

FISH EATING BEHAVIOR AND STAGES OF CHANGE  
IN RURAL, LOW INCOME, WOMEN OF CHILDBEARING AGE

by

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## ABSTRACT

Methyl Mercury (MeHg) is a known neurotoxin associated with poor neurodevelopmental outcomes in children. The primary route of exposure of MeHg in humans is from consumption of contaminated fish. Although some disparities in exposure patterns have been identified, little is known about rural, low income, women of childbearing age and their fish eating behaviors. The purpose of this study was to examine the relationship between stages of behavioral change in fish eating behavior and self-reported consumption of fish among 106 rural low-income women of childbearing age.

Results of the one-way ANOVA do not show a statistically significant difference in fish consumption within the sample based on stage of change. However, many of the participants of this study may be at risk for significant exposures to MeHg based on total fish consumption regardless of their decision to limit fish consumption. Further investigation is needed to determine types and sources of fish being consumed and fully understand exposure risks. Once risks are established, opportunities for prevention can be utilized to reduce impacts from MeHg exposures.

CHAPTER ONE  
INTRODUCTION TO THE STUDY

Introduction

Human exposures to chemicals, pesticides, and pollutants have been linked to significant global morbidity and mortality. Anthropogenic compounds such as lead, polychlorinated Biphenyls (PCBs), polyvinyl chloride (PVCs), arsenic, dioxin, mercury, and dichlorodiphenyltrichloroethane (DDT) have been implicated in emerging patterns of disease for both humans and animals. Trends in health outcomes on a population level are often delayed until the distribution of dangerous compounds makes true prevention difficult for clinicians and policy makers alike. Those compounds implicated in offenses to child/fetal growth and development are particularly troubling as the window for true prevention is attenuated. “The developing brain is extraordinarily sensitive to toxic chemicals. Exposure levels that have no lasting effect on an adult’s brain can have dramatic effects on the developing brain before birth or during childhood” (Brody, 2005, p. 46).

As science begins to determine the scope of exposure patterns to dangerous chemicals among children and pregnant women, describing opportunities for prevention is a primary task. One emerging concern is the exposure of developing fetuses to methyl mercury (MeHg) where a growing body of evidence has demonstrated not only irreversible health effects to children’s neurological development but also succinct ways to avoid exposure through changes in dietary behaviors as the primary route of exposure to humans.

Exposure to MeHg, primarily in women of childbearing age creates a significant problem because of the potential toxic effects the substance can cause to a developing fetus or child. MeHg is able to cross the placenta as well as the blood-brain barrier and concentrate in the central nervous system (Goldman & Shannon, 2001; Mozaffarian & Rimm, 2006; Trasande, Landrigan, & Schechter, 2005). The adverse effects of this exposure have been linked to decreased neurological and cognitive development leading to decreased IQ, language and memory problems, concentration difficulties, birth defects and disabilities (i.e. cerebral palsy), seizures, kidney disorders, and possible reproductive disorders (Burak & Costello, 2006; Centers for Disease Control and Prevention., 2004.; Cohen, Bellinger, Connor et al., 2005; Jarup, 2003; McDowell et al., 2004; Trasande et al., 2005). MeHg is considered a known neurotoxin with the potential for adverse effects on the central nervous system with varying symptoms including “sensory disturbance, followed by visual field constriction, ataxia, cognitive decline, and death” (Davidson, Myers, & Weiss, 2004, p. 1023),

Some research studies have shown that there are significant numbers of women of childbearing age whose MeHg exposure exceeds the United States Environmental Exposure Agency (USEPA) reference dose. This results in increasing numbers of newborns that have been exposed to MeHg in utero, some resulting in neurological problems as a child. (Anderson et al., 2004; Mahaffey, Clickner, & Bodurow, 2004).

Economic costs of MeHg exposure parallel other environmental exposures such as lead and PCB's. Using an economic forecasting model, Trasande et al. (2005) were able to demonstrate that exposure to MeHg results in significant costs to American society as it is “associated with lower wages and diminished lifetime earning power” (p. 592). According to their calculation model, the loss of lifetime economic power costs the

United States (U.S.) approximately \$8.7 billion (all costs in 2000 US\$) annually. The exposure to MeHg specifically due to emissions of coal-fired power plants in America was found to cost between \$0.1 - \$6.5 billion per year, also associated with loss of lifetime economic power. MeHg exposure will continue to be a prevalent environmental toxin unless there is some regulation on the use of available technologies to reduce mercury emissions.

Exposure patterns and detrimental effects of MeHg exposure have been identified for some groups but little is known about potential differential risk among rural populations. People who live near mining or smelting operations, coal-fired power plants, or in agricultural areas have greater potential to be exposed to a variety of pollutants and chemicals. Those who reside in rural areas may be at greatest risk of exposure due to the nature of their work such as agricultural and food productions, which include working with manure, pesticides and other chemicals (Phillips & McLeroy, 2004). Rural dwellers face other health disparities including access to care, lack of availability of health care workers, distance, transportation and access to health insurance (Galambos, 2005; Phillips & McLeroy, 2004). According to the National Center for Health Statistics, rural counties have higher death rates from unintentional injuries, higher rates of motor-vehicle accidents, higher suicide rates, greater infant mortality rates, fewer dental care visits, and fewer people have health insurance (Galambos, 2005). Educational and socioeconomic characteristics of the rural population play a large role in relationship to a variety of lifestyle characteristics such as smoking and obesity (Phillips & McLeroy, 2004), but how these factors relate to exposure of MeHg is unknown.

Because of more limited access to healthcare, Family Nurse Practitioners may represent an important resource to address environmental disparities. Family Nurse

Practitioners (FNPs) play an important role in improving the health of rural, low income, women of childbearing age through screening, educating and promoting healthy behaviors. The American Association of Colleges of Nursing (AACN) (as cited in Tracy, 2009) discussed the use of evidence as a guide to practice in which the FNP should be able to “synthesize, analyze, and apply pertinent data to care for populations and individuals” (p. 140). By using research-based practice, the FNP must first review and evaluate the current science, then translate the information into useful clinical guidelines, and finally implement the recommendations into current practice (Tracy, 2009). Both national and state entities have devised dietary recommendations specifically for women of childbearing age and fish consumption due to the potential risks of MeHg exposure. Based on these recommendations the FNP is able to determine what types and amounts of fish should be avoided, limited or encouraged to consume by women of childbearing age. This awareness will assist the FNP in facilitating appropriate interventions by promoting safe and healthy diets which include fish consumption. In turn, this will help ensure women of childbearing age will be knowledgeable about their potential risk to MeHg exposure as well as the benefits of including fish in their diets to further promote healthy lifestyles.

#### Purpose

There is growing concern for the safety of consuming fish not only in the U. S. but throughout the world. This is primarily due to the exposure of MeHg from ingesting contaminated fish. The purpose of this paper is to examine the relationship between stages of behavioral change in fish eating behavior and actions taken to avoid risk among

a sample of rural low income women. The following discussion will examine these findings in the context of risk reduction activities and advanced practice nursing.

## CHAPTER TWO

### LITERATURE REVIEW

#### Introduction

The purpose of this paper is to examine the relationship between stages of behavioral change in fish eating behavior and actions taken to avoid risk among a sample of rural low income women. A review of literature was conducted over the time frame of October 2007 to October 2008. Montana State University's library search portal was used to access search engines CINAHL, Medline, PubMed, and *JournaList* to obtain free/full text articles. Montana State University's Interlibrary Loan program was utilized to obtain copies of articles from journals not accessible online. Google search engine was also used more specifically to locate state and federal fish advisories and websites. Specific search terms that were used included "fish", "fish advisories", "fish consumption", "methyl mercury", "methyl mercury exposure", "methyl mercury risk", "environmental exposure", "women of childbearing age", "rural", "low income", "vulnerable population", "behavior changes", "dietary changes", "diet" "stages of change", "change theory", "Prochaska", and "transtheoretical model". While each individual search term was either too broad or too narrow to be used alone, the combination of terms yielded useful information.

Mercury (Hg) is a type of heavy metal which is considered a neurotoxin and a global pollutant (Booth & Zeller, 2005; McDowell et al., 2004; Zhang & Wong, 2007). The Agency for Toxic Substances and Disease Registry (ATSDR) ranks mercury as third out of 275 hazardous substances (arsenic and lead are first and second) requiring priority

attention (2007). The main sources of Hg emissions include anthropogenic and natural sources (Goldman & Shannon, 2001; Srogi, 2007; Zhang & Wong, 2007).

### Sources of Mercury

Anthropogenic (human related) sources of mercury include coal-fired electric power plants, gold mining, zinc, lead, and copper smelting, institutional boilers, chlorine production, fossil fuel combustion, agricultural materials, municipal solid waste, and medical waste incineration (Davidson et al., 2004; Goldman & Shannon, 2001; Mozaffarian & Rimm, 2006; Zhang & Wong, 2007). Items containing mercury include button batteries, switch plates in electrical appliances, thermostatic controls, mercury vapor lamps, fluorescent lighting, detergents, photographic chemicals, neon colored lamps, thermometers, barometers, thermostat probes, medical equipment such as sphygmomanometers, and dental amalgams (Goldman & Shannon, 2001; Jarup, 2003; Montana Department of Public Health and Human Services. Communicable Disease Control & Prevention Bureau. Food & Consumer Safety Section, 2005). Natural sources of Hg are found within the earth's crust such as ore (cinnabar) and are released into the environment from erosion, volcanic activity, and mining operations (Davidson et al., 2004; Goldman & Shannon, 2001; Srogi, 2007).

People have used mercury throughout human history. Because of its red color, mercury has been found in prehistoric cave drawings and in Egyptian tombs, and the Chinese used it to prepare ink over 3000 years ago. In ancient Greece, mercury was used as a cosmetic to lighten skin color (Clarkson & Magos, 2006; Jarup, 2003). More

recently, Hispanic women have been found to use a cosmetic cream that contains calomel, or mercurous chloride, which can produce mercury intoxication (Davidson et al., 2004). Some forms of Hg are used in certain cultural traditions or ceremonies, such as Sanataria, Voodoo, and Espiritismo, where mercury is sprinkled on the floor, worn in amulets, or added to candles or lamps (Clarkson & Magos, 2006; Davidson et al., 2004; Goldman & Shannon, 2001). The Hg is thought to have magical properties such as to attract luck, love, or wealth, or used to speed up the action of spells (Goldman & Shannon, 2001). Mercury has been used medically as a cure for syphilis, for gastrointestinal disorders, and for its diuretic properties (Davidson et al., 2004; Jarup, 2003).

### Types of Mercury

Mercury can found in three different forms: metallic (elemental) mercury, inorganic mercury, or organic mercury. The effects and exposure outcomes differ by the type of mercury involved.

#### Elemental Mercury

Also known as metallic mercury, mercury vapor, or *Quicksilver*, elemental mercury is a silvery, liquid metal that vaporizes at room temperature (Davidson et al., 2004; Goldman & Shannon, 2001; Srogi, 2007). The inhalation of this vapor poses health threats as it is readily absorbed by the lungs. Exposure to mercury vapor can occur from breakage of thermometers, during industrial processes such as extracting gold from ore,

or from cultural or traditional uses as mentioned above (Davidson et al., 2004; Goldman & Shannon, ; Srogi, 2007). Once exposed, the vapor travels from the pulmonary alveolar membranes into the blood system, also affecting the kidneys and central nervous system (CNS). The vapor is highly diffusible and lipid soluble thus allowing it to cross the blood-brain barriers and also the placenta (Clarkson & Magos, 2006). Immediate effects of exposure to mercury vapor may include dyspnea, paroxysmal cough, chest pain, pulmonary infiltration, nausea, vomiting and chills (Clarkson & Magos, 2006). Acute necrotizing bronchitis and pneumonitis, or death from respiratory failure is the result of inhalation of high concentrations of mercury vapor (Goldman & Shannon, 2001; Zhang & Wong, 2007).

In 17<sup>th</sup> century England, a concoction containing mercuric nitrate was used to treat the fur used for felt hats. Industrial exposure to mercury from hat making led to the origination of phrases such as '*mad as a hatter*' or '*hatter shakes*'. The behavior of the character the "Mad Hatter" from *Alice in Wonderland*, exemplifies of how the CNS may be affected from long term exposure to liquid mercury (Clarkson & Magos, 2006). CNS symptoms from continued exposure to elemental mercury may include insomnia, forgetfulness, loss of appetite, mild to progressive tremor, increased salivation, excessive sweating, and hemoconcentration, as well as erethism, which includes labile emotions, memory impairment, and redness of the palms (Clarkson & Magos, ; Goldman & Shannon). Because the mercury can also accumulate in the kidneys, renal toxicity, proteinuria, or nephritic syndrome may be noted (Clarkson & Magos, ; Goldman &

Shannon). The half-life of elemental mercury in adults is 60 days with a range of 35-90 days and is primarily excreted via fecal matter (Goldman & Shannon).

Elemental mercury is also found in dental amalgams which have recently raised concerns for mercury exposure. There is conflicting evidence at this time whether the dental amalgam exposes an individual to high enough levels of mercury to warrant replacing them (Clarkson & Magos, 2006; Davidson et al., 2004; Goldman & Shannon, 2001; Jarup, 2003).

### Inorganic Mercury

Inorganic mercury or mercury salts have been banned in the U.S. and continue to be used in other countries for their antibacterial, antiseptic, cathartic, and diuretic properties. This form of mercury is water soluble (Clarkson & Magos, 2006) and must combine with other elements such as chlorine, sulfur, or oxygen to form the salt or powder compound (Centers for Disease Control and Prevention., 2007). Calomel (mercurous chloride) and mercuric oxide can be found in teething powders and some cosmetic skin creams, which if ingested, can be fatal. Once ingested, ulceration and hemorrhage rapidly occur within the gastrointestinal system leading to rapid and toxic absorption of the mercury in the kidneys causing acute tubular necrosis or nephritic syndrome (Clarkson & Magos, ; Goldman & Shannon, 2001). Infants and children exposed to mercury salts can develop Acrodynia or '*pink disease*'. Symptoms may include profuse sweating, red, swollen, desquamating, painful feet and hands, maculopapular rash on the extremities, progressive weight loss, weakness, insomnia and

photophobia, peripheral nephropathy, hypertension, and renal tubular dysfunction (Clarkson & Magos, ; Goldman & Shannon). The half life of inorganic mercury is approximately 40 days and is excreted primarily via fecal matter (Goldman & Shannon, 2001).

### Organic Mercury

There are three forms of organic mercury; phenyl mercury, ethyl mercury, and methyl mercury. In order for mercury to be 'organic' the mercury must combine with carbon (Centers for Disease Control and Prevention., 2007). All three compounds have been formed from industrial products, for antiseptic, biocide, or fungicide properties (Clarkson & Strain, 2003; Goldman & Shannon, 2001).

Phenyl Mercury: A type of organic mercury, phenyl mercury was used in the U.S. in latex paint as a preservative and pesticide. While this compound helped to prevent mildew growth on painted walls as well as maintain color it is no longer used in paint products in the U.S. (Goldman & Shannon, 2001).

Ethyl Mercury: A more familiar name associated with ethyl mercury is thimerosal, which is a preservative, used in killed vaccines such as diphtheria and tetanus toxoids, acellular pertussis, *Haemophilus influenza* type b, hepatitis B, meningococcal, pneumococcal, rabies, and influenza vaccines. Each vaccine contained 12.5-25.0 µg/dose of organic mercury (thimerosal). By following the recommended childhood immunization schedule, infants could receive numerous vaccinations at each visit thus

resulting in exposure to mercury compounds above the federal guidelines of 0.1 to 0.4  $\mu\text{g}/\text{kg}/\text{d}$ . In 1999, the American Academy of Pediatrics, the Advisory Committee on Immunization Practice, the American Academy of Family Physicians, and the U.S. Public Health Service issued a precautionary statement recommending the removal of thimerosal from all childhood vaccines due to potential risks and increased exposure to mercury compounds. Thimerosal has since been removed from most childhood vaccines and is found in trace amounts in some immunizations such as some forms of influenza vaccines (Davidson et al., 2004; Goldman & Shannon, 2001; U.S. Food and Drug Administration, 2009).

Methyl Mercury: One of the first documented exposures to MeHg occurred in the 1860's in London where two chemists were exposed in their laboratory. Both individuals experienced rapid, detrimental neurological symptoms including numbness of hands and feet, dysarthria, loss of vision and hearing, and ultimately resulted in death (Clarkson & Magos, 2006). There are two more well documented individual MeHg exposures in the 20<sup>th</sup> century. The most recent exposure occurred in 1997 in a chemistry lab on Dartmouth College campus in New Hampshire. A chemistry professor was inadvertently exposed to form of MeHg during a procedure. Interestingly, she did not present with symptoms until almost five months after her exposure. A rapid, neurological deterioration occurred including difficulty with speech, ambulation, and auditory and vision changes. Approximately six months after her exposure, she became unresponsive to all forms of stimulus and died several months later (Clarkson & Magos, 2006). These individual

exposure examples have shown that even single exposures to MeHg primarily affect the CNS and can be fatal.

Entire populations can also be exposed to and affected by MeHg. Two substantial MeHg poisoning incidents occurred in Japan and Iraq which led to further research of the adverse outcomes within the exposed communities (Clarkson & Magos, 2006; Cohen, Bellinger, & Shaywitz, 2005; Cox et al., 1989; Jarup, 2003; Myers, Davidson, & Strain, 2007; Takaoka et al., 2008; Trasande et al., 2005). The primary outcomes from the related studies found that neurodevelopmental issues occurred in the children born to the pregnant women who were exposed to the high levels of MeHg. The first exposure occurred in Minamata and Niigata Japan in the 1950-60's from industrial factory waste polluting the local fishing waters, resulting in an illness called Minamata disease which is related to MeHg poisoning. A study by Takaoka et al. (2008) compared subjects who were exposed from eating poisoned fish in Minamata to a control group and suggested there was a relationship between exposures and somatosensory impairments. The second incident occurred in Iraq in the 1970's from eating contaminated grain resulting in MeHg poisoning. A temporal relationship was established when Cox, et al. (1989) looked at hair samples taken from 83 pregnant Iraqi women exposed to the contaminated grain and were able to approximate the time frame when the MeHg exposure began, when it peaked, and when the intake of the mercury stopped. The study went on to report a dose-response relationship related to the contaminated grain in Iraq with high MeHg concentration in hair samples from exposed pregnant women and increased neurodevelopment deficits in their subsequently paired children.

Research from these unfortunate events has shown there are profound adverse effects with high dose exposure to MeHg however; there is still uncertainty about effects of low dose exposure from consumption of contaminated food sources such as fish. For the purposes of this study, the remainder of this paper will take a closer look at outcomes associated with the exposure to and effects of MeHg and the relationship to contaminated fish.

### Methyl Mercury

The most prominent reason mercury is found in the environment is related to anthropogenic sources (approximately 70%), primarily from coal-fired power plants and smelting operations (Davidson et al., 2004; Mason, 1994; Trasande et al., 2005; Zhang & Wong, 2007). Industrialized countries such as the U.S. and China have seen a two to five fold increase in the level of Hg circulating in the environment due to increased power plant emissions and waste disposal in the last century (Anderson et al., 2004; Booth & Zeller, 2005; Davidson et al., 2004). Mercury is emitted into the atmosphere in the elemental or inorganic forms where it can be transported far from the source and is eventually deposited into the soil and water. The mercury either reacts with sulfate to form mercuric sulfide precipitate or it binds with carbon to become bioavailable. In this process of becoming bioavailable, the Hg reacts with bacteria thus forming monomethyl mercury ( $\text{CH}_3\text{Hg}^+$ ). In this form, MeHg bioaccumulates and biomagnifies up trophic levels from the bacteria, to plants such as plankton, on up the food chain to fish and other sea animals and birds. The main risk to human health is the ability of the MeHg to

biomagnify to potentially toxic concentrations in food sources such as fish (Anderson et al., 2004; Booth & Zeller, 2005; Mozaffarian & Rimm, 2006; Srogi, 2007; Trasande et al., 2005; U.S. Geological Survey, 2000).

### Effects of Methyl Mercury Exposure

Like the other forms of mercury, MeHg is considered a neurotoxin. MeHg is rapidly absorbed by the body when ingested. It is very mobile in the body because of the formation of water-soluble complexes which attach to the amino acid cysteine, thiol groups in proteins, or peptides such as glutathione. It is thought that the MeHg-cysteine structure crosses the blood brain barrier by being transported across the cell membrane of the endothelial cells on a large neutral amino acid carrier (Clarkson & Magos, 2006; Park & Johnson, 2006). It is generally accepted that MeHg exposure has more detrimental effects on the developing fetus rather than an adult. Exposure to high concentrations of MeHg have been linked to neurodevelopmental deficits such as effects on ambulation, vision and auditory changes, sensory and motor impairment, and death (Davidson et al., 2004; Goldman & Shannon, 2001; Park & Johnson, 2006). In the developing fetus, the MeHg can penetrate the placenta and deposit in fetal blood and tissues. The MeHg is partially broken down into inorganic mercury within the brain and can cause focal necrosis of neurons; destruction of glial cells, interrupts neuronal migration and organization of brain nuclei, as well as is toxic to the cerebral and cerebellar cortexes (Davidson et al., 2004; Goldman & Shannon, 2001). The half-life of MeHg is

approximately 50 days and is excreted from the body primarily by feces, bile, urine, and can be also excreted in breast milk (Clarkson & Magos, 2006; Park & Johnson, 2006).

### Exposure to MeHg and Fish

MeHg is a type of organic mercury that fish absorb from their food and from water passing over their gills. The mercury then binds to the proteins in the fish tissue, including the muscle which is the edible part of the fish. Unlike other types of contaminants, MeHg amounts cannot be decreased or removed from fish by cooking or cleaning them (Montana Department of Public Health and Human Services. Communicable Disease Control & Prevention Bureau. Food & Consumer Safety Section, 2005; Park & Johnson, 2006). Research has now shown that all fish contain some level of MeHg pollutant but the level varies from the type, the size, age, and the dietary patterns of the fish (Anderson et al., 2004; Clarkson & Magos, 2006; Mozaffarian & Rimm, 2006; Myers et al., 2007). It is generally advised that the larger, more predatory types of fish have higher levels of MeHg thus are not recommended for consuming, though differences exist depending on species and environmental placement.

The effects of MeHg exposure from fish consumption is a relatively new concept and there are increasing numbers of research studies looking at adverse effects exposure to develop a better understanding of the process to help decrease exposure. A number of studies focused on the effects of exposure to methyl mercury such as Transande et al. (2005), Cohen, Bellinger, & Shaywitz (2005), and Järup (2003). Some of these effects include cognitive and neuro-developmental delays. Cohen, Bellinger, & Shaywitz find

that lower IQ scores may result from exposure to MeHg. This may not seem substantial when viewed as an individual result however, could have considerable impacts on society as a whole. Transande et al. integrated the concept of lower IQ scores and the impact on society to a cost analysis associated with earning lower wages and therefore decreasing the lifetime amount of earning power.

Exposure has been examined using cord blood and hair samples to help determine MeHg body burden for women of childbearing age. For example, McDowell et al. (2004) researched hair mercury levels in U.S. children and women of childbearing age. Björnberg, Vahter, Peterson-Grawe, Cnattingius, Darnerud et al. (2003) looked at MeHg in Swedish pregnant women from cord blood samples. Hightower, O'Hare and Hernandez (2006) looked at blood samples and specific cultural groups such as Asian, Pacific Islander, and Native American. Consistently, the research has found that MeHg in cord blood and hair samples increased as consumption of seafood increased (Bjornberg et al., ; Mahaffey et al., 2004; McDowell et al.). Women of Asian, Pacific Islander, Native American, or multicultural ethnicity were found to have the highest levels of MeHg (Hightower et al., ; Mahaffey et al.). While some studies may have shown the dose-response relationship between intake of MeHg from contaminated fish and elevated biomarkers, there were no consistent results supporting neurodevelopmental issues associated with elevations (Davidson et al., 2004; Davidson, Myers, Weiss, Shamlaye, & Cox, 2006).

Two long-term prospective epidemiologic studies having been collecting and analyzing MeHg and fish consumption data from prenatal exposure through childhood in

the Republic of Seychelles (Seychelles Child Development Study or SCDS) and the Faeroe Islands. Interestingly, the Faeroe Islands study has shown neurodevelopmental problems in the exposed children up to 7 years old whereas the SCDS at 5.5 years old has not. There are many factors that may influence the difference in outcomes such as episodic versus constant fish consumption patterns, lifestyles, nutritional intake, and other contaminants found in the environment.

One possible explanation for the different results is the Faeroe Island people also eat pilot whale meat. Whale meat has high levels of MeHg and another known neurotoxin, PCBs (Clarkson & Magos, 2006; Davidson et al., 2004; Goldman & Shannon, 2001; Park & Johnson, 2006). More recent data was published for the SCDS in which the authors reported that current evaluation of the cohort is occurring and there is some concern for finding delayed or latent neurotoxicity at 16 years of age in the study population (Davidson et al., 2006).

Benefits of Fish Consumption: Some of the literature discussed the importance of eating fish for health benefits but also discussed the risks of eating certain types of fish. For example, many of the fish advisories posted by the U.S. Department of Health and Human Services or the Environmental Protection Agency (EPA) discussed the benefits of eating fish and also listed fish to avoid or limit for the specific population of women of childbearing age. The current recommendation is for women of childbearing age to consume up to two portions of oil-rich fish per week and to avoid fish higher up on the food chain such as shark, marlin, swordfish, and tuna.

Based on the preliminary research from the environmental incidents and the growing concern for decreasing MeHg exposure, conflicting information has resulted from further research investigations regarding safe amounts of fish for women of childbearing age to consume. The dilemma for this specific population is to be able to weigh the risks of MeHg exposure versus the health benefits related to eating fish.

The second significant problem related to the consumption of fish and MeHg exposure is the conflicting, or lack of information that is being circulated regarding safe amounts and types of fish to eat. It has been shown that eating fish can be part of a healthy diet because fish are high in protein and omega-3 fatty acids and low in saturated fat and cholesterol. These properties are associated with preventing heart disease, development of nerve tissue and prevention of birth defects in fetuses, and enhanced visual acuity in children (Anderson et al., 2004; Centers for Disease Control and Prevention., 2004.; Montana Department of Public Health and Human Services. Communicable Disease Control & Prevention Bureau. Food & Consumer Safety Section, 2005; U.S. Department of Health and Human Services. U.S. Environmental Protection Agency, 2004). The National Healthy Mothers, Healthy Babies Coalition (NHMHBC) made a recent press release stating “women of childbearing age should increase their fish intake to at least 12 ounces of seafood per week” (Aubrey, 2007). This announcement conflicts with the Food and Drug Administration (FDA) recommendation for safe fish consumption among women of childbearing age.

Fish Advisories: In 2004, the EPA and the FDA created guidelines for women of childbearing age and children concerning fish consumption. These include specific types of fish to avoid [shark, swordfish, tilefish, and king mackerel] because of high levels of MeHg, recommendations to eat up to 12 ounces of other safer types of fish, and checking local fish advisories for local rivers, lakes or streams guidelines. It should be noted that each State in the U.S. has different fishing advisories or guidelines. Anderson et al. (2004) concluded from their study that:

Most women of childbearing age consume commercial fish and a substantial number also consume sport-caught fish. Despite this potential exposure to dietary mercury, most are unfamiliar with their state's mercury fish consumption advisory. Most women were aware of the most toxic effects of mercury but less informed about mercury and its relationship to types of fish and fish characteristics (p. 315).

Anderson et al. (2004), Burak & Costello (2006), and Park & Johnson (2006) looked at women of childbearing age, how much fish they consume and awareness of exposure to MeHg from eating contaminated fish. Anderson et al. and Park & Johnson both looked at local fish advisories for relaying information to women of childbearing age and exposure to MeHg. The literature showed that women of childbearing age are eating fish and they may be aware of the toxic effects of mercury. However they may not be knowledgeable of the relationship between contaminated fish and exposure to MeHg (Anderson et al., 2004; Burak & Costello, 2006). This information supports the need for further investigation in how women of childbearing age are informed about potential

MeHg exposure and what type of dietary changes they choose to make based on that information.

### Populations at Risk

Rural, Low Income, Women of Childbearing Age: In their editorial, Phillips & McLeroy (2004) discussed the unique challenges of delivering health services in rural areas including “low population density, transportation issues, lack of access to grant funding, lower public funding levels for rural services and programs, difficulties in recruiting staff, and potential fragmentation of scarce resources” (p. 1663). Galambos (2005) also discussed the challenges of health care services in rural areas noting the shortage of medical personnel and the complications that hinder the existing medical providers such as extreme distances, transportation, and access. Galambos went on to discuss pertinent health disparities in rural populations including higher death rates from unintentional injuries, more motor vehicle injuries, premature mortality before age 75, fewer dental care visits, higher tobacco use, fewer residents with health insurance, and higher suicide and infant mortality rates.

Rural health perspectives and themes regarding rural health care have been described. Bales (2006) described health perceptions of rural dwellers to be unique when compared to urban dwellers. Rural dwellers defined health as “the ability to work, reliance on self and informal systems, and decreased willingness to use health care service provided by outsiders” (p. 66). Bales also discussed the unique internal and external characteristics of rural dwellers such as “self-reliance and reliance on informal

support systems of family, friends, and neighbors...and distance and lack of adequate health care resources may put rural individuals at increased risk for illness, disability, and premature death (p. 67). Rural women of childbearing age present with similar health needs as their urban counterparts such as the need for birth control, prenatal care, childbirth education and well-women exams. However, rural women of childbearing age also present with their own set of stressors. These factors include multiple demands from family relationships, home and work responsibilities, working outside of the home, fewer educational opportunities, fewer occupational choices, low-wage jobs, and fewer provisions for child care (Bales). Kenney (2000) reports that “multiple stressors can compromise the immune system therefore putting the individual at increased risk for acute and chronic illnesses (as cited in Bales, 2006). Hill & Butterfield (2006) pointed out that rural families are at greater risk for environmental exposures from agricultural (i.e. pesticides) and industrial facilities as well as contaminants from production-based economy such as mining, smelting, and dumping of nuclear waste in remote areas. The biggest concern with environmental exposures is how they can potentially affect young children as “the most rapid mental growth occurs during early childhood...are critical in the development of intelligence, personality, and social behavior” (Hill & Butterfield, p. 271). Thus, the literature suggests that rural, low-income, women of childbearing age may be considered a ‘doubly vulnerable’ population due to their increased risk of environmental exposures, unique rural stressors and characteristics, and decreased access to health care.

## Change Theory and Diet

Conceptual Framework: Prochaska's Transtheoretical Model is used as the guiding conceptual framework for this paper. By assessing individuals' readiness for change, interventions are tailored to the specific stage of change in which the person resides. Typical stages have been described as precontemplation, contemplation, preparation, action, and maintenance (Polit & Beck, 2008). This particular framework is individually driven and depends on where that individual is on the continuum of change as they can move forward and back or recycle through the five stages of change. The first stage is precontemplation in which the person is not interested or thinking about making any behaviors or problems. If in contemplation, the person is considering making a change but has no plan to follow through at this time. Preparation stage moves forward from contemplation in that a plan is developed regarding the change. The action stage utilizes the developed plan and the final maintenance stage makes the behavior or change integrated into everyday life. Outcomes are measured over a time frame and are successful if the person is able to complete their goal (Finnell, 2005).

The change theory or the Transtheoretical Model (TTM) has been utilized in many settings such as tobacco cessation and diabetes education. Finnell (2005) discussed using TTM to help guide therapeutic interventions "to assist people to modify their behaviors, cognitions, and emotions as they change health behavior" (p.13). Finnell goes on to describe TTM as

a useful framework for understanding when people are ready to change, what strategies they find helpful in modifying their behaviors, cognitions, and emotions, how they weigh the pros and cons of their behavior change, and their beliefs about changing their behavior (p. 13).

Ni Mhurchu, Margetts, & Speller (1997) conducted a literature review on applying the TTM to dietary changes. They reported problems with applying a model that was originally based on smoking cessation to dietary changes. Particularly supporting that dietary modification is more complex “that requires a person to continue with the behavior (eating) but to simultaneously adapt it” (p. 14). The authors recommended that “current stages-of-change model may not be sufficiently complex to take into account all stages of dietary change. The model may need to be adapted or extended to take into account the complexity of dietary change” (p. 15).

Although there has been some research done with the TTM model and dietary changes, no published articles that specifically related this theoretical concept to environmental risk reduction of methyl mercury exposure through consumption of fish were located during the review of literature. Therefore, it is reasonable to ask the question: Are fish eating behaviors related to stages of change?

## CHAPTER THREE

### METHODS

The history and uses of mercury were discussed in the previous chapter and dangers of methyl mercury exposure primarily due to consumption of contaminated fish were brought into perspective. The purpose of this paper is to examine the relationship between stages of behavioral change associated with fish eating behavior, and self-reported consumption of fish among a sample of rural low income women. In order to achieve this purpose, the author used data that was nested within an ongoing, larger study conducted by Dr. Wade Hill and Dr. Patricia Butterfield.

#### Sample

As part of the Environmental Risk Reduction through Nursing Intervention and Education (ERRNIE) study, 106 rural, low income women from Gallatin County, Montana and Whatcom County, Washington responded to the methyl mercury Questionnaire. Data collection took place from July 2007 to October 2008. Inclusion criteria for the study included the participant to be a woman of childbearing age (15 to 44 years) who has at least one child zero to six years old residing in the home and must be receiving public health or community clinic services. Additionally, household income must be  $\leq 200\%$  of the federal poverty level, the participant must reside in their current residence for the next year, have a non-municipal water source, and must be able to complete the research questionnaires. Exclusion criteria for participants included inability

to read or speak English, severe health problem(s); and participation in the baseline data collection phase of the study that occurred from 2005 to 2006.

Participants were solicited through recruitment flyers in waiting rooms and exam rooms of the community clinics and public service offices which contained the study information. The families could then seek further information by discussing the study in private with a public health nurse (PHN). The PHN clarified further background information and explained the process of submitting their names to the research teams.

Gallatin County, Montana and Whatcom County, Washington were chosen for inclusion in this study because of the strong relationship between the county health departments and the university systems within each county. While Whatcom County is larger, more ethnically and racially diverse than Gallatin County, there are pertinent similarities that make this combined sample worthwhile. Both counties are similar in terms of land area, home ownership rate and housing value, per capita income, percentage of persons below federal poverty level, and 1990 to 2000 population growth rates. Also, both Gallatin and Whatcom Counties are influenced by a university population of approximately 12,000 students per county. Traditional rural and “new” rural make up the economy base for both counties. There is a mixture of agriculture, transportation and extractive industries as well as service, tourism and recreation industries.

Both counties have existing natural conditions which would suggest the population is at risk for MeHg exposure via fish consumption. For example, Hebgen Reservoir in Gallatin County has mercury levels up to 0.60 ppm in fish 19 inches or

longer. This mercury level is very close to 0.66 ppm level where recommendations suggest that women of childbearing age, children under six years of age and nursing mothers should not eat these fish (Montana Department of Public Health and Human Services. Communicable Disease Control & Prevention Bureau. Food & Consumer Safety Section, 2005). Lake Whatcom, in Whatcom County, has a fish advisory in place that recommends women of childbearing age do not consume smallmouth bass and limit consumption of yellow perch to one meal per week due to their high levels of mercury (Washington State Department of Health, 2008).

#### Measurement

Fish consumption was measured by a single item asking participants to rate on an 8-point scale how many fish meals (6 oz) they consumed per month (see Table 1). Stage of behavioral change was measured by a single item that asks, “Which of the following best describes your thoughts about limiting your exposure to mercury”, followed by four choices aligned with the stages of change (see Table 1).

Table 1. Fish Consumption and Behavioral Change Questions.

For the questions below, on average, how many servings of the following do you eat per

MONTH (a standard serving is 6 oz.):

Total fish consumed, not included shellfish: 0 1 2 3 4 5 6 7 > 7

Which of the following best describes your thoughts about limiting your exposure to mercury (Please mark one box with an X):

I've never thought about limiting my exposure to mercury

I'm undecided about limiting my exposure to mercury

I've decided I do want to limit my exposure to mercury

I've already taken action to limit exposure to mercury

### Definitions

#### Women of Childbearing Age

The U.S. Census Bureau defines women of childbearing age to be between the ranges of 15 to 44 years old. This specific population has the greatest risk to exposure to MeHg because of the potential problems MeHg can cause to developing fetuses and young children (Mahaffey et al., 2004).

#### Methyl Mercury

Methyl mercury is an organic form of metallic mercury resulting from biochemical changes. It comes primarily from emissions of coal-fired electric power plants and is then released into the atmosphere. It travels through the air and is deposited

into water sources where microorganisms transform the metallic mercury to methyl mercury (Trasande et al., 2005).

### Fish

Fish can be either ocean/commercial or freshwater fish. Certain ocean fish that women of childbearing age are advised to avoid includes shark, swordfish, king mackerel or tilefish (golden bass or snapper). Due to their predatory nature, these fish tend to have higher concentrations of MeHg. Certain types of fresh water fish women of childbearing age should avoid are the larger fish such as lake trout, northern pike, bass and walleye. There are consumption guidelines for other fish such as tuna, snapper, grouper, halibut, canned tuna, crab, cod, and mahi mahi, recommending women of childbearing age to limit serving size and meals per week. Fish that are deemed safe for women of childbearing age to consume up to four 6 ounce meals per week include salmon, perch, tilapia, shrimp, scallops, flounder, and some types of trout (Mahaffey et al., 2004; Montana Department of Public Health and Human Services. Communicable Disease Control & Prevention Bureau. Food & Consumer Safety Section, 2005).

### Rural

This paper will focus on rural Gallatin County in Montana and Whatcom County in Washington where the data has been gathered for the research study of Dr. Hill and Dr. Butterfield. According to the U.S. Census Bureau, Gallatin County's population is approximately 80,900 with about 26 people per square mile. The largest urban area is the town of Bozeman, MT in which approximately 37% of the county population resides.

Whatcom County is comprised of approximately 193,000 people or 92 persons per square mile. Bellingham, WA is the largest city in the county where approximately 40% of the county population resides.

### Low Income

According to the U.S. Census Bureau, the definition of poverty is based on income thresholds and family size. For Gallatin County, the 2006 U.S. Census Bureau data indicates that 4.5% of all families with children under 18 years of age are below the poverty level. This percentage is similar to the statistical information compared to married families with children less than 18 years of age, who are 3.1% below the poverty level. However, there is a large disparity when comparing families with single women as the head of the household with children less than 18 years of age at 19.8% below the poverty level. Whatcom County has 12.9% families with children less than 18 years old that are below the poverty level. Single women as the head of the household with children less than 18 years old are 41.9% below the poverty level.

## CHAPTER FOUR

## RESULTS

Sample Description

There were 106 female participants who were mostly married, white and of non-Hispanic ethnicity. Over half of the participants were between the ages of 31 to 40 years old with the average age of 33 years. More than half the participants had completed high school and had some level of college education. The total gross income of the participants was almost equally distributed into thirds with the exception of 10% earning greater than \$55,000. Approximately 64% of the participants had some form of insurance while 19% were uninsured and 18% were covered by Medicaid. See Table 2.

Table 2. Sample Description

<b><u>Age</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
20-30 years	43	40.6
31-40 years	51	48
41-52 years	12	11.1
Total	106	100%
<b><u>Race</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
White	91	85.8
Black/African American	3	2.8
Native American, Eskimo or Aleut	6	5.7
Asian or Pacific Islander	1	0.9
Other	5	4.7
Total	106	100.0
<b><u>Hispanic ethnicity</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
Yes	7	6.6
No	99	93.4
Total	106	100.0
<b><u>Education</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
High School or less	32	30.1
Junior College or less	36	33.9
More College	38	35.9
Total	106	100.0
<b><u>Total Gross Income</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
\$24,900 or less	31	29.2
\$39,900 or less	32	30.2
\$54,999 or less	31	29.3
\$55,000 or more	11	10.4
Valid Total	105	
Missing	1	0.9
Total	106	100.0
<b><u>Health Insurance</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
Medicaid	19	17.9
Private health insurance	58	54.7
Another type of health insurance	9	8.5
No health insurance	20	18.9
Total	106	100.0
<b><u>Marital Status</u></b>	<b><u>N</u></b>	<b><u>%</u></b>
Married	81	76.4
Divorced/separated	12	11.3
Living with partner	7	6.6
Never married	5	4.7
Other	1	0.9
<b>Total</b>	<b>106</b>	<b>100.0</b>

### Statistical Results

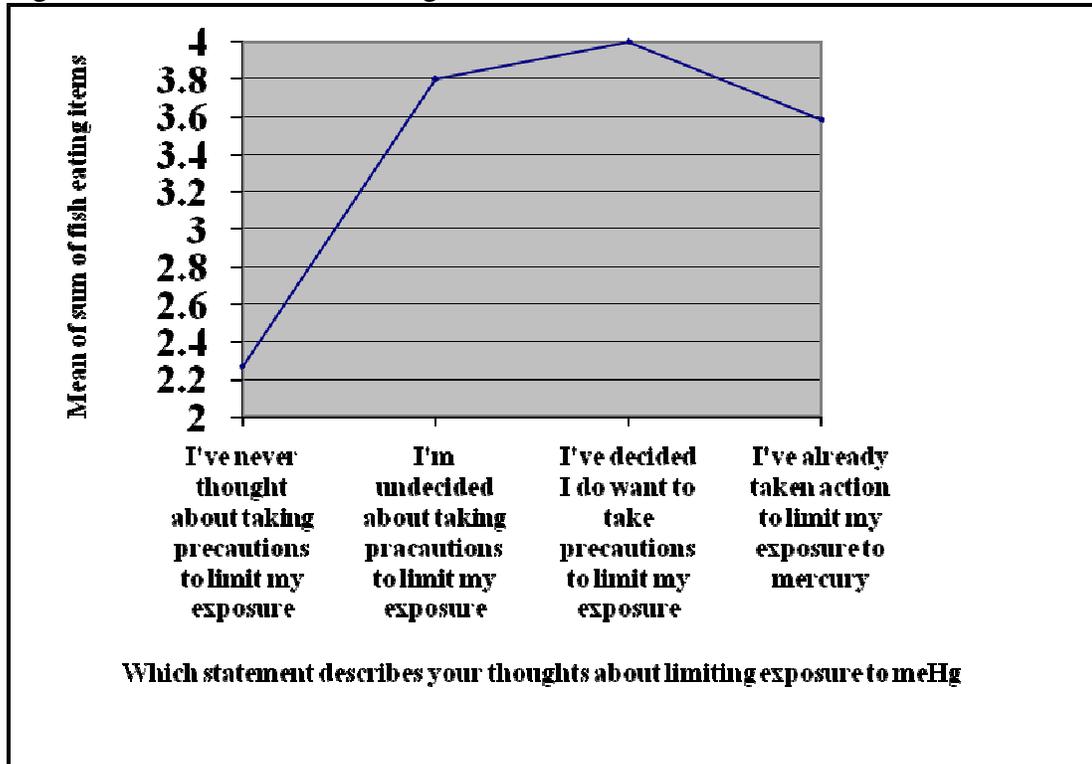
A one-way analysis of variance was conducted to evaluate the relationship between fish consumption and stages of change among rural, low income women of childbearing age. The independent variables, the stages of change, included four levels: never thought about taking precautions, undecided about taking precautions, decided to take precautions, and already taken action to limit exposure to methyl mercury. In the first level, there were 41 (38.7%) women who responded “I’ve never thought about taking precautions to limit my exposure”. Fifteen (14.2%) women responded that they were “undecided about taking precautions to limit their exposure”. The third level, “I’ve decided I do want to take precautions to limit my exposure”, had 21 (19.8%) responses. There were 29 (27.2%) responses reporting they had already taken action to limit their exposure to mercury. The range of number of fish meals eaten for all women was 2.27 – 4.0 fish meals per month with an average of 3.19 fish meals per month. See Table 3 for the average fish meals consumed per month reported by stage of change. The dependent variables, the fish eating behaviors, were assessed by using a forced decision scale of 0 – 8 with zero being zero servings of fish consumed and 8 being more than seven servings of fish consumed.

Table 3. Average fish meals by stages of change

<b>Sum of fish eating items</b>	<b>N</b>	<b>Mean</b>	<b>S.D.</b>	<b>Min</b>	<b>Max</b>
I've never thought about taking precautions to limit my exposure	41	2.27	2.70	.00	13.00
I'm undecided about taking precautions to limit my exposure	15	3.80	2.96	.00	10.00
I've decided I do want to take precautions to limit my exposure	21	4.00	2.39	1.00	10.00
I've already taken action to limit my exposure to mercury	29	3.59	3.42	.00	13.00
Total	106	3.19	2.95	.00	13.00

The mean number of fish meals eaten per month according to stage of change is illustrated in Figure 1. Of the 41 women who never thought about taking precautions to limit their exposure to MeHg via fish consumption, they averaged 2.3 fish meals per month. The remainder of the participants ate on average almost one fish meal per week regardless of which stage of change. The results of the one-way ANOVA do not show a statistically significant difference in fish consumption among rural, low-income, women of childbearing age based on stage of change.

Figure 1. Mean sum of fish eating items



The ANOVA was not significant,  $F_{(3, 102)} = 2.34, p = 0.08$  (See Table 4 ANOVA results). Therefore no further statistical testing was done to explore differences between groups.

Table 4. ANOVA Results

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	58.74	3	19.58	2.34	.08
Within Groups	855.48	102	8.39		
Total	914.23	105			

## CHAPTER FIVE

## DISCUSSION

Evaluation of Results

While the results of the ANOVA analysis do not suggest a difference in fish eating behaviors among rural, low-income, women of childbearing age based on stages of change it does not lessen the importance of this topic. The results clearly show that of the 106 participants, approximately 39% of the women answered they never thought about taking precautions to limit their exposure to MeHg and they consumed less fish overall. It is interesting then that the 61% of the women who reported they are undecided about making changes, decided they would like to make changes, or have already taken action to limit their exposure to MeHg consume almost one fish meal per week. There is a statistically non-significant trend indicating that those who already took action did eat less fish than those who are deciding to take action (4.0 down to 3.6) suggesting that there may be an effect related to stages of change even if slight. It would seem that the results should be reversed with those thinking about or taking action to limit their exposure to MeHg would consume less fish than the group that has never thought about taking precautions.

There are a couple possible answers as to why these results are not as expected. First, the group of women who answered they never thought to take precautions may not consume fish as a regular part of their diet. This could be due to many reasons such as dislike for the taste of fish, or access to fish due to cost, cultural or social norms, or

location of where they live. This group may also consume less fish as they are not aware of the health benefits from consuming fish as part of their regular diet. The remainder of the group quite possibly consumes more fish on average for the opposite reasons; liking the taste of fish, having access to fish from local waters and are able to afford the types of fish they enjoy eating. Another suggestion would be that this group is more aware of the positive health benefits from consuming fish and is following the current recommended EPA guidelines of eating up to 12 ounces of fish per week. While the types of fish consumed and reasons for not consuming fish were not analyzed for this particular paper, inclusion of these variables may shed light on the observed trend.

Of concern is that there is a distinct possibility that any of these women may be exceeding the safe fish consumption guidelines thus increasing their exposure to MeHg depending on what types of fish are included in their diets. Both MT and WA have fish advisories in place for lakes, rivers and streams within the state and the National fish advisory covers commercial caught fish from the oceans. If a woman from Whatcom County is eating one fish meal per week composed of smallmouth bass from Whatcom Lake she is potentially exceeding her MeHg intake. If a woman from Gallatin County consumes lake trout, walleye, or northern pike greater than 15" in length, she also is potentially exceeding her MeHg intake. It is imperative to know what types of fish women are consuming because even one fish meal can put them at greater risk of exposure to MeHg.

### Family Nurse Practitioner Practice

Dietary counseling on fish consumption with women of childbearing age is a delicate balancing act for the FNP as a primary care provider owing to the confusion about whether fish is healthy or dangerous as a food source. Therefore, the FNP must be knowledgeable about the environmental risks, and the current guidelines and recommendations revolving around MeHg and fish consumption. The FNP begins by assessing patient's dietary history and providing education to each individual to help limit potential exposure to MeHg but at the same time promoting healthy fish consumption for the cardiovascular benefits. This can appear almost contradictory to some patients. By being aware of the local fishing advisories, providing educational handouts and specific lists of amounts and types of fish deemed safe to consume, the FNP can help patients better understand the risks and benefits of including fish as a regular part of their diet.

FNPs have the ability to impact their patients on many levels. A basic screening for assessing risk of MeHg exposure from consumption of contaminated fish and providing education is one simple way to positively change a person's health outcomes. The FNP has the potential to further impact the health of the community, state and nation. FNPs can be influential by lobbying for fish advisories to be posted in the grocery stores, the use of commercials and public announcements to make the people aware of their risk of exposure to MeHg from fish consumption as well as advocating for a cleaner environment and protecting our food and water sources from devastating pollutants.

These are just a few but powerful examples of how FNPs can provide holistic care on an individual and greater community level.

### Assumptions and Limitations

One assumption related to the research question would be that women of childbearing age would want to eat a healthy diet, including fish. If this population was knowledgeable about the types of fish high in mercury, they would make healthy choices by selecting fish to eat that had lesser amounts of mercury contaminates.

Limitations for this study include women of childbearing age in selected rural, western counties who speak English. Because the participants are self-selected, these participants may have more concerns for environmental exposures such as MeHg and therefore may have different perceptions and knowledge than those who did not participate in the study. Other limitations include the sample consisting primarily of Caucasian participants. Results may not generalize to other populations with differing racial and ethnic characteristics. Last, fish eating behavior was not actually observed thus self reporting was used to collect data. It is recognized that self reporting is a limitation within itself due to possible recall bias.

### Conclusion

Findings from this study suggest that stages of behavioral changes may not be related to fish consumption as anticipated. It would be important to conduct further research asking the same question, but using a larger sample size of rural women of

childbearing age. It would be interesting to compare a larger, rural sample with a similar urban sample to see if there is a difference between rural and urban women of childbearing age and their fish eating behaviors related to stages of change. There is some level of confusion related to the recommended guidelines for consumption of fish for a healthy diet and limiting intake of fish because of the potential risk of exposure to harmful chemicals such as MeHg. This confusion is exacerbated because there is not only a national fish advisory guideline but each state has an individual fish consumption advisory which could further be broken down to individual counties within that particular state. Women of childbearing age who are consuming fish would need to be aware of all the different levels of advisories in order to be knowledgeable about safe fish consumption for a healthy diet. FNPs can help decrease this confusion and increase their client's knowledge through education. The FNP must first be aware of and know how to access any local fish advisories as well as the national guidelines. The FNP then must make a point to assess the client's knowledge and discuss both the local and national fish advisories with his/her patients to help promote safe and healthy fish eating behaviors. Further research is necessary to help determine the risk of exposure to MeHg from consuming contaminated fish in rural women of childbearing age. Once risks are established, modes of prevention need to take place to help decrease risks of exposure and promote healthy fish eating behaviors.

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