/virginia-map.jpg
Regional map source: http://www.newrivernotes.com/gif/vamagisterial1.jpg

The Appalachian Regional Commission (ARC) has designated three unique sub-regions of Appalachia based on homogeneous characteristics of topography, demographics, and economics (ARC, 2003). Both Wise and Tazewell counties fall into the region of central Appalachia. This region is typically denoted as being the most socially and economically depressed region of Appalachia, with the highest regional rates of poverty and unemployment in the country (Wood, 2005). The ARC denotes counties in the Appalachian region as "Distressed Counties" each year if the per capita income is low and rates of poverty and unemployment are high. Wise County was classified as "distressed" during the fiscal years of 2002-2004, while Tazewell County was classified as "transitional." Additionally, poverty rates in both counties are higher and income is lower than the state average (table 3.1).

Table 3.1. Economic situation of Wise and Tazewell Counties compared to the rest of Virginia

	Tazewell County	*Wise County*	*Virginia*
Personal Income			
Per Capital Income, 2002	$22,269	$20,170	$32,793
Unemployment (%)[1]			
Unemployment Rate, 2003	5.3	5.7	4.1
Unemployment Rate, 2002	4.8	5.7	4.1
Unemployment Rate, 2001	4.4	5.5	3.4
Poverty (%)[2]			
Poverty Rate, 2000	15.3	20.2	9.6
Poverty Rate, 1990	19	22.1	10.2
Poverty Rate, 1980	14.3	15.7	11.8
Education			
Percent of Adults with High School Diplomas, 2000	67.5	62.9	81.5
Percent of Adults with College Degrees, 2000	11	11.1	29.5
Economic Status			
Fiscal Year 2006	Transitional	At-Risk	-
Fiscal Year 2005	Transitional	Transitional	-
Fiscal Year 2004	Transitional	Transitional	-
Fiscal Year 2003	Transitional	Distressed	-
Fiscal Year 2002	Transitional	Distressed	

[1]The number of unemployed persons as a percentage of the civilian labor force
[2]The ratio of persons below poverty level to the total number of persons for whom poverty status has been determined

Source: U.S Department of Commerce, Census Bureau, Census of Population and Housing 1980 and 1990 Summary Tape File 3A, and 2000 Summary File 3. Complied by the Appalachian Regional Commission, October 2003.

3.4.1 *Mosquito-borne disease in southwest Virginia*

The geographical situation of Wise and Tazewell counties is conducive for the ecology of LAC and WNV; the combination of the mountainous, wooded region of southwest Virginia with generally rural communities results in human populations being located very close to the natural habitat of vectors and hosts. *Ae. triseriatus,* also referred to as the 'Eastern Treehole mosquito', is present in the region and prefers to feed on woodland mammals. Thus, it is often active in wooded areas, breeding in both natural bodies of standing water (particularly in holes of trees) and in artificial containers (Walker, 1992).

Research indicates that lower socioeconomic status (SES) is correlated with *Ae. albopictus* (Asian Tiger mosquito, or ATM) activity in southeast Virginia, with the socio-economic profile of an ATM-friendly environment including low rent values, low levels of education, and low median income level (Ratigan, 1999). Variables related to low SES, such as a lack of air-conditioning, have also been correlated with increased transmission activity, as exemplified by the dengue fever outbreak spread along the US-Mexico border by *Ae. aegypti* (Reiter et al., 2003) because there is a greater chance of mosquitoes entering the home when

windows are left open during warmer months. Given the generally low socioeconomic situation of the study area, the built environment creates an additional chance for disease transmission in an already suitable physical environment.

In temperate regions, such as southwest Virginia, occurrence of mosquito-borne disease is seasonal. Disease transmission is highest in, and usually limited to, the warmer, summer months as a result of biological constraints on the vector. For example, it has been documented that *Ae. triseriatus* have the highest level of ovipositon activity during the summer months (Loor & DeFoliart, 1970), as the LAC virus over winters in transovarially infected eggs that hatch in the spring (Balfour et al, 1975). As a result, LAC transmission typically occurs during the months of May-October in this region, with case numbers peaking in August (Szumlas et al., 1996). Similar seasonal trends are seen with other forms of mosquito-borne encephalitis as well.

La Crosse encephalitis

La Crosse encephalitis has typically been confined to the mid-western US and southern regions of Appalachia where the vector *Ae. triseratus* resides (Grimstad, 1988). However, as the virus has spread into southwestern Virginia, *Ae. albopictus* has also been identified as a possible competent vector (Cully et al, 1992). Small mammals, such as the eastern chipmunk (*Tamias striatus)* (Gauld et al, 1957) and the grey squirrel (*Sciurius carlinensis)* (Ksiaszek & Yuill, 1977), are believed to serve as host populations for the virus. The continuing emergence of LAC in southwest Virginia is of increasing concern, as West Virginia (which borders this region) is now the foci of LAC in the U.S, accounting for over half of the cases reported nationwide in 1999 (Nasci et al, 2001).

Of the approximated 28 reported LAC cases in Virginia, 16 have been reported from the southwest region of the state. Specifically, there have been 10 cases in Tazewell County, five cases in Wise County, and one case in Dickinson County (VDH, 2008a). Because of this, southwest Virginia is becoming an increase focus of LAC emergence (Barker et al., 2003). A community education seminar was held in 2002 regarding the mosquito-borne disease situation in Wise County (Wise County Board of Supervisors meeting notes, 2002), although results of this study suggest the message was only minimally retained.

One challenge of dealing with LAC, and other types of viral encephalitis, is the correct identification of symptoms. LAC is often misdiagnosed and underreported, as symptoms mimic

those of many other ailments (Hardin et al, 2003). This is not surprising given that it is estimated that there may be 300,000 human LAC cases contracted per year in the United States, yet far fewer are properly diagnosed and reported (Rust et al., 1999).

West Nile virus

West Nile virus first emerged in the United States in 1999 in New York City (Lanciotti et al., 1999). Since then, the virus has spread across the continental United States and has reached the western coast of the country (CDC, 2004). Several species of *Culex* mosquitoes are predominantly responsible for transmitting WNV in Virginia; however, WNV has also been identified in *Ae. albopictus* (VDHa, 2008). The virus is maintained within local bird populations through the bite of infected mosquitoes. Certain species of birds are more susceptible to WNV, particularly crows, which have a 100% mortality rate (Kramer et al., 2005).

Human cases of West Nile virus in southwest Virginia have been limited to Roanoke County, the City of Roanoke, and Bedford County. Pools with mosquitoes actively circulating WNV have been identified in Roanoke and Botetourt counties. However, cases of WNV infection in dead birds have been reported in nearly all counties in southwest Virginia (VDHa, 2008), suggesting that the virus is actively circulating throughout the region. However, as with LAC, it is hard to get an accurate assessment of the disease in this region given that WNV is also often misdiagnosed and underreported. Additionally, due to a lack of health department funds in the region, many health districts stopped testing dead birds for WNV, accepting that the virus is now established in the region (VDH, 2005b). Thus, although there have been more cases of LAC reported in the region, WNV is included in this research because the threat of illness exists for both of these diseases in the region and prevention measures for both LAC and WNV are similar.

3.5 Methods

A questionairre was developed within the framework of the HBM and submitted for approval to the Virginia Tech Institutional Review Board (appexndix B). The document focused on the perceptions and knowledge of mosquito-borne disease, as well as potential barriers to taking preventative action. Individuals were recruited for participation at the county level because this is the level at which the Virginia Department of Health reports mosquito data. Within Wise County, surveys were conducted in the towns of Big Stone Gap and Wise, and in

Tazewell County, surveys were conducted in Bluefield, Tazewell and Richlands. To ensure consistency in sampling, surveys were conducted at each town's main post office, located in the central business area.

All individuals entering the post office were approached and briefed regarding the study and asked if they would like to participte through a process of verbal consent. An initial screening process was then performed to ensure individuals resided in the specific county. Willing and eligible participants were then given a questionnaire consisting of a series of short questions pertaining to mosquito-borne diseases on the following topics framed by the Health Belief Model: knowledge, perceived seriousness/susceptibility, and barriers/benefits of taking action. Demographic data including income, education, age, gender, and length of residence in the county were also collected. The survey instrument (see appendix A) contained a mixture of open-ended and multiple-choice questions and took roughly 5-10 minutes to complete.

Data were collected over a two week period during the last week of July and first week of August in 2008 during peak mosquito season to ensure accounts of preventative behaviors were reported as accurately as possible. Sampling at the post offices was conducted during the morning, lunch, and evening hours, as well on both weekdays and weekends, to ensure that individuals with varying schedules could be included in the sample. A total of 589 individuals were approached, with 191 consenting to participate, yielding a response rate of 32%. The most common reasons given for not participating in the study included needing to meet prior obligations and having family members waiting in the car.

Similar studies have shown success with using phone-based surveys that ask specific questions regarding mosquito-borne disease perceptions and practices (e.g., Herrington, 2003; Aquino et al., 2004); however, surveying from public places ensured that individuals without phones were not excluded. This is an important aspect because lack of a landline phone may be related to specific place-based socioeconomic characteristics important in this study. Additionally, stronger federal rules against calling home phones as well as the increasing use of unpublished cellphone numbers as the main line are considerable barriers to doing surveys over the phone.

Following data collection, data were coded numerically, and each response was assigned a specific numeric value. Knowledge and susceptibility/seriousness scores were calculated by summing the responses to several questions. Knowledge of the presence of disease was assessed

by asking individuals to name any mosquito-borne diseases they were aware of in their area as well as in the state. Total knowledge scores were then calculated for each participant by giving a score of 3 if they stated they were aware of a disease and being able to correctly identify a disease, 2 if they stated they were aware of a disease but failed to correctly identify one, and 1 if they stated they were unaware of diseases spread by mosquitoes (both in the state of Virginia and in the area). The combined state plus area score was then totaled to assign each participant a "knowledge" score. For the local area knowledge score, correct answers included LAC and WNV. For the state knowledge score, correct answers included LAC, WNV, eastern equine encephalitis, St. Louis encephalitis and malaria (which has been locally transmitted in isolated areas in northern Virginia).

Total seriousness/susceptibility scores were calculated by first assigning a numerical value to each possible response to questions 3, 4 and 5 (Table 3.2). The sum of the responses equated to the total percieved seriousness/susceptibility, reflecting the level of concern a participant has about being bitten by a mosquito, contracting a disease if bitten, and feeling a need to seek medical attention.

These values were then entered into a spreadsheet in JMP statistical software. Percentages were calculated for each response on the survey to ascertain a larger view of the opinons within the study area. The use of percentages have been useful in similar studies (e.g., Aquino et al., 2004) because it gives a general overview of how common specific responses were. Multivariate logistic regression analyses were run using JMP statistical software to examine statistically significant predictors of behaviors taken to prevent exposure to mosquitoes. Five predictor variables related to demographic and socioeconomic characteristics (gender, income, education level, age and length of residence in the county) were analyzed for each question to examine the relationships between demographic and SES variables, and knowledge of disease and practice of preventative behaviors. Multivariate regression analyses have been useful in similar past studies because they demonstrate variable interaction (e.g., Herrington, 2003; Aquino, 2004).

Table 3.2. Summary of survey responses used in multivariate analyses: n (%)

Knowledge

1. Are you aware of any diseases spread by mosquitoes in Virginia?	*Yes:* 75 (39.5)	*No:* 115 (60.5)
2. Are you aware of any diseases spread by mosquitoes in your area?	*Yes:* 31 (16.3)	*No:* 159 (83.7)

Perceived Seriousness / Susceptibility

	Very	*Somewhat*	*A Little*	*Not at all*
3. How concerned are you about being bitten by mosquitoes in your community?	51 (27.1)	78 (41.5)	40 (21.3)	19 (10.1)
4. How concerned are you that you will contract a disease if bitten by a mosquito in your community?	41 (21.6)	58 (30.5)	65 (34.2)	26 (13.7)
5. If you contracted a disease from a mosquito bite in your community, how likely do you feel that you would need to seek medical help?	101 (53.7)	41 (21.8)	31 (16.5)	15 (8.0)

Perceived Barriers / Benefits of Taking Action

	Very	*Somewhat*	*A Little*	*Not at all*	*Have not tried this*
Perceived effectiveness of various preventative measures:					
6. Staying indoors	90 (47.9)	52 (27.7)	28 (14.9)	6 (3.2)	12 (6.4)
7. Wearing long pants and sleeves	79 (42.0)	64 (34.0)	32 (17.0)	8 (4.3)	5 (2.7)
8. Removing standing water around the home	142 (75.1)	32 (16.9)	6 (3.2)	4 (2.1)	5 (2.6)
9. Wearing insect repellent	73 (38.6)	81 (42.9)	25 (13.2)	7 (3.7)	3 (1.6

	Strongly agree	*Slightly agree*	*Slightly disagree*	*Strongly disagree*	*Unsure*
10. Agreement: Using an insect repellent will make you sick	8 (4.5)	32 (18.2)	37 (21.0)	53 (30.1)	46 (26.1)
11. Agreement: Using an insect repellent will make children sick	13 (7.5)	33 (19.0)	42 (24.1)	39 (22.4)	47 (27.0)
12. Agreement: Using an insect repellent is harmful to the environment	22 (12.6)	29 (16.7)	42 (24.1)	29 (16.7)	52 (29.9)

	Always	*Sometimes*	*Never*
13. How often do you wear insect repellent when mosquitoes are present outdoors?	29 (17.5)	97 (58.4)	40 (24.1)

14. Do you empty standing water in your yard?	*Yes:* 108 (59.7)	*No:* 73 (40.3)

15. Where would you first seek information on mosquito-borne diseases in your area?	*Television:* 5 (2.8)	*Radio:* 6 (3.4)	*Internet:* 73 (41.0)	*Newspaper:* 9 (5.1)
	Physician: 31 (18.0)	*Flier:* 0 (0)	*Family/Friends:* 5 (2.8)	*Public Health Office:* 24 (13.5

3.6 Results

3.6.1 *Knowledge*

Participants were asked in an open-ended format which diseases they were aware of as being transmitted in both their area and within the state. Only 16.3% of individuals reported being aware of any diseases spread by mosquitoes in their area (defined as their county or bordering counties), while 39.5% said they were aware of diseases spread by mosquitoes within the state of Virginia. Of those stating they were aware of diseases spread within the area, the most common responses were West Nile (6%, n=13), encephalitis (unspecified) (2%, n=4) while one individual stated specifically that La Crosse encephalitis was present. Additionally, four percent (n=8) stated that malaria was locally transmitted. Awareness of diseases present within the state was 14% for West Nile virus, 6% for encephalitis (unspecified), 6% for malaria, and only one individual specifically stated La Crosse encephalitis. Other diseases mentioned as being spread by mosquitoes included AIDS, yellow fever, eastern equine encephalitis, Rocky Mountain spotted fever and Lyme disease.

3.6.2 *Perceived Seriousness and Susceptibility*

Among southwest Virginia residents in the sample, 52.1% reported being concerned with the number of mosquitoes present in their community, while 68.6% said they were somewhat to very concerned about being bitten by mosquitoes. Approximately half (52.1%) reported being somewhat to very concerned that they would contract a disease if bitten, and 75.5% reported that they felt contracting a disease from a mosquito would require seeking medical attention. Finally, 57.6% stated that they felt the same disease would impact their quality of life one year later.

3.6.3 *Barriers and benefits of taking action*

Table 3.2 summarizes the percentages of participants viewing personal protective behaviors as very or somewhat effective. For each behavior (wearing long sleeves, staying indoors, using insect repellent and removing standing water), the majority of individuals felt it was an effective form of protection against mosquitoes. Removing standing water and wearing repellent were viewed as being most effective (somewhat or very). Although the majority of participants (81.5%) felt that insect repellent is effective, only 17.5% reported always wearing it

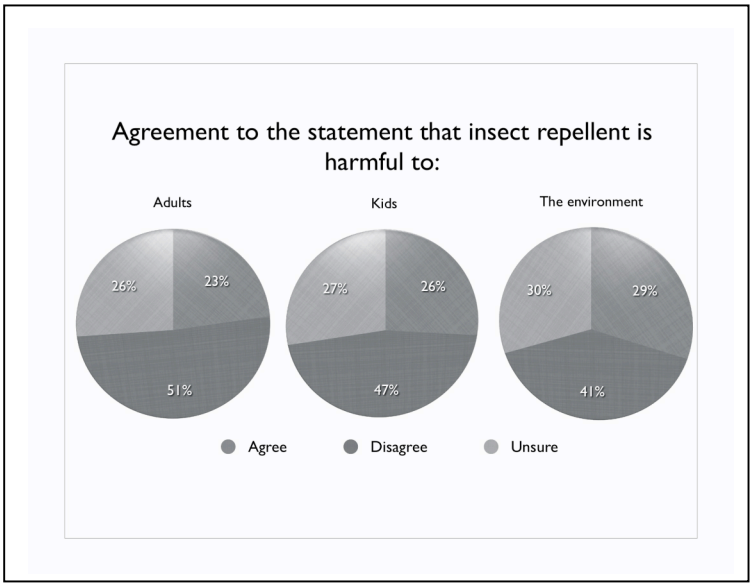

Figure 3.3 Results of perceived danger of insect repellent to adults, children, and the environment

outdoors when mosquitoes are present. Participants were also asked if they agreed with the statement that insect repellent is harmful to adults, children, and the environment (figure 3.3). Roughly half of the sample (51%) disagreed with this statement with regards to adults, while the other half was approximately evenly split stating they either agreed insect repellent is harmful or they were unsure (figure 3.3). Slightly less than half disagreed when asked if they believed insect repellent was dangerous to children (47%) and the environment (41%). Again, the remaining half of the population was approximately evenly split between agreeing with the statement, or being unsure.

3.6.4 *Demographic and SES predictors*

The demographic and socioeconomic profiles of the two counties were relatively similar (table 3.3). Results of the logistic regression analyses demonstrated that two out of the five input variables (age, gender, and residence time in the county) were significant predictors of either knowledge or practices at the 0.05 significance level or better (table 3.2). Age was found to be a significant predictor of perceived effectiveness of personal protective behaviors ($p=0.003$), suggesting that as age as increases, individuals are more likely to think that these measures are effective. Finally, the length of residence time in the county significantly affects information seeking behaviors ($p=0.0033$). The longer someone had been residing in the county, the more likely they were to seek information with physicians or public health offices while the newer one was to the county, the more likely they were to seek information from the internet. When asked what diseases were present in the area, men were significantly more likely to state that they are aware of the mosquito-borne diseases spread and correctly identify the disease ($p=0.0051$). Yet, females are more likely to report being concerned about being bitten by mosquitoes, contracting a mosquito-borne illness, and needing to seek medical attention for treatment of the disease

(p=0.0625). This final result is considered statistically significant at the .10 significance level, but is still reported here as this information may still be of use to public health programs.

Table 3.3. Breakdown of demographic and socioeconomic profiles of survey sample (%) and 2000 Census (%)

Survey Sample*

	Tazewell County	Wise County
Gender		
Male	42.6	40.7
Female	57.4	59.3
Age		
18-24	8.1	9.4
25-34	14.0	17.0
35-44	14.0	11.3
45-54	20.9	30.2
55-59	20.9	7.5
60-64	11.6	9.4
64-74	10.25	13.2
75-84	-	1.9
85+	-	-
Education		
No High School Degree	3.7	4.2
High School Degree	20.7	14.6
Some College	37.8	33.3
College Degree	24.4	41.2
Advanced Degree	13.4	6.3
Income		
Under 10,000	4.1	2.1
10,000 – 14,999	9.5	10.6
15,000 – 24,999	16.2	6.4
25,000 – 34,999	14.9	17.0
35,000 – 49,999	14.9	29.8
50,000 – 74,999	14.9	10.6
75,000 – 99,999	12.2	14.9
100,000 – 149,000	9.5	6.4
150,000 – 199,999	2.7	2.1
Over 200,000	1.4	-
Length of residence		
< 10 years	16.7	12.7
10 - 29 years	24.1	22.8
30 – 49 years	37.0	40.0
> 50 years	22.2	26.6

2000 Census*

	Tazewell County	Wise County
Gender		
Male	36.9	48.7
Female	41.6	51.3
Age		
20 – 24 years	5.7	6.8
25 – 34 years	11.8	13.0
35 – 44 years	15.4	15.0
45 – 54 years	16.2	14.9
55 – 59 years	6.1	5.3
60 - 64 years	5.2	4.6
65 – 74 years	8.6	7.6
75 – 84 years	5.3	4.9
85 + years	1.7	1.5
Education Attainment		
Less than 9th grade	16.7	19.4
9th to 12th, no diploma	15.8	18.0
High school graduate	32.5	29.9
Some college, no degree	17.9	16.6
Associate degree	6.2	5.2
Bachelor's degree	7.3	6.8
Graduate / Professional degree	3.7	4.1
Income		
Less than $10,000	14.5	17.0
$10,000 - $14,999	9.9	11.7
$15,000 - $24,999	20.7	19.4
$25,000 - $34,999	16.4	14.1
$35,000 - $49,999	16.8	16.3
$50,000 - $74,999	12.9	13.6
$75,000 - $99,999	4.6	4.6
$100,000 - $149,999	2.7	1.8
$150,000 - $199,999	0.7	0.6
$200,000 or more	0.8	0.9

*Note that the survey population % does not include those who did not answer the question. The Census % given is out of the entire population

Source: U.S. Census Bureau, Census Summary File 3

3.7 **Discussion**

3.7.1 *Knowledge*

The findings suggest that there are generally low levels of awareness of mosquito-borne disease in the study region. Higher awareness of diseases present in other regions of the state suggests that there is a disconnect between the actual local threat level and the perceieved level within the population. Although West Nile is present and active in Wise and Tazewell county mosquito and bird populations, there have been no reported human cases of the disease. Yet, West Nile was the most commonly reported disease by individuals when asked what diseases they are aware of in their area. However, Wise County was noted to be a "hot spot" for La Crosse activity earlier in the decade, and historical records show that town meetings were held to inform the public of the disease. Similarly, Tazewell County borders the foci region of La Crosse encephalitis in West Virginia, yet only one out of 191 participants was able to specifically name La Crosse enephalitis as a disease present in the area. It is not possible to determine if the participants who stated generally "encephalitis" meant La Crosse encephalitis or another form (including West Nile encephalitis); however, even the numbers of those stating general enecephalitis were lower than those specifying West Nile. Similarly, malaria was reported at similar levels as unspecified encephalitis despite the fact that the reported cases have been contained to areas around Dulles airport in northern Virginia and linked to travel.

Gender was the only variable that was significantly predictive of knowledge. Although men and women were equally likely to be aware of mosquito-borne diseases in their area and in the state, men were more likely to correctly identify the specific diseases. Results of previous studies suggest that there is a correlation between income/education and knowledge; however, neither of these were found to be significant predictors of knowledge in the study area. The results of this portion of the study suggest that knowledge of mosquito-borne disease is low in these regions. Therefore, it is of critical importance for local health departments to raise awareness of the threat, as the Health Belief Model demonstrates that awareness of a threat is a critical input to following through with recommended actions.

3.7.2 *Perceived Seriousness and Susceptibility*

Women were significantly more likely than men to report being concerned about being bitten by mosquitoes and contracting a disease if bitten. They were also more likely to feel that a disease contracted by a mosquito would require medical attention. Therefore, it is important to ensure that men are also educated about the potential threat of mosquito-borne disease to both themselves and their children.

3.7.3 *Barriers and benefits of taking action*

The removal of standing water was perceieved to be the most effective form of preventing mosquito bites, yet only 40% of individuals reported actually emptying standing water around their homes. The two most frequent reasons cited for not emptying water was that standing water did not collect around the home and that it was time-consuming. This is an important barrier, particularly because mosquitoes require only a small amount of water for oviposition, and there are likely potential breeding sites around all homes. However, if the perception is that standing water does not collect, people will not take action to clear potential breeding sites nor take additional protective measures when outdoors around the home. Again this ties back to knowledge of disease threat and perceieved susceptibility and seriousness of the problem. If people are not aware of mosquito-borne diseases or not concerned about their potential threat, the hassle of removing standing water will outweigh any percieved potential benefits.

The vast majority of participants (81.1%) reported that using insect repellent was somewhat to very effective in protecting against mosquito bites. However, only 17% of participants said they always use it outdoors when mosquitoes are present. A barrier to using insect repellent appears to be the perception of its danger. Thus, it appears that the safety of insect repellent should be stressed in local public health campaigns, rather than simply outlining its effectiveness for preventing bites.

3.7.4 *Information seeking behavior*

The length of time one has lived in the county appears to be an important indicator of information-seeking behavior, likely linked to the establishment of personal relationships with doctors and public health officials; those residing in the county longer reported seeking information through these sources, whereas those newer to the area reported seeking information

on the Internet.

Given that many participants stated that they would seek this information on the Internet, and the ease of finding information via this medium, this would be a beneficial avenue for local authorities to consider utilizing to inform the public of these threats. The Wise County homepage does mention mosquito-borne disease generally, but makes no mention of specific threats in the region, and provides links to the Virginia Department of Health webpage. The Tazewell County homepage makes no mention of mosquito-borne disease threats. It would be useful, and require very little effort on the part of the counties, to include more detailed information on the county webpages so residents are made aware of the threats that exist. Simply linking to the Virginia Department of Health webpage, which then requires users to navigate through to find specific regional threats, likely deters many individuals from following through to the correct information. It would be more effective to have the local threats presented on a local webpage.

3.8 Limitations of Study

Limitations of this study are generally related to the use of the survey as a data collection tool. Because individuals may attempt to provide the perceived "correct answer" to please the researcher, it is possible that there was bias introduced. Additionally, there may be recall and reporting biases on the part of participants when identifying their personal behaviors. Not all individuals were comfortable revealing their true income status, choosing rather to select the "prefer not to answer" option. This presented challenges when attempting to examine correlations present in other studies with income level and may partially explain why the expected correlations were not found. Finally, as the survey pertained to health-sensitive issues, participants may have felt hesitant to admit if they were not taking precautions they felt they should be. These issues are inherent to this type of research, however, and the assurance of confidentiality was used to attempt to minimize this effect. Although the survey underwent several rounds of editing, and was reviewed closely for content validity, a full pilot study was not possible due to time and financial constraints. The use of a pilot study may have also helped address some of the issues related to bias issues discussed above. Additionally, although post offices were chosen in an attempt to obtain a representative sample, it is possible that certain segments of the population frequent post offices more or less, which may have skewed results.

Further investigation is still necessary to understand place-based approaches to health,

and how they can be used to enhance local public health programs. The role of income and education with regards to mosquito-borne disease is an area that should continue to be investigated. It would be particularly useful to understand finer mechanisms of the stratification of knowledge with relation to income and education. Finally, as it appears that the push for LAC awareness in Wise County in 2002 has left little lasting impressions on the population, it would be important for public health officials to know if there is a temporal factor related to how long public health messages may be retained in a community.

3.9 Conclusion

Although La Crosse encephalitis and West Nile virus may not appear to pose imminent threats to the counties of Wise and Tazewell, they are a cause for concern. Given the issues of mis- and under-reporting with these diseases and the increasing number of cases in bordering West Virginia, it is not unreasonable to expect that the true number of cases is higher than they appear and may continue to increase. This makes the actual threat higher than it may initially appear. Additionally, taking action regularly to control mosquitoes will likely help to stifle potential future outbreaks. With financial resources of local public health departments strapped, individual action to protect against mosquitoes is not only most efficient, but also cost-effective. Based on the results of this study, it appears that at least in Wise county, past methods of raising awareness of La Crosse encephalitis through town seminars were not effective long-term.

Within the framework of the Health Belief Model, public health campaigns in the study region can be strengthened by raising awareness of mosquito-borne disease present in the area, by understanding what the general population feels are hinderances to following suggested guidelines, and what preventative methods are generally accepted. Because women reported being most concerned with the disease, programs can potentially be designed to effectively target men to minimize the gender gap. Additionally, campaigns can be specifically tailored to focus on the two largest barriers to taking action: removing standing water and the percieved danger of insect repellent. With regards to removing standing water, specifically mentioning that it can collect in very small containers is important, given that many individuals stated that standing water does not collect in their yards. Insect repellant is also a simple and affordable way to prevent against mosquito bites, yet roughly half of those surveyed felt it was unsafe to use or were unsure. This is another issue that can be specifically addressed by public health campaigns

to clear up misconceptions about the product.

The results of this research extend beyond southwest Virginia. Various socioeconomic variables were predictive of specific perceptions or behaviors, demonstrating that this place-based approach can be used to target certain demographic groups or to adjust health campaigns as necessary. These results can also help public health programs in strained financial economic times because they emphasize individual preventative action around the homes rather than emergency reactionary plants that would ultimately fall on shoulders of local and state governments. Although it is not feasible to do a study such as this before the development of each campaign, this research adds to the body of literature suggesting how perceptions and practices vary within a group of individuals and is of use to public health officials dealing with both mosquito-borne and other types of diseases.

3.10 Acknowledgements

This research was funded by the Sidman P. Poole Scholarship through the Department of Geography at Virginia Tech and the Graduate Research and Development Program through the Virginia Tech Graduate School. Statistical assistance was obtained through the Laboratory for Interdisciplinary Statistical Analysis (LISA) at Virginia Tech.

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Appendix A: Survey Document

This survey is being conducted as part of Masters degree requirement for the Geography Department at Virginia Tech. We want to know if mosquitoes are a problem in your area, and your insight is very valuable to us. All answers will be kept confidential. You are free to stop the survey at anytime. Thank you for your participation!

The following questions will be used to help classify your answers and will not be traced back to you.

A. Gender: **MALE FEMALE**

B. Age: **[18-24] [25-34] [35-44] [45-54] [55-59] [60-64] [64-74] [75-84] [85 years and older]**

C. Education: **[No HS degree] [HS degree or equivalent] [Some college] [College degree] [Advanced degree]**

D. Household income (combined income of all members living in your home):
[under 10,000] [10,000-14,999] [15,000-24,999] [25,000-34,999] [35,000-49,999] [50,000-74,999] [75,000-99,999] [100,000-149,000] [150,000-199,999] [over 200,000] [Prefer not to answer]

E. County of Residence: _____

Please circle the answer that best describes your response to each of the questions below:

1. Are you concerned with the number of mosquitoes in your community? **YES NO**

2. Are you aware of any diseases spread by mosquitoes in Virginia? **YES NO**
   2a. If YES, please list: _____

3. Are you aware of any diseases spread by mosquitoes in your area (county or bordering counties)? **YES NO**
   3a. If YES, please list: _____

4. Do mosquitoes in your area bite during (circle all that apply): **Morning Afternoon Evening Night**

5. How concerned are you are you about being bitten by mosquitoes in your community?
   Very Somewhat A Little Not at all

6. How concerned are you that you will contract a disease if bitten by a mosquito in your community?
   Very Somewhat A little Not at all

7. If you contracted a disease from a mosquito bite in your community, how likely do you feel that you would need to seek medical attention? **Very Somewhat A Little Not at all**

8. If you or a family member were to locally contract a disease from a mosquito bite, do you feel it would have a negative impact on your quality of life in the present? **YES NO**

9. Do you feel that the same disease would negatively impact on your quality of life one year later? **YES NO**

10. What age group(s) in your area do you feel is/are most at risk for contracting a disease spread by mosquitoes? (circle all that apply)
    6 years & younger 7-18 years 19-49 years +50 years No age difference Other_____

11. How effective is staying indoors when mosquitoes are most active in avoiding mosquito bites?
    Very Somewhat A little Not at all

12. How effective is wearing long pants and sleeves in protecting against mosquito bites?
    Very Somewhat A little Not at all

13. How effective is removing standing water around your home in eliminating mosquitoes?
    Very Somewhat A Little Not at All

14. How effective is using an insect repellent in protecting against mosquito bites?
    Very Somewhat A Little Not at all

15. How often do you use insect repellent when outdoors? **Always** **Sometimes** **Never**

15a. If **YOU DO**, does it contain DEET? **YES** **NO** **UNSURE**

16b. When you use insect repellent, do you use it on your skin? **YES** **NO**

16c. When you use insect repellent, do you use it on your clothes? **YES** **NO**

15b. If **YOU DO NOT**, please list reasons why you do not use insect repellent: _____

_____

_____

For the following three statements, please circle the answer that most represents your opinion
(Strongly agree=5, slightly agree=4, slightly disagree=3, strongly disagree=2, unsure=0)

16. Using an insect repellent will make you sick; **5 4 3 2 0**

17. Using an insect repellent will make children sick; **5 4 3 2 0**

18. Using an insect repellent is harmful to the environment; **5 4 3 2 0**

19. Do you ever have your windows open during the summer months? **YES** **NO**

19a. Does your home have air-conditioning? **YES** **NO**

19b. Do your windows have screens? **YES** **NO**

19c. If yes, do you have any screens with holes or tears in them? **YES** **NO** **UNSURE**

20. Do you empty standing water in your yard? **YES** **NO**

20a. IF **YES**;

19a. How frequently? _____

_____

19b. From what objects do you empty water? _____

_____

20b. IF **NO** - why you do not remove standing water? (circle all that apply)

1. Removing standing water is time consuming
2. Standing water does not collect in my yard
3. The water in my yard is a natural body (lake, pond, stream, etc)
4. Removing standing water does not reduce mosquitoes
5. Please list other reasons why you may not clear standing water

_____

_____

21. If applicable, please list any other actions or products you use to keep mosquitoes away:

_____

_____

22. Who do you think should be responsible for controlling mosquitoes around homes?

The homeowner **The government** **Both** **Other**_____

23. Where have you received information on diseases spread by mosquitoes in your area? (circle all that apply)

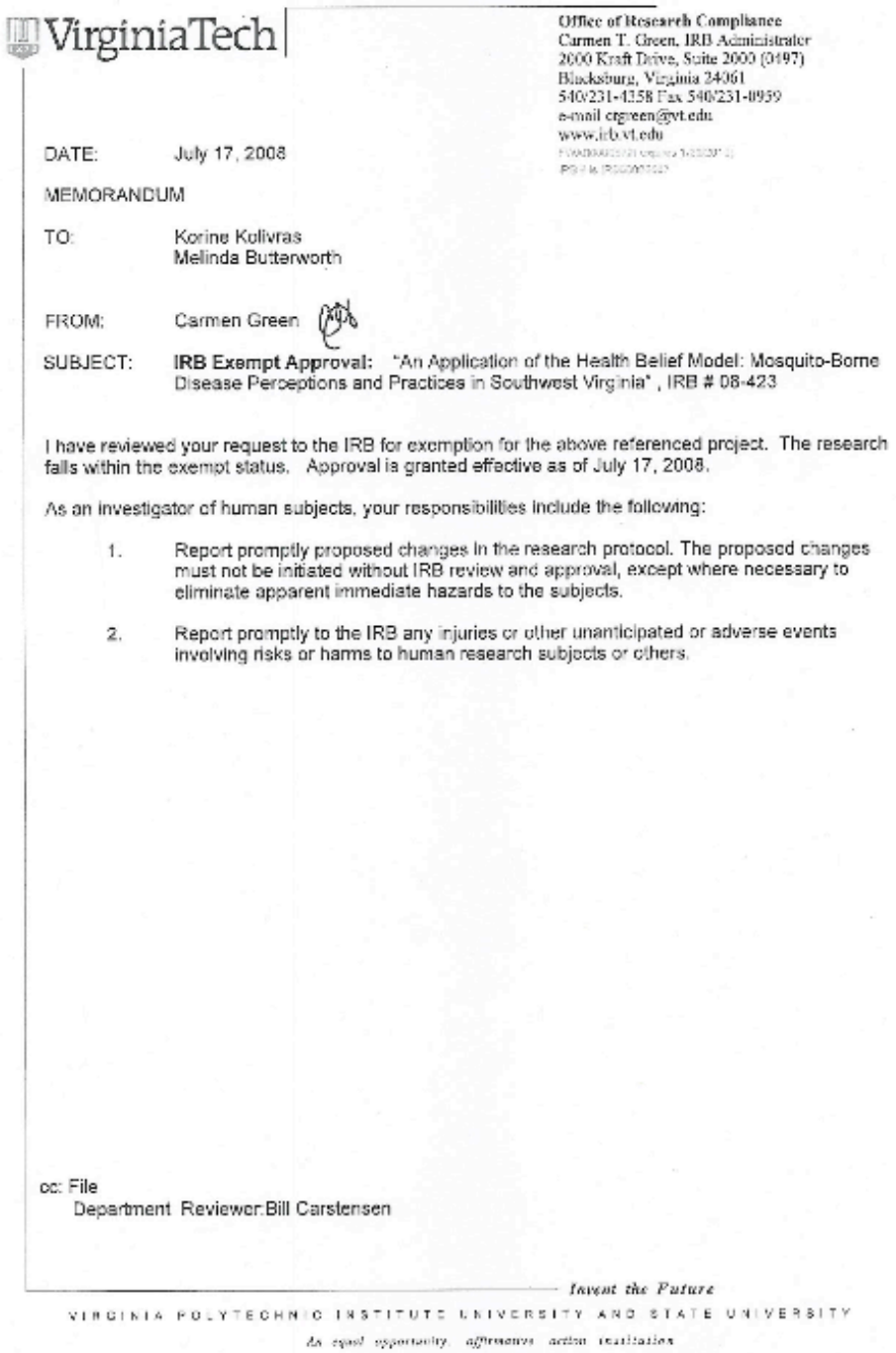
Never received information	Radio	Internet
Newspaper	Public health office	Fliers or posters
Physician	Family/friends	Television
Other_____		

24. If you were interested in information on diseases spread by mosquitoes and what protective actions to take, where would you **FIRST** seek this information? (circle only one)

Television	Radio	Internet
Newspaper	Public health office	Fliers or posters
Physician	Family/friends	
Other_____		

THANK YOU AGAIN FOR YOUR PARTICIPATION!

Appendix B: IRB Approval Form



VirginiaTech

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e-mail ctgreen@vt.edu
www.irb.vt.edu

DATE: July 17, 2008

MEMORANDUM

TO: Korine Kolivras
Melinda Butterworth

FROM: Carmen Green

SUBJECT: **IRB Exempt Approval:** "An Application of the Health Belief Model: Mosquito-Borne Disease Perceptions and Practices in Southwest Virginia" , IRB # 08-423

I have reviewed your request to the IRB for exemption for the above referenced project. The research falls within the exempt status. Approval is granted effective as of July 17, 2008.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in the research protocol. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File
Department Reviewer:Bill Carstensen

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