2008

CHALLENGES AND OPPORTUNITIES TO RURAL NUTRITION EDUCATION PROGRAMS IN KENTUCKY'S SUPERFUND COMMUNITIES

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ABSTRACT OF THESIS

CHALLENGES AND OPPORTUNITIES TO RURAL NUTRITION EDUCATION PROGRAMS IN KENTUCKY'S SUPERFUND COMMUNITIES

The National Electric Coil Company/Cooper Industries, Inc. plant in Harlan County, Kentucky was a mining support operation primarily engaged in the cleaning and repair of mining equipment from 1951 to 1987. Trichloroethylene (TCE) and degradation byproducts, polychlorinated biphenyls (PCBs), and vinyl chloride were released into the areas surrounding the plant periodically for decades. Routine water sampling of area wells by the Kentucky Department of Environmental Protection Division of Water revealed significant levels of TCE, PCBs, and vinyl chloride. The toxicology of these chemicals implicates various systems, including cardiovascular, dermal, endocrine, and neurological.

University of Kentucky's Superfund Basic Research Program's (UK-SBRP) biomedical research is based on the premise that nutrition can modulate the effects of Superfund contaminants. In this study, the Community Outreach Core developed and delivered nutrition education programs to community members to address three issues: reduce total dietary fat, increase omega-3 fat, and increase dietary fiber. Initial efforts revealed the need for a holistic approach to identify and build trust with community members before programs could be presented. Results from informal discussions, qualitative assessments, and 24-hour dietary recalls using 2007 Nutrient Data System for Research were used to measure specific outcomes; increased knowledge, improved attitudes, and dietary behavior changes.

KEYWORDS: Dietary Change, Nutrition Education, Superfund, Polychlorinated Biphenyls, Community Outreach

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May 5, 2008

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THESIS

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science in the College of Agriculture
at the University of Kentucky

By

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2008

ACKNOWLEDGEMENTS

It is with sincere appreciation that I thank the Superfund Basic Research Program at the University of Kentucky for funding this research initiative. Acknowledgement is further due the National Institutes of Health and National Institute of Environmental Health Sciences, Grant No. NIH/NIEHS P42ES007380, for making this work possible.

To a very great extent, I owe a debt of gratitude to my Thesis Chair, Dr. Lisa Gaetke. She has taught me what it means to be a mentor and to approach work as a scientist. She has guided, encouraged, and challenged me, and has been a steady and reasoned influence throughout. Further, I would like to thank my thesis committee: Dr. Hazel Forsythe, Dr. Maria Boosalis, and Dr. Elizabeth Easter, who have contributed valuable insights to content, form, and structure.

Sincere thanks are offered to Megan Finnie, my SCAN coworker, for her tireless efforts, keen nutrition insight, and emotional support throughout. Thanks also is due Theresa Howard, Harlan County Cooperative Extension Service Family and Consumer Science Agent, without whose welcoming influence we would neither have met the wonderful folks of Harlan County, Kentucky, nor have proceeded with this effort.

Finally, I thank my husband and three sons who have nourished body, mind, and soul throughout this process. May God bless them!

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National Electric Coil Company/Cooper Industries, Inc. was a mining support operation in Dayhoit, Harlan County, Kentucky, primarily engaged in the remanufacturing of mining equipment from 1951 to 1987. As a result of improper chemical disposal methods, the facility was identified as one of the Environmental Protection Agency's (EPA) 16 National Priorities List (NPL) sites in Kentucky, implicating the site as posing "immediate threats to human health" (US-EPA Region 4, *Five Year Review* 2003). Site remediation was undertaken in September 1997, and the 2003 Five Year Review Report indicated detectable but decreasing levels of toxicants in groundwater.

University of Kentucky's Superfund Basic Research Program (UK-SBRP) is based on the premise that nutrition can modulate the toxic effects of Superfund contaminants. The Community Outreach Core of the UK-SBRP, referred to as Superfund Community Action through Nutrition (SCAN), develops and delivers nutrition education programs to individuals who are directly or indirectly impacted by these contaminants. SCAN selected the National Electric Coil Company/Cooper Industries, Inc. site as a community for its nutrition education programs. Initial efforts in Harlan County revealed a need for a holistic approach to identify and build trust with community members before programs could be presented. In the present study, relevant community characteristics were identified and changes in knowledge, attitudes, and behaviors were measured using qualitative and quantitative methods.

Background

Superfund

When toxic chemical spills occur or are discovered, they may be reported to the EPA. All reports are entered into the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), which initiates a chain of activities, including site assessment, hazard ranking, public health assessments, identification of responsible parties, recommended and executed remediation activities, records of decision, and periodic reviews. CERCLIS was established by Congress in 1980 as part of the Comprehensive Environmental Response, Compensation, and

Liability Act (CERCLA), which additionally created a tax on specific industries to fund remediation activities at the worst of these sites, ranked as National Priorities List (NPL) sites. "Superfund" refers to the fund created by this tax for NPL remediation efforts, and it refers to the environmental program with oversight authority for cleanup of sites in the United States.

When the EPA determines that no further action is necessary to protect human health or the environment, the site may be removed from NPL ranking. Kentucky currently has fourteen sites listed as NPL sites, though another six sites have been removed from NPL ranking in recent years. One site currently listed as a NPL site is the National Electric Coil Company/Cooper Industries, Inc. site, located in Dayhoit, Harlan County, Kentucky. This site was chosen by SCAN in part because of the presence of PCB contamination, which coincided with ongoing UK-SBRP environmental and biomedical research efforts.

National Electric Coil Company/Cooper Industries, Inc.

National Electric Coil Company (NEC) operated a rebuilding and manufacturing facility for the coal mining and related industries from 1951 to 1985. The company was sold at that time to Cooper Industries, Inc. (Cooper Industries), but continued operations under the same management until 1987. Located on 3.5 acres in the town of Dayhoit, Harlan County, Kentucky, the facility is bounded on the west by Old Route 119, on the north by a Kentucky Utilities Company substation, and on the east by the Cumberland River. At the southern boundary stood the Holiday Mobile Home Park, which was home to approximately forty families and separated by a chain link fence. The town of Dayhoit was immediately downstream and was home to approximately 350 people.

NEC/Cooper Industries cleaned and remanufactured machinery for the coal mining and related industries. Solvent was maintained in a 4000-gallon concrete lined cistern below ground level and heavy machinery submerged for cleaning prior to servicing. From 1951 to 1976, the cistern contained trichloroethylene (TCE). Methylene chloride was used as a cleaning solvent from 1976 to 1985. These solvents were periodically drained through pipes and surface runoff directly into the Cumberland River.

Sludge from the cistern was disposed of along the riverbank. While empty, the cistern was cleaned manually by employees.

Additional contamination occurred on the site. Polychlorinated biphenyl (PCB)-laced oil was drained from electrical transformers directly onto the ground and through a system of pipes directly to the river. An unvented lead furnace created coal ash and waste with high concentrations of heavy metals. These were disposed of along the riverbank as well.

Water is supplied to the town of Harlan from the Cumberland River, though municipal water intake is upstream from the site. Residents and businesses down gradient of the site use ground water sourced from the bedrock aquifer supplying a system of wells. As part of a routine water supply sampling, the Kentucky Department of Environmental Protection (KDEP) Division of Water identified contamination of groundwater with vinyl chloride and DCE. In April 1989, Cooper Industries excavated soil and chemical drums located in the fill area adjacent to the riverbank in an effort to remove the source of contamination. Private and commercial wells were closed and municipal water supplied to the area. Soil and water samples indicated contaminant levels that either met or exceeded EPA's action levels, indicating "immediate threats to human health" (2003 Five Year Review).

Three categories of hazardous substances, as classified by CERCLA were determined to meet or exceed action levels, including (1) volatile organic compounds (VOCs): trichloroethylene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), vinyl chloride, benzene, toluene, and ethylbenzene; (2) polychlorinated biphenyls (PCBs); and (3) heavy metals: lead and chromium. Other contaminants were detected, but they did not meet or exceed levels requiring action.

Figure 1.1. Site of NEC/Cooper Industries (now National Electric Service Company); Holiday Mobile Home Park can be seen immediately beyond the building and separated by a chain link fence.

In 1991, 5,100 tons of soil was excavated. One hundred seventy (170) tons of soil was additionally removed from within and around the boundaries of the Holiday Mobile Home Park and community water lines extended to the community. Analytical sampling of approximately 140 water wells indicated VOC contamination of several, including the NEC/Cooper Industries site, the Holiday Mobile Home Park, Dayhoit, and several area businesses. The community well at Holiday Mobile Home Park served over 100 people; the State Transportation Office was approximately 1000 feet south of the site. In particular, TCE and two degradation products, vinyl chloride and cis-1,2-DCE, were detected in concentrations as high as 350 µg/l and 905 µg/l. Safe Maximum Contaminant Levels (MCL) are 2 µg/l and 70 µg/l, respectively. The flow of water in bedrock aquifer is not influenced by the river, but follows its own slope. A lateral plume of contamination was detected about 3000 feet in a southwest direction of the site originally, though this plume was determined to have reduced in size to 1500 feet by the EPA 2003 Five Year Review. Contaminant levels have been decreasing in the aquifers, but remain present at detectable levels.

NEC/Cooper Industries was finalized as a NPL site on October 14, 1992, which dictated federal as well as state oversight with a periodic review process until contaminants are reduced to levels that would allow for "unlimited use and unrestricted exposure" (2003 Five Year Review). Recovery of groundwater quality continues by a system of pumps, air stripping and capturing of VOCs with activated carbon, discharge of

treated water into the Cumberland River, and monitoring of air and water quality. The next EPA five year review of the site is due August 2008.

Contaminants and Health Effects.

Several contaminants were detected in groundwater and air sampling on and around the site. Only those meeting or exceeding safe MCLs are discussed in greater detail.

Trichloroethylene (TCE)

TCE is a colorless, sweet-scented, solvent primarily used for cleaning grease from metal. Also a constituent in adhesives, paint and spot removers, it has been detected in 861 NPL sites throughout the United States. In the environment, TCE has low water solubility, but can remain in ground water for long periods of time. It evaporates easily from surface water and sticks to soil particles and sediment. TCE in soil tends to be stable and may pass into deeper aquifers. About half of TCE in the air will decompose within a week, though degradation products may be toxic to humans and animals.

TCE has different routes of exposure and may be inhaled, ingested, or absorbed. Small exposures may cause headaches, lung irritation, problems with coordination and concentration, nerve, liver, and kidney damage, impaired immune system function, skin rashes, and dizziness. Large or long term exposures may result in impaired heart function, coma, and possibly death. The International Agency for Research on Cancer (IARC) has determined that TCE is "probably carcinogenic to humans" (IARC Monographs).

Classified as a volatile organic compound (VOC), TCE was detected in groundwater, bedrock aquifers, and soil. Maximum levels of TCE detected at the NEC/Cooper Industries site were 17,000 parts per billion (ppb) in the shallow aquifers and 15,000 parts per million (ppm) in on-site soil. Twenty (20) ppb TCE was detected in private well water. EPA's MCL for TCE in drinking water is 5 parts per billion (ppb).

Table 1.1. EPA maximum contaminant levels and maximum detected levels of TCE in water.

EPA MCL	TCE Detected	
Drinking water	Shallow Aquifer	Private well water
5 ppb	17,000 ppb	20 ppb

1,2-Dichloroethene (DCE)

DCE is a highly flammable liquid that is used to produce solvents and other chemical mixtures, but is also released when materials made of vinyl are incinerated. It has a sharp, unpleasant odor and is easily detected in the air. DCE can contaminate air, water, or soil, has a half life of 5-12 days in the air, and breaks down in 13-48 weeks in groundwater.

Lower oral dose exposures have been reported to cause decreased numbers of erythrocytes and effects on the liver. High dose exposures are limited to animal studies. Breathing high levels are reported to cause nausea and fatigue, but may cause liver, heart, and lung damage. The EPA has determined that cis-1,2-DCE is not classifiable as to its potential as a human carcinogen (EPA Technical Fact Sheet on 1,2-DCE). A slight risk of DCE degrading to vinyl chloride exists.

Classified as a VOC, 1,2-DCE was detected in groundwater, soils, and well water. Both cis-1,2-DCE and total (cis- and trans-1,2-DCE) were detected in private wells at maximum levels of 133 ppb and 39 ppb, respectively. Cis-1,2-DCE was detected in the shallow aquifers on-site at levels of 3700 ppb. The EPA MCL in drinking water for cis-1,2-DCE is 70 ppb; MCL for trans-1,2-DCE is 100 ppb.

Table 1.2. EPA maximum contaminant levels and maximum detected levels of cis-1,2-DCE in water.

EPA MCL	Cis-1,2-DCE Detected	
Drinking water	Shallow Aquifer	Private well water
70 ppb	3700 ppb	133 ppb

Vinyl Chloride

Vinyl chloride is manufactured to produce polyvinyl chloride (PVC), a pervasive plastic found in pipes, wire and cable coatings, packaging materials, upholstery,

automotive parts, wall coverings, and housewares. Since the mid-1970s, however, production has been limited to the manufacture of PVC. Importantly, vinyl chloride is also a degradation byproduct of trichloroethane, trichloroethene, and tetrachloroethylene. It is a colorless gas with a mild, sweet odor, is flammable, evaporates rapidly if near the surface of soil or water, and is water soluble.

People exposed to high levels over time may experience nerve damage, changes to liver structure, and altered immune response. Several studies have indicated an increased risk of certain cancers at moderate exposure levels (100 ppm) of vinyl chloride in air or drinking water (Marion & Boivin-Angele 1999; Bosetti, La Vecchia, Lipworth, McLaughlin 2003; *ATSDR Toxicological Profile of Vinyl Chloride*). "Animal studies also suggest that infants and young children might be more susceptible than adults to vinyl chloride-induced cancer." (ATSDR PHS Vinyl Chloride, 1.6)

Classified as a VOC, vinyl chloride was detected in ground water, soil, and several private wells. The maximum level detected in a private well was 350 ppb. Levels in the shallow aquifers on-site were determined to be 77 ppb. EPA requires drinking water to have less than or equal to 2 ppb vinyl chloride.

Table 1.3. EPA maximum contaminant levels and maximum detected levels of vinyl chloride in water.

EPA MCL	Vinyl Chloride Detected	
Drinking water	Shallow Aquifer	Private well water
2 ppb	77 ppb	350 ppb

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are persistent chemical mixtures that can exist in soil, water, air, or sediment, and have been detected in the environment virtually worldwide. PCBs were first manufactured in the 1920's and were widely used as coolants and lubricants. Though the manufacture of PCBs was banned in the United States in 1977, they were used extensively in capacitors, transformers, hydraulic fluids, and gas transmission turbines and may be found in older equipment still in use. PCBs have neither odor nor taste, and may be colorless or light yellow. The 209 different congeners vary widely in toxicity, stability, and solubility. Valued in industry precisely for their chemical stability, these lipophilic compounds have proven to be stable in the

environment and animal tissues as well. Humans may inhale PCBs, absorb them through skin, or ingest them with food or water. PCB exposure also occurs in vivo via placental transfer and during lactation. PCBs are biomagnified through the food chain as they accumulate in fish, marine mammals, animals, and humans.

Persons exposed to significant levels of PCBs may be at an elevated risk of chronic disease. The IARC and EPA have both designated PCBs as "probable human carcinogens" due to tumor induction in animal studies (IARC Monographs; EPA Technical Factsheet on PCBs). Other health effects seen primarily in industry exposures include chloracne from dermal exposure (Fischbein, et al. 1982) and changes in liver enzymes.

The EPA action level for PCBs in soil is 1 ppm. PCBs were detected in soil at NEC/Cooper Industries at levels of 10 ppm and in groundwater. PCB-contaminated soil at the Holiday Mobile Home Park may have exposed residents, though only 1:29 soil samples exceeded the EPA action level of 1 ppm. However, children were reported to have played outside barefoot and residents occasionally went swimming or held baptisms in the Cumberland River, as well as caught fish for meals. Effects of combined exposures were not addressed.

Table 1.4. Soil PCB action level and detected level at NEC/Cooper Industries.

Action level for PCBs in soil	Maximum detected level at NEC/Cooper Industries site
1 ppm	10 ppm

Ethylbenzene

Ethylbenzene is naturally occurring in coal tar and petroleum, and is manufactured as a solvent, in inks, pesticides, paints, and as a component of the chemical, styrene. Found in water, soil, and air, it decomposes within three days when exposed to sunlight. Routes of exposure include inhalation, ingestion, and absorption.

Long-term exposure (several days to weeks) at low levels has been observed to cause inner ear damage, vertigo, and possible irreversible hearing loss in animals (Fechter, et al. 2007; ATSDR Toxicological Profile for Ethylbenzene). The AIRC has determined that long-term exposure may cause cancer in humans (AIRC Monographs).

EPA has set "not-to exceed" levels for ethylbenzene of 30 ppm for one day or 3 ppm for 10 days to prevent any harmful effects in children. Lifetime exposure should not exceed 0.7 ppm; water should contain no more than 0.53 ppm. Ethylbenzene was detected in groundwater at the NEC/Cooper Industries site.

Methylene Chloride

Methylene chloride is a manufactured industrial solvent and paint stripper, but is also used in some pesticides, photographic film, and aerosols. It has low water solubility, but is easily released in air, with a resulting half life of 53 to 127 days. The most common exposure route is inhalation, thus adequate ventilation is important.

Central nervous system damage can occur from inhaling large amounts. Skin and eye contact may result in burning and irritation. Methylene chloride has not been shown to cause cancer in humans exposed to vapors in the workplace, though animal studies indicate an increased incidence of cancer in mice exposed to high levels of vapors over long periods of time. The IARC has classified methylene chloride as a Group 2B agent, "possibly carcinogenic to humans" (IARC Monographs); and the EPA has determined it to be "a probable human carcinogen" (EPA Technical Factsheet on dichloromethane).

Methylene chloride was detected at NEC/Cooper Industries in both groundwater and soil samples.

Benzene

Benzene ranks in the top twenty chemicals for production volume in the United States. It is used widely as a component of lubricants, dyes, detergents, drugs, pesticides, plastics, resins, and nylon. Benzene passes easily into air from water and soil, where is breaks down within a few days. Inhalation of vapors is the most common exposure route.

Industrial exposures are the most common and can result in dizziness, rapid heart rate, headaches, confusion, and unconsciousness. Longterm exposure may damage bone marrow, resulting in decreased erythrocyte production and anemia. Longterm exposure to benzene vapors in air can cause myelogenous leukemia (AML), leukemia of the blood forming organs. IARC and EPA have determined benzene to be carcinogenic to humans (IARC Monographs; EPA Technical Factsheet for Benzene).

Classified as a VOC, total soil levels, including benzene, at the site were 10 ppm. VOCs were also detected in groundwater and bedrock aquifers. Benzene was detected in

shallow aquifers at the site at levels of 19,000 ppb. EPA MCL for benzene in drinking water is 5 ppb.

Table 1.5. EPA maximum contaminant level and detected level for benzene.

EPA MCL for drinking water	Detected in Shallow Aquifer
5 ppb	19,000 ppb

Toluene

Toluene occurs naturally in crude oil and is produced in the manufacture of fuels from crude oil and coke from coal. It is a component of paints, fingernail polish, adhesives, and is used in some printing and leather tanning processes. Toluene is clear and colorless, has a distinct odor, and is unstable in the environment.

Low to moderate exposures are reported to affect the central nervous system with common symptoms of confusion, weakness, nausea, memory loss, and the appearance of drunkenness. These are reportedly transient. High level exposures may affect the kidneys, cause unconsciousness, and death. Based on human and animal studies, toluene does not cause cancer.

Classified as a VOC, total soil levels, including toluene, at the site were 10 ppm. VOCs were also detected in groundwater and bedrock aquifers. Drinking water levels of toluene per EPA should not exceed 20 ppm for one day, 3 ppm for 10 days, or 1 ppm for lifetime consumption.

Lead

Lead is an element found naturally in small amounts in the earth's crust and it has vast uses in manufacturing and mining. Many of its uses have declined in recent years and lead in gasoline was banned in 1996. While lead compounds may break down in the environment, elemental lead does not. Lead can enter the body through the GI tract or smaller particles may be inhaled, where it travels to soft tissues, and within a few weeks is either redeposited into bones or teeth or is excreted. While adults excrete about 99% of inhaled or ingested lead, children excrete only about 32% and are much more vulnerable to lead poisoning.

Lead can adversely affect any tissue in the body, but the central nervous system is a primary target. EPA considers lead a "probable human carcinogen" (EPA *PHS for*

Lead). The IARC has determined that inorganic lead is most likely carcinogenic and there exists insufficient evidence to determine whether organic lead compounds are carcinogenic in humans (IARC *Monographs*).

EPA requires testing of public water systems and ≤ 10% of residences must contain lead levels below 15 ppb to avoid action (*Lead & Copper Rule,* 40 CFR Part 141). Lead levels in shallow aquifers at the site were detected at 127 ppb. NEC/Cooper Industries workers and nearby residents were exposed to the unvented lead furnace and fumes, though ambient air contamination was not measured. Total lead and chromium levels in soil at NEC/Cooper Industries were 100 ppm.

Chromium

Chromium is a naturally occurring element pervasive in the environment and present in several forms, including the essential nutrient form Chromium (III). The forms commonly used in industry are the metal (0), which is used in steelmaking, and (VI) and (III), which are used in chrome plating, dyes, leather tanning, and wood preserving. Chromium binds to soil easily and has low water solubility. Exposure occurs by inhalation, ingestion, and absorption.

Breathing high levels of chromium (VI) has been found to cause nasal irritation, nosebleeds, and ulcers to the nasal septum. Ingesting high levels have been found to cause ulcers, kidney and liver damage, convulsions, and death. Skin contact may cause ulcers. World Health Organization (WHO) has determined that Chromium (VI) is a human carcinogen (WHO Chemical Fact Sheets); EPA has determined that chromium (VI) in air is a human carcinogen (EPA Technical Factsheet on Chromium); IARC classifies Chromium (VI) as a group 1 agent, "carcinogenic to humans" (IARC Monographs*)*.

The MCL for chromium (III) and chromium (VI) in drinking water is 100 ppb (EPA CFS on Chromium), though higher short-term exposures are not expected to cause damage. Chromium levels in shallow aquifers at the site were detected at levels of 594 ppb. Total lead and chromium levels in soil at NEC/Cooper Industries were 100 mg/kg.

Importantly, the impact to health caused by exposure to chemical mixtures or of multiple routes of exposure in tandem, has not been assessed.

Harlan County, Kentucky

Harlan County borders the state of Virginia in southwestern Kentucky. Harlan, the county seat, is approximately four miles east of the NEC/Cooper Industries site, and is situated approximately 150 miles from Lexington, KY; 102 miles from Knoxville, TN; 172 miles from Huntington, WV, and 109 miles from Abingdon, VA. The town is surrounded by several mountain systems, including Stone Mountain and Black Mountain, which runs along the Kentucky-Virginia border and at 4,145 feet above sea level, is the highest point in the state. One of the oldest-growth forests in the country, Blanton Forest, is located on Pine Mountain. This topography makes the county more suited to coal mining than agriculture. The county has an interesting history, dating its first settlement to 1796, and includes a rich coal mining and logging legacy.

Post-secondary education opportunities have greatly increased in recent decades. The Southeast Kentucky Community and Technical College has a campus in Harlan; several small 4-year colleges are 50 or more miles away. The Frontier School of Midwifery and Family Nursing is located 34 miles north in Hyden, Kentucky. Census data from 2000 indicate that 41.3% of Harlan County residents did not graduate from high school. Another 34.3% finished high school, but did not pursue further education. U.S. Census Bureau State and County Quick Facts for 2004 indicate that 29.3% of Harlan County residents live below the poverty level; median household income the same year was $22,891.

Mortality data for Harlan County from 2003 indicate that of 465 deaths, 22.8% were related to heart disease, 21.9% were due to cancer, 8.8% were due to chronic lower respiratory diseases, 8.4% were due to unintentional injuries, 5.8% were due to cerebrovascular disease, and 4.5% were due to complications from diabetes mellitus. University of Kentucky County Extension Service (UK-CES) data of leading causes of death in Harlan County, Kentucky, as compared to other Kentucky counties and U.S. rates, found Harlan County in the highest quintile for all cancers, chronic lower respiratory disease, unintentional injury, and diabetes. Further analysis revealed Harlan County in the highest quintile in lung, colorectal, and cervical cancers. State Cancer Profiles data through 2002 indicated that the death rate for all cancer sites for Harlan County were above US rates with a rising trend (NCI SEER, State Cancer Profiles).

Table 1.6. 2000 Census Data for Harlan County, Kentucky

	Number	Percent
Total Population	33,202	100
Female	17,314	52.1
Median Age	37.8	---
White	31,728	95.6
Education (≥ 25 years of age)		
Less than 9th grade	4,832	21.9
High school, no diploma	4,268	19.4
High school graduate	7,553	34.3
Some college, no degree	2,415	11.0
Associate degree	1,021	4.6
Bachelor' degree	953	4.3
Graduate or professional degree	999	4.5
Employment status (≥ 16 years of age)	10,315	39.7
Industry		
Education, health, social services	2,710	30.3
Agriculture, forestry, fishing, hunting, mining	1,263	14.1
Retail trade	1,225	13.7
Construction	527	5.9
Arts, entertainment, recreation, food services	526	5.9
Public administration	489	5.5
Manufacturing	387	4.3
Median income		
Less than $10,000	3,563	26.8
$10,000 to 24,999	4,504	33.9
$25,000 to 49,999	3,327	25.0
$50,000 to 99,000	1,585	11.9
$100,000 and up	302	2.3
Per capita income	11,585	---
Poverty status	2,737	29.1

Problem

The Environmental Protection Agency (EPA) identifies hazardous waste sites, the most serious of which comprise the National Priorities List (NPL) and are targeted for remediation with federal and state oversight. Individuals directly affected by the toxicants found at these sites include industry workers; residents in proximity who are exposed to air, water, and soil contamination; and individuals regularly consuming the animal and marine foods with appreciable tissue concentrations of these chemicals.

The major contaminants of concern at these sites, classified as persistent organic pollutants (POPs), are a group of manmade, chlorine-containing chemicals with similar characteristics. They are persistent, i.e. resistant to biological and chemical degradation, toxic to humans and animals at certain exposure levels, pervasive in the environment due to their ability to travel long-range, and are able to bioaccumulate in the body fat of living organisms. PCBs, TCE, 1,2-DCE, vinyl chloride, and methylene chloride were all detected at the NEC/Cooper Industries, Inc. site, though PCBs are of particular interest.

Of the nearly 1,600 current or former NPL sites, about 500 contain PCBs. Much research has been conducted on the effects of PCBs in recent decades. PCBs had many and varied industrial uses until they were banned in 1977, and are therefore pervasive in the environment. There are 209 different PCB congeners (chemical structures) that vary widely in stability and toxicity. These are known to bioaccumulate in animal tissues and have been detected in the atmosphere, soil, water sourced to intermediate and bedrock aquifers, rivers, sediment, fish and wildlife. They are stored in human adipose tissue as well with possible dire consequences.

Research efforts to date have focused on environmental cleanup efforts, the biomedical effects of acute and chronic exposures, and single nutrient or chemical therapies to address health risks. Ongoing research into the incidence of chronic diseases occurring over time due to exposures has established their damage to health. These include carcinogenicity, cardiovascular disease, diabetes, reproductive and related hormonal changes, neurodegenerative disorders, and dermal effects, such as chloracne. Studies are primarily prospective, observational studies; individual case studies; or controlled laboratory experiments conducted on animal organisms. Importantly, impacted communities are living with the effects of exposure today that in many cases predates them by one or two generations.

While trials focusing on the effect of a single nutrient or single chemical on various systems of differing organisms are essential to understanding the dynamic, they are also time consuming, costly, and narrow in scope. Behavior change interventions that address risks to health and dietary, whole food strategies designed to minimize chronic disease risk due to exposures, are justified and vital in the present.

Purpose

The purpose of the study is threefold. The first purpose is to identify the community characteristics of the NEC/Cooper Industries Kentucky Superfund site. Second, to identify the barriers commonly met that inhibit or prevent interaction with community members; and third, to measure changes in knowledge, attitudes about health risks and improvements in diet quality and quantity before and after delivery of nutrition education programs.

UK-SBRP's biomedical research is largely focused on the damaging effects of PCB exposure to the cardiovascular system. Research to date has indicated that chronic exposures as may be seen in industry, improper dumping, residential proximity to a toxic waste site, or regular consumption of sport fish or game with elevated PCB levels, may accelerate deposition of atherosclerotic plaque in both arteries and the abdominal cavity. For this reason, nutrition education programs were delivered that informed participants to reduce total fatty acid intake, increase omega-3 fatty acid intake, and increase total dietary fiber intake.

Results will be used to assess the differences that diet and geo-social characteristics play on nutrition and health-related behaviors.

Research Objectives

(1) To identify the community characteristics that may impede qualitative and quantitative measures, inhibit or enhance trust building, and serve as de facto social marketing for development of programs that effectively meet the nutritional and health needs of community members. (2) To identify barriers commonly found in Superfund communities that effectively or absolutely bar interaction. (3) To measure specific outcomes, i.e. increased knowledge, improved attitudes, and dietary behavior changes.

Research Questions

(1) What are the community characteristics that must be addressed before acceptance into the community, building of trust, and development of targeted programs can be accomplished?

(2) What are the barriers present in a specific Superfund community that effectively or absolutely bar interaction?
(3) Did quantitative analysis of programs indicate participants had increased knowledge, improved attitudes regarding their health risk, and changed dietary behaviors?

Justification

Kentucky currently has fourteen NPL sites that span the state. They vary widely not only in geographic location, but degree of urbanization, demographics, and receptivity to outside influence. NPL sites present "immediate threats to human health" and exposures occur to industry workers and residents in proximity, who are exposed to air, water, and soil contamination. The commonality of these Kentucky sites, as well as sites beyond state borders, is the increased health risks associated with exposure. Identifying environmental characteristics common to the community with the goals of effective communication, trust building, and program development is warranted.

Research addressing individual nutrient-based therapies and overall whole food approaches to improved dietary quality are ongoing, but promising. High fiber diets have been demonstrated to reduce serum cholesterol levels, improve glycemic response (Klingberg, et al. 2008; Weickert and Pfeiffer 2008), and reduce overall net calories. Omega-3 fatty acid research indicates enhanced anti-inflammatory and anti-proliferative metabolic pathways that confer benefits beyond treatment of a single disease. The standard American diet is estimated to provide between 35-50% of calories from fat. Cardiovascular disease continues to be the most common cause of death in Kentucky and the United States. Nutritional recommendations for the reduction of total fat to ≤ 30% of energy intake are justified and designated as part of the *2005 Dietary Guidelines for Americans*.

Dietary strategies that are designed to reduce total fatty acids, increase omega-3 fatty acids, and increase fiber content of the diet were chosen for the present study for several reasons. Absorption of persistent organochlorine compounds (OC), such as PCBs, is enhanced by the dietary fat molecule and once in the body they are deposited in adipose tissue. Weight loss has not been conclusively proven to reduce the body burden

of these contaminants. Human studies are limited to exposures that are uncontrolled and multifactorial (Geusau, Abraham, Geissler, Sator, Stingl, Tschachler 2001; Jandacek, et al. 2005); Pelletier, Imbeault, Tremblay 2003; Redgrave, Wallace, Jandacek, Tso 2005). An animal study evaluating body burden and excretion levels of the pesticide hexachlorobenzene (HCB), indicated that as weight was lost, serum levels of HCB were elevated in the short-term, as expected, and though some HCB was excreted in stool, significant amounts were deposited into organs and muscle (Jandacek, et al. 2005). A total dietary fat intake that meets the current dietary guidelines and enhances the maintenance of a healthy weight, rather than weight loss, may be advisable as an important part of nutritional management of OC exposure.

Omega-3 fatty acids are essential to health and must be provided by food or supplement form as humans lack the enzymes necessary to synthesize de novo. Current American Heart Association (AHA) recommendations for people without documented coronary heart disease (CHD) are to consume fatty fish two or more times per week and to include plant food sources of omega-3-rich foods, such as flaxseeds, walnuts, soy, and canola oil. Documented CHD patients are recommended to consume 1 gram EPA/DHA per day, preferably from fatty fish or to supplement under the guidance of a physician. To lower serum triglycerides, 2-4 grams EPA/DHA per day are currently recommended, with physician oversight, for the reduction of cardiovascular disease risk, with the warning that excessive amounts may cause bleeding in some.

Fiber intake of fourteen grams or more per 1000 calories has been recommended by the Institute of Medicine (DRIs, IOM 2006). Soluble fiber has been shown to modestly reduce serum cholesterol levels by binding the molecule in the small intestine during enterohepatic circulation. This nutritional recommendation, if adopted, may result not only in improved lipid parameters, but may have the potential to impact concentrations of circulating OCs as well (Jandacek and Tso, 2007).

Research on individual phytochemicals is ongoing and provocative. Recent studies of interest include sulphoraphane as a Phase II enzyme inducer (Cornblatt, et al. 2007); and the potential of polyphenols, such as quercetin, isorhamnetin, and catechins in preventing endothelial cell damage (Ramadass, et al. 2003). In the absence of randomized, controlled trials, however, these strategies are not considered as valid

nutritional recommendations at this time. Further, a cautionary approach to recommendations was underscored by recent revelations that some single nutrient approaches have the potential to further damage health. The Beta-Carotene and Retinol Efficacy Trial (CARET), which supplemented individuals at high risk of developing lung cancer, was halted abruptly due to clear evidence of significant increases in both incidence and death to lung cancer (Omenn, et al. 1996). During a 12-year follow-up of this trial, food frequency questionnaires revealed significant positive associations between fruit and vegetable intake and lower lung cancer risk, but only in the placebo group. Placebo subjects consuming over eleven servings of fruit per week had a 44% lower lung cancer risk than those consuming less than two servings per week (Neuhouser, et al. 2003). The intervention group showed no statistically significant decrease in risk, even with high fruit intake. Even so, improved chemical methods for identifying and isolating individual phytonutrients in recent years have led to new studies of single nutrient supplementation on disease risk, morbidity, and mortality.

Importantly, dietary strategies replete in whole-food sources of nutrients continue to be beneficial. SCAN programs were therefore developed to improve nutritional behaviors long range, were based on established nutritional guidelines, and cognizance of both the biochemical nature of OC contaminants and their impact on health and chronic, progressive disease.

Assumptions

For quantitative measurements, the sample (n=14) was representative of the population. The participants were honest and accurate in their responses. Participants were impacted either directly or indirectly by exposure to environmental contaminants.

Limitations

All community interactions, nutrition education programs, and study designs were in compliance with the NIH/NIEHS grant that funded all activities. Though programs were possible precisely because of this funding, certain restrictions were imposed on data collection. Neither invasive procedures, such as blood samples, nor clinical data collection were permitted. The population studied was limited to adults. Further,

qualitative data collection through informal discussions, pre- and post-data questionnaires, and surveys were dependent on agreement of participants, who initially stated they neither wanted to write anything down nor wanted to be "research subjects." Nutrition education programs were instructed by grant parameters to be based on community feedback of topics they requested and efforts were made to integrate their requests for information with nutritional programs designed to improve overall health post-exposure.

Ongoing litigation related to NEC/Cooper Industries Superfund site prevented contact with any individual or family involved in the litigation nor collection of written records conformation. Attorney(s) for complainants maintained a type of gatekeeper access to community members and, though aware of the benefits of nutritional counseling and desirous of improved quality of life for their clients, were fearful of any gathering of data in written format that could be used by defendants. Other initial barriers to interaction related to a natural, engrained distrust of outsiders within the Dayhoit community, especially from a university, and the need for a mutually trusted liaison within the wider area of Harlan County who could provide setting and context for meetings.

Further, efforts were made to respect participants' desire for privacy and confidentiality. Pre- and post-dietary recalls using 2007 Nutrient Data System for Research (NDSR) were executed before and after nutrition education programs on fatty acids and fiber. Participants who agreed to participate, attended both nutrition education programs, and were reached for both pre- and post-dietary recall data collection numbered fourteen ($p > .05$). A larger number of respondents may provide statistical significance, though this level of respondents was unlikely to occur with the limitations posed by geo-social community characteristics, grant parameters, and ongoing litigation.

Chapter Two

Review of Related Literature

SCAN programs provide direct support and guidance to individuals and communities affected by environmental contaminants. Contaminants, such as the VOCs, PCBs, and heavy metals found at the NEC/Cooper Industries Superfund site, expose individuals to increased risk of illness (Carpenter, et al. 1998; Adeola 2004). Opportunities for nutrition and environmental health programs that address current challenges to health, as well as increased risks due to exposure, abound. Approaches that adhere to established nutrition guidelines, acknowledge specific increased risks to health, and recognize current and developing research findings continue to be important.

Nutrition Management

Adipose tissues are distributed in various locations of the body, but differ in form and function. Generally, brown adipose tissue (BAT) is involved in heat and energy expenditure, while white adipose tissue (WAT) is primarily involved in energy storage. Up to 90% of a white adipose cell is comprised of triglycerides (Klaus 2004), which makes it a prime target for lipophilic contaminants. The presence of PCBs in WAT is thought to promote obesity-related diseases, such as metabolic syndrome (Lee, et al. 2007; Mullerova and Kopecky 2006) by altering their function and influencing weight regulation. While WAT makes up approximately 15-25% of body weight in a lean person, this may increase to over 50% in the obese, with a corresponding increased capacity for storing PCBs. Arsenescu, et al. 2008, demonstrated varying effects of PCB77 on weight gain, differentiation of adipocytes, and atherosclerosis considered to be aryl-hydrocarbon receptor (AhR) dependent. Conversely, an animal study (Rozman, et al. 1986), in which sub-lethal doses of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) were administered resulted in destruction of BAT, significant weight loss more characteristic of wasting disease, and skin lesions. These studies suggest an altering of the natural differentiation, metabolism, and function of specific adipose tissues with implications far exceeding body mass.

Not surprisingly, weight reduction results in increased serum levels of lipophilic contaminants as triglyceride stores are mobilized. Jandacek (2005) documented in a mice study that a hypocaloric diet inducing weight loss resulted in increased levels of HCB in

other tissues as well. Tissue biopsy post mortem indicated the kidneys and brain were particularly vulnerable. During the study, however, ad libitum feeding after weight loss to mimic so-called "yo-yo dieting" resulted in redeposition of contaminants into WAT, suggesting a significant internal mode of ongoing exposure. A 20-year prospective study by Michalek (1999) of air force soldiers who facilitated TCDD-herbicide spraying during the Vietnam War examined elimination rates of the toxin in relation to percent body fat and changes in body fat over time. Half-life estimate for elimination of TCDD was 7.6 years; as percent body fat increased, the rate of TCDD elimination slightly decreased and it was hypothesized that TCDD is eliminated at a slower rate in individuals with greater body fatness.

These studies suggest that while a healthy BMI of 18.5-24.9 would be ideal for minimizing the damaging effects of OC exposures, insufficient data currently are available to safely recommend weight loss.

PCBs, TCDD, and chlorinated pesticides are known endocrine disruptors. Lee, et al. 2007, 2006, analyzed NHANES 1999-2002 data of serum concentrations of POPs in relation to rates of Type II diabetes and insulin resistance and found significant positive correlations with chlorinated pesticides and non-dioxin-like (non-coplanar) PCBs. Stunningly, rates of Type II diabetes and insulin resistance were more prevalent among respondents with high concentrations of contaminants even with a BMI < 30 than in respondents with BMI > 30 and very low levels of POPs in serum, suggesting one causative link between OC exposures and current rates of these conditions. Other studies have indicated altered thyroid function (Turyk, et al. 2007; Calvert, et al. 1999), altered immune response (Halperin, et al. 1998), and altered reproductive function (Steinberg, et al. 2008) even to the second generation.

Studies at the University of Kentucky (Toborek, et al. 1995; Hennig, et al. 2001, 2002) indicated increased risk factors for CVD, including chronic inflammation, disruption of the endothelium, and acceleration of atherosclerotic plaque formation. In a later study, (Hennig, et al. 2005), PCB77 had little effect on olive oil fed mice, whereas corn oil fed mice exhibited decreased plasma fatty acid levels, suggesting deposition of the omega-6 PUFA in endothelial tissues.

Exposure to industrial pollutants such as vinyl chloride, benzene, and ethylene resulted in increased incidence of non-alcoholic steatohepatitis (NASH) in a group of Brazilian petrochemical workers (Cotrim, et al. 1999). NASH, also referred to as fatty liver disease, shares hallmark characteristics of Metabolic Syndrome, i.e. insulin resistance, hyperlipidemia, hypertension, and obesity (McClain, et al. 2004). In the Brazilian study, 112 workers presented with abnormal liver enzymes, 32 received liver biopsies, and 20 were determined to have NASH. Ten of these were removed from the work site and all ten showed improvement in liver enzymes over time.

Interventions designed within past decades to counter the adverse health effects of PCB exposure have focused on removal of toxins from the body by various means: mineral oil (Polin, et al. 1989, 1991); cholestyramine (Mutter, et al. 1988); and Olestra (Moser & McLachlan, 1999; Geusau, et al. 2001; Redgrave, et al. 2005; Jandacek, et al. 2004, 2005). Olestra combined with caloric restriction yielded the most dramatic reduction in body burdens.

Total Dietary Fat

Maintaining a healthy weight, defined by World Health Organization (WHO) as a BMI 18.5 to 24.9, is important to the long term health outlook of persons exposed to environmental contaminants. In 2003, National Center for Health Statistics estimated that 66.3% of adults in the U.S. are overweight or obese. Composition of the overall diet is important as a total dietary fat intake greater than 30% of energy needs is known to have deleterious effects on health due to possible weight gain and the effects of excess weight on cardiovascular health, insulin sensitivity, and diet-related cancers. Dietary strategies should address both body composition with regard to maintaining a healthy BMI and composition of the diet due to food sources of PCBs. PCBs are fat soluble, so are prevalent in animal foods rather than plant foods. Dietary recommendations for fat free dairy, lean protein in moderate amounts, low total dietary fat, and increased plant foods will enhance weight maintenance and minimize dietary exposure to PCBs as well.

Currently, no recommended dietary allowance (RDA) for fat in the American diet exists. The 2005 Dietary Guidelines for Americans recommends ≤ 30% of energy intake from fatty acids, primarily in the form of monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA). However, ongoing research on omega-6 fatty acids, as well as

relevance of the omega-6 to omega-3 ratio in the diet, suggests this recommendation may require further study. Kris-Etherton, et al. (2004) while finding overall benefits of reduced saturated fat and increased PUFAs in the diet, demonstrated elevated cardiovascular risks with PUFA intake due to the tendency of unsaturated bonds to oxidize. This further supports studies indicating accelerated rates of atherosclerosis in the presence of omega-6 fatty acids, such as corn oil (Hennig 2005). The absence of randomized controlled trials supporting dietary recommendations for reduced omega-6 PUFAs undercuts this as a valid recommendation for dietary change at this time. Saturated fatty acid intake from animal foods is a well-known risk factor for CVD and dietary restriction has been a part of AHA recommendations for several years. The bioaccumulation of PCBs in fatty tissues of animal foods, however, provides an additional reason for restricting those high in saturated fat.

Omega-3 Fatty Acids

Recent and ongoing research of omega-3 fatty acids continues to reinforce their anti-inflammatory and anti-proliferative effects to the population in general and would be expected to confer protective benefits to individuals exposed to PCBs as well. Primary food sources of omega-3 fatty acids include fatty fish, such as salmon and tuna; flaxseed; and walnuts. As mentioned previously, the fatty fish that are high in omega-3 fatty acids may contain significant levels of PCB and mercury in the lipid portion (Carlson and Hites 2005; Hamilton, et al. 2005; Jensen, Egan, Canady, Bolger 2001). The USDA and Institute of Medicine recommendations for intake should be followed, especially for women of childbearing potential. IOM recommendations for women who may become pregnant or are breastfeeding are to consume two 3-ounce servings per week, though they may safely consume up to 12-ounces per week. They are cautioned to avoid large predatory fish with long life spans, such as shark, swordfish, tilefish, or king mackerel (Nesheim and Yaktine, 2007).

Dietary fatty acids are in reality combinations of different fatty acid chains. Canola oil is primarily a monounsaturated fatty acid (MUFA), but contains the omega-3 α-linolenic acid, and the second lowest amount of saturated fatty acids of the common dietary fats. One tablespoon canola oil contains 1.031 grams saturated fatty acids, 8.859 grams monounsaturated fatty acids, 2.661 grams omega-6 fatty acids, and 1.279 grams

omega-3 fatty acids, making it a recommended source of both monounsaturated and omega-3 fatty acids (NDB #04582, USDA Nutrient Analysis Laboratory). Overall dietary recommendations to decrease energy intake in the form of total, saturated, and trans fats, and to increase intakes of omega-3 fats are to be recommended.

Dietary Fiber

The effectiveness of dietary fiber in modifying cardiovascular disease risk is well established (Theuwissen, Mensink 2008). Recommendations for increasing soluble fiber content of the diet have resulted in the reduction of total cholesterol and LDL cholesterol levels (Bell, et al. 1990; Van Horn, et al. 1988). Significant sources of soluble fiber include oats; dried beans, peas, and lentils; and some fruits and vegetables. Insoluble fiber will regulate bowel movements; significant sources are whole grain wheat, rice, and unrefined corn. The Institute of Medicine of the National Academies has set an Adequate Intake (AI) for total dietary fiber intake based on levels observed to protect against coronary heart disease, recommending 14 grams per 1000 kcal for persons one and older (DRIs, IOM 2006). While lower levels will not result in functional or clinical symptoms of a deficiency, higher levels (~ 50 g/day) may yield protective benefits on glycemia, insulinemia, and lipemia (Franz, et al. 2002).

As discussed, OCs, such as PCBs, are lipophilic, stable, and present in fatty foods. This would direct them to the digestive mix of fatty acids, bile, and fat-soluble vitamins within the proximal small intestine. Portions of the various lipid components of the diet and bile acids are repackaged into micelles and absorbed via enterocytes. A reasonable approach to reduce the body burden of PCBs may be to capture them during enterohepatic circulation by soluble fiber, facilitating excretion from the body. Vermeylen, et al. 2007 & De Vos, et al. 2005, demonstrated decreased absorption of dietary PCBs and slightly enhanced excretion of existing PCB body burden in rats fed a wheat bran diet. Dietary approaches that increase both soluble and insoluble fiber content of the diet are desirable.

Whole-Foods Diet

Several studies have been conducted in recent years on the benefits of the Mediterranean diet, which is characterized by high intakes of whole grains, legumes,

vegetables, fruits, nuts, fish, olive oil, and moderate alcohol intake. In a prospective, cohort study of 22,043 Greek adults, an inverse relationship was seen with greater adherence to the Mediterranean diet and death due to coronary heart disease and cancer (Trichopoulou, Costacou, Bamia, Trichopoulos 2003). Analysis of individual dietary components revealed no strong associations with mortality from either cause, suggesting a synergistic benefit from the integrated diet.

Total antioxidant capacity levels were evaluated in 3042 healthy adults, defined as no clinical evidence of cardiovascular disease, following a Mediterranean dietary pattern (Pitsavos, et al. 2005). Greater adherence to the Mediterranean diet was positively associated with increased total antioxidant capacity levels and consumption of fruit, vegetables, and olive oil; and inversely associated with LDL-cholesterol concentrations and consumption of red meat. This same population of 3042 healthy adults from the Attica area of Greece was analyzed for BMI and prevalence of obesity (Panagiotakos, Chrysohoou, Pitsavos, Stefanadis 2005). Again, a greater adherence to the Mediterranean diet was associated with an approximately 50% lower likelihood of being overweight or obese and a 59% lower risk of having central obesity, though benefits were attributable to the overall Mediterranean lifestyle, which included daily physical activity. Importantly, potential confounders, such as physical activity, social status, and smoking were statistically controlled.

Total adherence to the Mediterranean diet was not an objective in this study, as doing so would necessarily consider the benefits of daily moderate alcohol intake and red meat consumption of no more than 4-6 servings per month. The advantages of these recommendations, though not disputed, may be viewed by the community as first, improper, and second, highly unrealistic. Dietary change is a process. A whole-foods approach that includes several servings of fruits and vegetables per day, whole grains, legumes, nuts, olive and canola oil, and lean protein, may be expected to enhance overall health prospects, weight maintenance, and provide a steady supply of many of the micronutrients and phytochemicals currently under consideration in supplement form for modulation of risks due to OC exposure.

Chapter Three

Methodology

The purpose of this study was to develop a better understanding of the environmental characteristics that impact successful delivery of nutrition education programs to individuals and community members who have been exposed to Superfund contaminants, and to measure the success of programming on improved attitudes, increased knowledge, and changed health-related behaviors. Results of programs will be used to assess the differences that diet and geo-social characteristics play on nutrition and health issues, and to design new diet strategies for individuals, families, and communities to enable them to optimize their health in the face of exposure to Superfund toxicants.

The study was directed to male and female Harlan County community members and efforts made from the outset to form a genuine relationship, gauge their perceptions and attitudes regarding their health risks, knowledge of healthy diets and lifestyle, and behavior change as indicated by improved dietary practices. As the study evolved, the focus became, "What are the factors that influence community acceptance of University of Kentucky dietetic researchers, receptivity to the nutrition message, and trust building?" The overarching consideration at all times, per grant restrictions, was to respond to their wants. Participants expressed the intention to not write anything down. They did not want to be "research subjects". Accordingly, neither questionnaires, surveys, structured interviews, nor pre- and post-data were compiled. After fourteen nutrition programs were held over 1-1/2 years, 21 participants agreed to take part in 24-hour dietary recall collection using 2007 Nutrient Data System for Research (NDSR). Fourteen individuals completed pre- and post-recall interviews as well as attending two nutrition education programs on fatty acid and fiber intake.

Identify the Population

The first task was to identify community members affected by a Kentucky Superfund NPL site. The NEC/Cooper Industries site contained PCBs and other chlorinated organic compounds, which coincided with SBRP research being conducted at UK regarding the cardiovascular effects of PCB exposure. Initial attempts undertaken to bond with residents of the town of Dayhoit, immediately downstream of the site, were unsuccessful. Efforts were subsequently undertaken to identify residents of the extended

community of Harlan County who might foster community acceptance of researchers. Early attempts included a community activist, attorneys, a health department nurse, and cooperative extension service agent. The Harlan County Cooperative Extension Service Family and Consumer Science (FCS) Agent was the individual willing and able to provide a setting and context for programs. An advisory board was formed, which included the health department nurse, the FCS agent, and the Director of the Appalachian Center at UK.

Some attendees were not directly affected by the site; others lived in proximity of the site or were widows and relatives of industry workers. Interaction was encouraged and participants were asked what topics they would like to discuss in the future. Comments were transcribed as stated.

Trust Building

A casual format was constructed that became a template for subsequent sessions. Programs were held in the early evening and were prefaced by greeting and casual conversation. A buffet meal that complemented the nutrition program was incorporated early in the event, followed by a brief presentation, group interaction, and covert or unobtrusive transcription of comments. Participants were provided with free, healthy food to take home, usually fresh baked whole grain bread, fresh pineapples, or a dried fruit, nut, oat cereal mix, to support the nutrition message.

Factors were noted that contributed to robust interaction, and relationship and trust building. Formats that enhanced these markers were incorporated into future programming; formats that inhibited these markers were abandoned. Early program discussions were punctuated with questions posed individually, such as, “Where are you from?” “Where are your people from?” Stories of past programming unrelated to UK-SBRP that residents considered unpleasant were relayed in passing. Dialogue was directed more by community members and characterized by fluidity in topic, tone, and tenor. The period of trust building with community members is ongoing.

Program Development

Once trust was developed with community members, SCAN personnel encouraged participants to help in the design and implementation of the nutrition

education programs. This took considerable time, and approximately seven months elapsed until the first SCAN program took place.

Thirteen nutrition education programs were held at the Harlan County Extension Service from April 6, 2006 to October 25, 2007. Programs were advertised through the extension office and in the local newspaper. Records were kept of attendance at each program. Attendance varied from 8 to 400, depending on the event and concurrent activities within the community.

The first four programs were held during spring 2006. Programs were then suspended during the summer months as researchers were told the community stays busy with 4H activities, local festivals, and the growing season. Two programs were held during fall 2007. Programming was suspended during the holiday and winter months. Five programs were held during spring 2007, and three programs were held during fall 2007. The first trip during fall 2007 was undertaken to reconnect with community members, obtain consent for dietary intake data collection, and to execute as many recalls as possible. Six recalls were completed at this visit. Subsequent trips were undertaken October 18 and 25, 2007, to present programming on fatty acid and fiber intake. These events were attended by 25 and 23 individuals, respectively.

Table 3.1. Nutrition Education Programs

Date	Topic	Attendees
4-6-06	**Cancer, fruit smoothies**	**25**
4-20-06	**Food & mood; portion size**	**11**
5-4-06	**Whole grains**	**18**
5-18-06	**Spice up your immune system**	**14**
10-17-06	**Arm yourself w/ antioxidants**	**75**
11-9-06	**Holiday around the world; Healthy snacking**	**400**
3-22-07	**Diabetes & Light Desserts**	**8**
4-5-07	**Fiber**	**27**
4-19-07	**Superfoods**	**8**
4-23-07	**Extension Family Night**	**147**
5-1-07	**Grilling with a Lexington Chef**	**33**
9-27-07	**Initial NDSR dietary recall / Blueberry Flax bread**	**6 completed on-site**
10-18-07	**Dietary Fatty Acids**	**25**
10-25-07	**Fiber**	**23**

Qualitative Data Collection

Environmental scanning techniques were considered to identify relevant community characteristics and a holistic perspective adopted that embraced demographic, social, cultural, perceptual, ecological, economic, educational, and legal/political characteristics of the affected Superfund community. Researchers had two parallel objectives throughout: (1) to plan and deliver meaningful programs; and (2) to form a deepening bond with community members. Programming was informal, interactive, and genial at all times. Efforts to gather data as to the effectiveness of SCAN programs had to comply with both the NIH non-invasive procedure limitation and with limitations resulting from the realities of litigation that were critical to the affected individuals. This shaped the nature of the SCAN programs. Instead of planned nutrition outcome measures to document program results, SCAN personnel were limited to utilizing non-invasive assessment methods, such as measuring height, weight, body mass index (BMI), and body composition, as well as recording and analyzing food and supplement intake and exercise records. Unfortunately, individuals of this community group found even this information sensitive and were not required to participate in any nutrition assessment techniques.

Qualitative measures in the form of personal and group narratives during programming provided responses relating to traditional, local food-ways; family health and social customs; cancer and chronic disease incidence within families; coping strategies to perceived risks to health; perceptual barriers intrinsic to outsiders; limited incomes; loyalty to the Superfund employer; and legal issues.

Quantitative Data Collection

NDSR dietary intake data were collected twice. Initial data collection took place before the first of two nutrition education programs; second data collection took place after the two programs were held. Nutrient and dietary analysis were analyzed to evaluate the effectiveness of the two programs as reflected by changes in total fatty acid intake, omega-3 fatty acid intake, and dietary fiber intake. Other markers of healthy dietary changes were evaluated, including total calorie; cholesterol; and saturated, trans, and omega-6 fatty acid intake.

The first of two nutrition education program was held on reduction of total fatty acids and increase of omega-3 fatty acids on October 18, 2007, at the Harlan County Extension Office. The second nutrition education program was held on increasing the fiber content of the diet at the Harlan County Extension Office on October 25, 2007.

Dietary NDSR

Dietary intake data were collected and analyzed using Nutrient Data System for Research (NDSR), software version 2007, developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. NDSR uses a dietary intake multiple pass approach that prompts respondents for complete food descriptions, detailed food preparation methods, additions, and diverse amount descriptions. Considered the most accurate and comprehensive nutrient and food group serving count calculation software available for research purposes, it has the capacity to evaluate 155 nutrients, nutrient ratios, and dietary supplements.

NDSR provides a complete nutrient profile for all foods in the database. If an analytic value is not available for a nutrient in a food, NCC calculates the value based on the nutrient content of other nutrients in the same food or on a product ingredient list, or estimates the value based on the nutrient content of similar foods. A missing value is allowed only if (1) the value is believed to be negligible; (2) the food is usually eaten in very small amounts (i.e. spices); (3) it is unknown if the nutrient exists in the food at all; or (4) there is no way to estimate the value because the food is unlike any other.

The precision of NDSR software is evident in the techniques used for total energy and dietary fat calculations. When calculating the calorie content of individual foods, NDSR uses the specific Atwater energy factors, which account for energy losses that occur during digestion and metabolism. The general Atwater energy factors of 4 kcal per gram carbohydrate and protein, 9 kcal per gram of fat, and 7 kcal per gram alcohol, will differ for individual food calories in the NDSR data output as these do not consider net energy losses to digestion and metabolism. However, general Atwater factors are used to determine the percent caloric intake from each of the energy nutrients. For this reason, the sum of percent calories may equate to more or less than 100% of total energy intake.

Similarly, total dietary fat intake will not equate to 100% of the sum of the dietary fat content of individual foods as components such as the glycerol backbone of

triglyceride, sterols, and the structural phospholipids are not included in the energy intake calculation, yet are present in individual foods.

A Dietary Supplement Assessment Module (DSAM), added in 2007, is an enhanced version of the National Health and Nutrition Examination Survey (NHANES) Dietary Supplement Database 2003-2004, which was developed under the guidance of the National Institutes of Health, Office of Dietary Supplements (ODS).

Research studies utilizing NDSR are numerous; recent studies include:

> Davis, et al. Associations of dietary sugar and glycemic index with adiposity and insulin dynamics in overweight Latino youth *Am J Clin Nutr.* 2007 Nov;86(5):1331-8
>
> Yaroch, et al. Baseline design elements and sample characteristics for seven sites participating in the nutrition working group of the behavior change consortium *J Nutr.* 2008 Jan;(138)1:185S-192S
>
> Pierce, Natarajan, Sun, Al-Delaimy, Flatt, Kealey, Rock, Thomson, Newman, Ritenbaugh, Gold, Caan. Women's Healthy Eating and Living Study Group. Increases in plasma carotenoid concentrations in response to a major dietary change in women's healthy eating and living study *Cancer Epidemiol Biomarkers Prev.* 2006 Oct;15(10):1886-92

Additional articles that reference the nutrient database accessed by NDSR are:

> Schakel SF. Maintaining a nutrient database in a changing marketplace: Keeping pace with changing food products – A research perspective. *J Food Comp and Anal.* 2001; 14:315-322.
>
> Schakel SF, Buzzard IM, Gebhardt SE. Procedures for estimating nutrient values for food composition databases. *J Food Comp and Anal.* 1997;10:102-114.

In the present study, quality control was maintained by registered dietitians trained and certified in the multiple pass method and NDSR software. The relevance of this approach became apparent during data collection of foods either (1) not included in the database, such as hog-jowl; (2) requiring additions, such as triple chocolate brownies, and macaroni and cheese with three cheeses, sour cream, and egg; and (3) deletions, such as Salisbury steak with half gravy scraped off.

Twenty-one community members agreed to 24-hour dietary intake data and pre-intervention data collection began nineteen months after the first Harlan County nutrition

education program was undertaken. Fourteen community members completed pre-dietary intake data collection, attended two nutrition education programs, and completed post-dietary intake data collection. Of the seven participants who did not complete the quantitative portion of the study, four neglected to attend the nutrition education programs held between pre- and post-recalls, one declined to continue due to illness from the effects of chemotherapy, and the remaining two were a married couple. The husband completed the first dietary intake collection, was brief and impatient in his responses, attempted to restructure the interview by giving a quick inventory of foods consumed, and then declared that no further calls should take place. This couple continued to attend programs, partake of meals and gifts, but declined further interaction of any type. The policy to respect community members' requests was honored.

The remaining fourteen participants who completed all components of the quantitative portion of the study were female, Caucasian, and regular attendees of Harlan County Extension Service programming. Mean age of the participants was 64 years. They varied as to marriage and employment status.

Table 3.2. Age ranking of NDSR dietary data collection participants

AGE	< 50 years	50-59 years	60-69 years	70-79 years	> 80 years
NUMBER	1	5	5	2	1

The first dietary intake data were collected from six participants in person at the Harlan County Extension Service offices on September 27, 2007. Telephone dietary intake data were collected from the remaining thirteen between the dates of September 27, 2007 and October 11, 2007.

Final dietary intake data were collected from October 30, 2007 to February 15, 2008 by telephone. The final recall took much longer than anticipated as participants were difficult to contact during the extended holiday season. Final dietary intake data collection was completed as follows:

Table 3.3. Final dietary intake data collection

Second Dietary Recall Completion	
Number	**Month**
1	October
8	November
0	December
2	January
3	February

Nutrients Evaluated

Intakes were calculated for total energy, total fatty acid, total carbohydrate, total protein, cholesterol, total saturated fatty acid, total monounsaturated fatty acid, total polyunsaturated fatty acids, total omega-3 polyunsaturated fatty acid, total dietary fiber, soluble fiber, and insoluble fiber. NDSR dietary supplement intake data using the DSAM module were reviewed for omega-3 fatty acid and fiber supplement intake.

Outcomes Evaluated

Qualitative and quantitative data obtained from informal discussions and dietary intake data using NDSR 2007, were used to evaluate improved attitudes, increased knowledge, and changed health-related behaviors. Results will be used to assess the differences that diet and geo-social characteristics play on nutrition and health issues, and to design new diet strategies for individuals, families, and communities to enable them to optimize their health in the face of exposure to Superfund contaminants.

Statistical Analysis

Data analysis was carried out using SPSS Statistical Software Version 15.0.1 dated 22 November, 2006. Dietary recall data were compared pre- and post- nutrition intervention using paired t-tests. Sample means and standard deviations (SD) are presented in the tables. Statistical significance was determined at the 0.05 level.

Chapter Four

Results

Results from this study are qualitative narrative responses and comments from individuals attending nutrition education lessons, and quantitative data, consisting of pre- and post-dietary intake data from fourteen participants who attended programs on fatty acid and fiber intake during fall 2007.

Qualitative

Qualitative responses may be classified using the holistic scan identifiers: social, cultural, perceptual, economic, educational, health, and legal/political. These environmental factors were considered relevant to dietary and other health-related behavior change. Social cognitive theory (Bandura 1986), which considers the individual, his/her cognitive and emotional processes, and the environment when predicting and explaining behavior, presupposes that, just as the environment and cognition can shape behavior, so can behavior shape the environment and cognition. Though successful behavior change is largely considered a function of self-efficacy, i.e. a belief that the tasks undertaken can be achieved, the environmental landscape is necessarily intertwined and must be considered. Identifying the relevant environmental characteristics and demonstrating sensitivity to community members was necessary for bonding, identifying potential barriers to improved dietary change, and developing successful programs.

Holistic scan identifiers used by SCAN to better understand community characteristics relevant to behavior change are briefly described below. A few of the community member quotations considered revealing are referenced in Appendix B.

Social

Social environmental characteristics were considered to be any shared characteristic that affected community members' association with others. Noted examples were the recognition of Sunday as a day of rest and of Wednesday night as church night, i.e. neither programs nor phone calls should occur at these times. Some husbands were known to come home for lunch on weekdays. Some dietary intake respondents preferred to not receive calls during lunch or of an evening once their husband was home. During one of the first trips to Harlan, a SCAN dietitian attempted to

purchase a working lunch for a local attorney at a local restaurant and was forbidden to do so by the waitress. Faith, family, adherence to traditional gender roles, and avoidance of the appearance of unethical behavior were identified as important social factors.

Cultural

Cultural environmental characteristics were the observed behavioral norms and belief systems of community members. Conversations revealed a self-reliant spirit, an observed ability to resolutely face health-related challenges, and knowledge of historical food and home-medical customs. Marriage was not considered unusual for a fourteen year old girl until the most recent decades. Poke berries, vinegar, and honey were used by grandparents to treat arthritis. Indigenous foods, such as creasey greens, hickory chickens (mushrooms), and pokeweed were discussed, and gifts of locally grown pokeweed and persimmons brought for SCAN members.

Perceptual

Perceptual environmental characteristics were considered to be community members' awareness or understanding of any given situation. An initial distrust of outsiders and especially university researchers with offers of help was apparent. Participants were initially guarded, though polite, and inquisitive about SCAN members' home and family background. A perception of the Superfund employer as somewhat beneficent in providing a good job that kept men out of the coal mines was present. A perception of the local water company as doing an inadequate job was communicated.

Ecological

Ecological environmental characteristics were considered to be aspects of the local environment that impacted lifestyle choices at every level. An increasing prevalence of fast food chains and the decline of individually owned local restaurants was a prime ecological factor impacting food behaviors. Secondary medical care was seldom received locally, and study participants were at times unavailable for part or all of the day due to personal, family, or friend medical appointments in other towns.

Economic

Economic environmental characteristics related to any factors that impacted the ability to the produce, purchase, and consume goods or access services. The affordability of nutritious foods, such as fresh fruit and vegetables bore consideration, and gifts of

pineapple and whole grain breads were always appreciated. Multiple generations residing together due to unemployment or absence of a parent in the family structure significantly affected the economic status of some families.

Educational

Educational environmental characteristics were considered to be any factors that impacted the ability to acquire knowledge, training, and skills for vocation or avocation. As mentioned earlier, the most recent Census data indicated 34% of Harlan County residents did not pursue post-secondary education and 41% did not finish high school (2000 Census data, Harlan County, Kentucky). The regular participants of Harlan County Extension programming, who comprised our study, were informed, inquisitive, and interested in topics related to their health and the environmental issues impacting their community, even though educational status was not determined.

Health

Health environmental characteristics were considered as two-fold: (1) an observed wellbeing of the body, mind, and spirit; and (2) community members' perception of the state of their health and the health of family and friends. Participants often shared stories of their successful battles with cancer, loss of family and friends to cancer or heart disease, and current approaches to dealing with diabetes within families. Early suggestions for programming included the role of food in managing depression, diabetes, arthritis, and reducing the risk of cancer.

Legal/Political

Legal environmental characteristics referred to the presence of lawsuits as part of the Superfund landscape and any political ramifications that could affect community interaction. In the present study, direct interaction with community members involved in litigation was discouraged, and data collection was strictly prohibited.

Quantitative

Descriptive Statistics

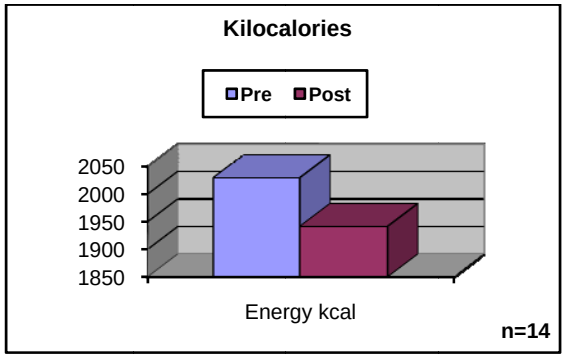
A convenience sample was used for this portion of the study. The mean age of participants was 64; the sample was 100% female and Caucasian. Dietary intake data were collected on all participants who attended the September 27, 2007 event or had signed up to take part previously at the May 1, 2007 program.

Nutrient Data System for Research (NDSR)

Twenty-four hour dietary intake data collection was executed in person or by telephone. Cursory data was collected that identified the person by name, alias, or code word; birthday; gender; day of recall; and day of intake. This four-pass method prompted participants to more accurately recall their intakes of food, beverage, and supplements. Results of total calorie intake; carbohydrate, protein, total fat intake; saturated fat, monounsaturated fat, polyunsaturated fat, trans fat, and omega-3 fat; dietary cholesterol; and total, soluble, and insoluble dietary fiber are indicated in the figures below.

Figure 4.1 displays the changes in mean total energy intake before and after delivery of nutrition education programs on October 18 and 25, 2007.

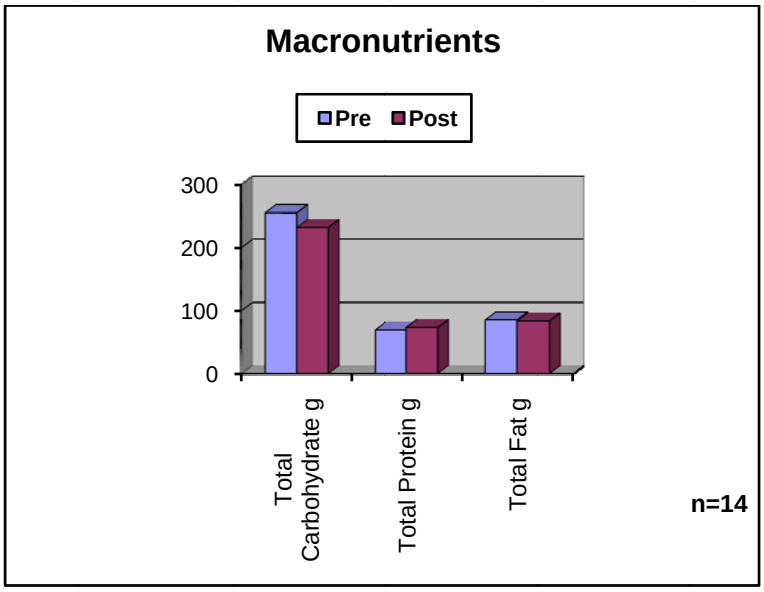
Figure 4.1. Total kilocalorie intake pre- and post- nutrition education programs.



Mean kilocalorie intake decreased from 2029.6 ± 851.5 to1941.5 ± 943.9, reflecting a 4.3% decrease in mean energy intake.

Figure 4.2 displays mean changes in total carbohydrate, total protein, and total fatty acid intake before and after programming.

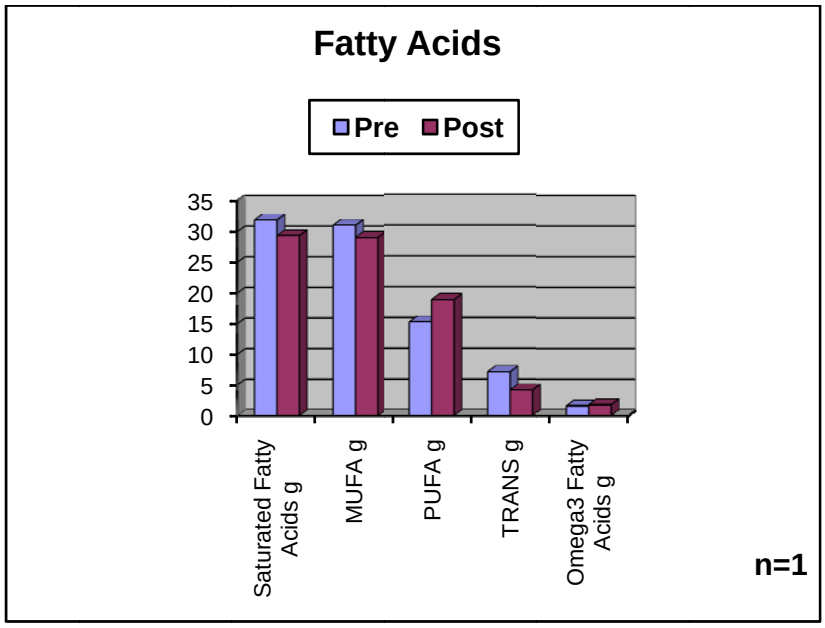
Figure 4.2. Total carbohydrate, protein, and fatty acids pre- and post- nutrition education programs.



Decreases were seen in the mean energy intake from carbohydrate (255.2 ± 120.5 to 231.7 grams ± 101.2) and total fatty acids (84.8 ± 36.6 to 83.5 grams ± 49.0). An increase was seen in the mean energy intake from total protein (69.1 ± 30.8 to 72.9 grams ± 40.8).

Figure 4.3 displays mean changes in fatty acid intake before and after programming. No changes were noted in types of dietary fat chosen from the first recall to the second. Participants continued to use the same percent milk fat, type of butter or margarine, salad oil, and salad dressing. No change was indicated in omega-3 fatty acid supplementation between pre- and post-recalls.

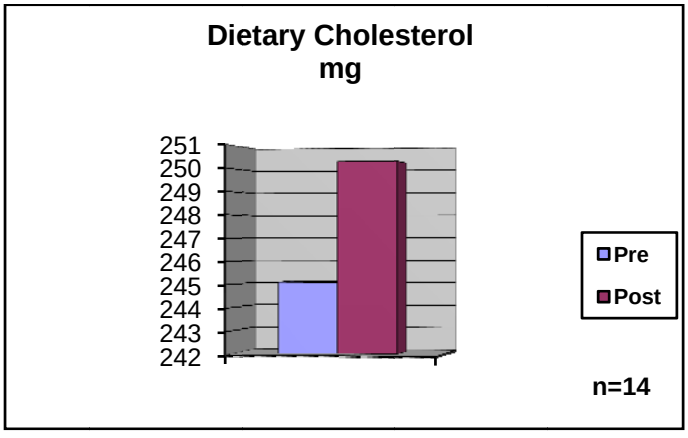
Figure 4.3. Fatty acid intake pre- and post- nutrition education programs.



Decreases in mean fatty acid intake were seen for saturated fatty acids (31.9 ± 13.9 to 29.3 grams ± 16.8); monounsaturated fatty acids (31.0 ± 14.9 to 29.0 grams ± 18.6); trans fatty acids (7.1 ± 6.6 to 4.2 grams ± 2.6). Increases in mean fatty acid intake were seen for total polyunsaturated fatty acids (combined n-6 and n-3) (15.2 ± 8.3 to 18.8 grams ± 13.5), and omega-3 polyunsaturated fatty acids (1.6 ± 0.9 to 1.8 grams ± 0.9).

Figure 4.4 displays mean changes in dietary cholesterol intake before and after programming.

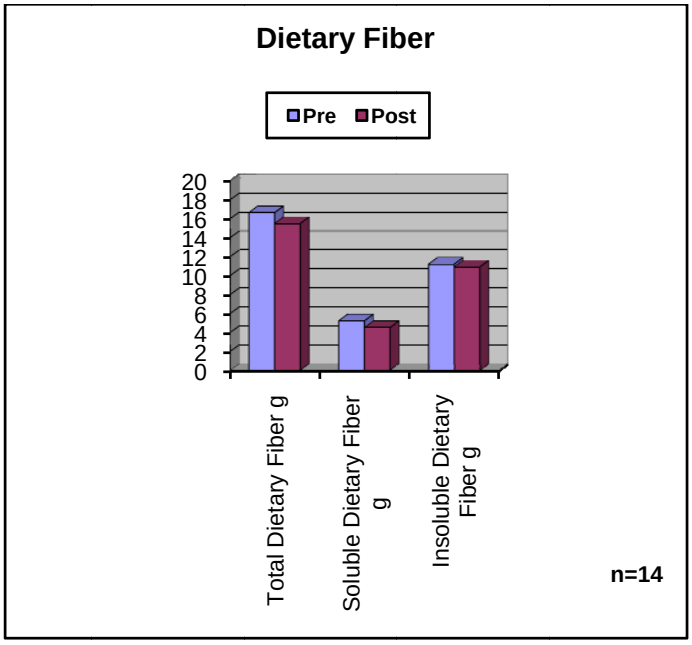
Figure 4.4: Total cholesterol intake pre- and post- nutrition education programs.



Mean intake of dietary cholesterol increased from 245.1 mg. ± 161.6 to 250.3 mg. ± 126.3.

Figure 4.5 displays mean changes in total fiber, soluble fiber, and insoluble fiber intake before and after programming.

Figure 4.5: Total fiber intakes pre- and post- nutrition education programs.



Decreases were seen in mean intakes of total dietary fiber (16.6 ± 8.5 to 15.5 ± 11.8); soluble fiber (5.2 ± 3.0 to 4.5 ± 2.4); and insoluble fiber (11.2 ± 6.6 to 10.9 grams ± 9.8). No changes were indicated in dietary patterns for fiber containing foods. Though some participants routinely consumed 100% whole grain bread, they were already doing so when the first recall took place.

Table 4.1. Paired t-tests of dietary intake data

	Pre-test	Post-test	Difference of means
Total kcal	2029.6 ± 851.5[a]	1941.5 ± 943.9 [a]	88.1 ± 624.2 [a]
Total carbohydrate	255.2 ± 101.2 [a]	231.7 ± 101.2 [a]	23.5 ± 97.4 [a]
Total protein	69.1 ± 30.8 [a]	72.9 ± 40.8 [a]	-3.9 ± 21.5 [a]
Total fatty acids	84.8 ± 36.6 [a]	83.5 ± 49.0 [a]	1.3 ± 37.9 [a]
Total saturated fatty acids	31.9 ± 13.9 [a]	29.3 ± 16.8 [a]	2.5 ± 15.6 [a]
Total monounsaturated fatty acids	31.0 ± 14.9 [a]	29.0 ± 18.6 [a]	1.9 ± 16.3 [a]
Total polyunsaturated fatty acids	15.2 ± 8.3 [a]	18.8 ± 13.5 [a]	-3.6 ± 9.5 [a]
Total omega-3 poly-unsaturated fatty acids	1.6 ± 0.9 [a]	1.8 ± 0.9 [a]	-0.2 ± 0.8 [a]
Total trans fatty acids	7.1 ± 6.5 [a]	4.2 ± 2.6 [a]	2.9 ± 6.3 [a]
Cholesterol	245.1± 161.6 [a]	250.3 ± 126.3 [a]	-5.2 ± 172.2 [a]
Total dietary fiber	16.6 ± 8.5 [a]	15.5 ± 11.8 [a]	1.1± 8.7 [a]
Soluble fiber	5.2 ± 3.0 [a]	4.5 ± 2.4 [a]	0.7 ± 3.6 [a]
Insoluble fiber	11.2 ± 6.6 [a]	10.9 ± 9.8 [a]	0.3 ± 6.7 [a]

[a] = Standard Deviation

Chapter Five

Discussion

Challenges and opportunities to programs

The NIH limitations on the use of invasive procedures for the gathering of data and the presence of private environmental litigation have created certain challenges. As with most challenges, however, while formidable, they were not insurmountable. The restrictions imposed on programming set a pace that in retrospect may have been necessary for community bonding and that effectively led to new and creative approaches in order to circumvent these limitations.

Perhaps the most keenly felt limitation was in the development of evaluative methods to determine the effectiveness of programming. Had no restrictions been imposed on data collection, a biochemical marker, such as serum levels of environmental contaminants, and the use an intervention group and of a control group not living in proximity of the site would have been embraced. The limitation imposed by the grant preventing use of invasive procedures, however, led to consideration of anthropometric measures, such as BMI and waist circumference. A second, important grant dictate was to respond to community members' desires for programming, and individuals stated early on that they neither wanted to be treated as "research subjects" nor to provide any personal information. This led SCAN dietitians to abandon use of anthropometric measures, and to adopt the qualitative and quantitative methods of data collection mentioned previously. These included covert transcription of personal narratives and NDSR dietary and supplement recall collection. Importantly, dietary recall collection was only possible after 1-1/2 years of relationship and trust building within the community. By causing SCAN to be more sensitive and cautious in seeking useful data, this limitation may provide benefits through the solidifying of trust and a growing sphere of influence within the wider, affected community.

After selecting a Superfund site for SCAN programming, a significant challenge was to identify individuals and community groups for interaction. In many cases, those affected may not know they have been exposed to Superfund contaminants. As mentioned before, the identification of pollutants and the method(s) by which they were and/or continue to be released into the environment may not be known. Contaminant

plumes within bedrock aquifers follow their own trajectory; contaminant plumes within surface water are vulnerable to evaporation and condensation, and are likely to be carried through the atmosphere to locations not in proximity of the site; incineration of VOCs or burning of other contaminants in the lead furnace may disperse contaminants to areas determined by the air current, again to locations not in proximity of the site. Given the pervasive nature of these pollutants, it was considered probable that the extended community was affected.

While identifying the affected community members was an ongoing challenge, openly discussing the likelihood of exposure and inherent risks to health was not considered a reasonable approach. It was uncommon to meet a family unscathed by untimely death, often to cancer or cardiovascular disease, or who were not presently affected by either diabetes, cancer, or a neurological disorder. To incite fear or other negative emotion, even unintentionally, to garner interest in programming would have been unacceptable. This axiom heightened sensitivity, but inhibited SCAN from directly approaching those considered most affected by Superfund contaminants. It is a paradox encountered in this area that those most affected are either absolutely barred from our programs by their involvement in the litigation that results from exposure and risks to health, while those not barred from programming are either unaware of exposures and inherent risks to health or may be considering litigation. This specter of litigation may always be a factor in Superfund community outreach and SCAN researchers must maintain an awareness of their charge to improve dietary and health-related behaviors and not indirectly promote community activism, which could ultimately lead to litigation.

Once the affected individuals and community groups were selected, the task of identifying any barriers that would either inhibit or absolutely bar interaction became critical to advancement. Distrust of outsiders, especially university researchers with offers of help, became apparent as a barrier early on and underscored the need for a trusted liaison within the community to gain initial entry and help engender trust. Identification of possible liaisons, and the benefits and limitations imposed by these relationships, became critical to advancement as well.

Superfund sites, such as NEC/Cooper Industries, are often located in economically deprived areas and the individuals have limited educations and low

incomes, though this cannot be presumed. The ridge and valley topography of the area promotes heterogeneity in residences. The area immediately downstream of the NEC/Cooper Industries site was a mobile home park with a community well (until municipal water lines were provided). The public health assessment conducted by ATSDR as part of CERCLIS mandated activities referred to barefoot children and dogs playing in the dirt (ATSDR Public Health Assessment, Nov. 1994). By contrast, a two-story house immediately across Old Route 119 and uphill from the site was home to the high school home economics teacher, a well-respected community member. This observation underscored the need for an ecumenical approach to interaction.

Environmental litigation provided other opportunities and challenges to programming and may reasonably be expected to be a part of the Superfund landscape. Early on, one individual asked if she could bring her attorney with her to a SCAN program. Others stated that they would only take part if their attorney(s) gave permission. Though attorneys were at times helpful in allaying concerns about invasive procedures or trust issues in general, they also prohibited dietary data collection of individuals currently involved in the lawsuit. While desirous of interventions that would improve their clients' quality of life, they were most concerned of any collection of data that could be used by defendants in the suit. Specifically, they stated that if dietary recall data indicated a poor diet quality, then plaintiffs' ill health might be attributed to this factor rather than environmental contamination. Attorneys remained alert to ways participation could affect their clients' legal claim and as such, were the primary gatekeepers to access.

As a result of these factors, efforts to gather data regarding effectiveness of SCAN programs had to comply with both the grant non-invasive procedure limitation and with barriers resulting from the realities of litigation. Further, some individuals found even NDSR dietary intake collection intrusive and either declined to take part at all or did not finish participation in dietary recalls, though they continued to attend programs. Given the policy to structure programs to meet the needs and desires of community members, these limitations may be viewed as an opportunity for more qualitative techniques and exploring the opportunities within.

Programs and outcomes

Nutrition recommendations for this population adhered to the *Dietary Guidelines for Americans 2005*. More specifically, however, participants were encouraged to reduce total fatty acids, increase omega-3 fatty acids, and increase soluble and insoluble fiber. Inherent in these recommendations, though not precisely articulated, was the maintenance of a healthy weight. These nutritional recommendations represent an important first step to maintaining or improving serum lipid values and reducing oxidative stress.

No statistical significance was achieved in the quantitative dietary recall portion of this study. Approximately 300 respondents would have been required to reach this standard. Still, cursory review of the data reveals some intriguing trends. Mean decreases in kilocalorie (-4.4%), total fatty acid (-1.5%), and total carbohydrate (-9.22%) intakes occurred though 64% of post-recall data collection took place during the holiday season. Discussion with participants revealed refined carbohydrate foods, such as hummingbird cake, which contained a bag of butterscotch chips in the cake batter, or fudge, being brought to work daily. A church potluck supper offered foods, such as three cheese-sour cream-macaroni and cheese, with reports of most foods at the potluck being sampled or portioned. A very slight increase in omega-3 fatty acid intake was considered encouraging. No changes in supplementation of omega-3 fatty acids occurred; any changes in intake of this nutrient occurred through food consumption. Increases in mean intakes were seen in total protein (+5.3%) and dietary cholesterol (+2.1%). Dietary cholesterol is found in animal foods and may be expected to correspond with an increase in protein intake, though mean saturated fat intake, also found in animal foods, decreased (-5.3%). No improvements were seen in dietary fiber intake. Nutritional recommendations for increased whole grain consumption rather than increased fiber intake may be easier to incorporate into meal plans.

Obstacles to attaining statistical significance due to lack of sufficient respondents have been discussed. Other possible implications include the use of only one pre-recall and one post-recall, use of a pre-established contextual setting for programming, and the imperative to defer to respondents' willingness and degree of participation at all times. NDSR recalls reasonably take 30-60 minutes and though early study design discussions included a second pre- and post-recall, it quickly became apparent this was unlikely to

occur due to time constraints, respondent availability, and concern over attrition rates. The contextual setting of the Harlan County Extension Service presented dynamic, often spirited, and successful programming throughout much of the year. There were several advantages to this setting; however, a group setting dedicated to improved nutrition practices in the face of Superfund contaminant exposures may well have yielded different results.

Chapter Six

Conclusions

There are numerous Superfund sites within Kentucky and many of them are contaminated with PCBs and other OCs known to be persistent, toxic, and pervasive within the environment. SCAN nutrition education programs are an important service to individuals and communities affected by these sites. Several key steps have emerged in the successful execution of these programs, including identifying affected community groups, identifying community characteristics and barriers to interaction, and measuring changes in knowledge, attitudes, and dietary behaviors.

Challenges and Opportunities

Several challenges have emerged in working with Superfund communities, including the restriction on invasive procedures and the limitations imposed by litigation. These challenges provided opportunities as well in identifying and developing trust with affected community members, providing meaningful programs, and increasing understanding of the subtle community characteristics relevant to behavior change.

By structuring programs that were at once informal, interactive, and genial, several techniques emerged that improved programs, deepened relational bonds, and informed future research directions. These included asking open-ended questions; learning participant names; appropriate self-disclosure; an attitude of reciprocal learning, i.e. interest in historical food and medical habits; allowing participants to set the agenda; taking scientists from various disciplines to programs and encouraging interaction on their areas of expertise; and giving gifts of nutritious foods, information, and prizes.

Early trends in qualitative and quantitative measures suggest increased knowledge and improved attitudes regarding healthy dietary practices and the ability to improve the health prospects of individuals, families, and community members. NDSR dietary recall data collection, while lacking statistical significance, was beneficial to increasing cultural competencies and cataloguing dietary trends. Above all, it signaled the community group's willingness, for the first time, to permit quantitative data collection. Future programs will continue to be a crucial part of the SBRP Community Outreach Core charge to improve health prospects of communities affected by Superfund contaminants.

Future Research

Future research efforts must continue to be designed and executed within grant and community parameters for program development and data collection. Further, avoidance of litigation in all stages of discovery, trial, and/or settlement is an imperative. This has led SCAN to forgo any attempt to develop research opportunities at some sites. A community group in proximity of the Paducah Gaseous Diffusion Plant has had more concerns about litigation than improving dietary habits. Similarly, a community group in an industrialized section of Louisville adjacent to a residential community, known as Rubbertown, continues to be engaged in several lawsuits at varying stages of completion. Given these considerations, three opportunities for future research have evolved.

The Cumberland River flows to Bell County, which lies approximately ten miles downstream of the NEC/Cooper Industries site. Increased rates of cancer have been reported in Bell County children. Dietary and environmental health modules targeted to Bell County primary care physicians and pediatricians, as well as nutrition education programs for mothers are a possible research approach. Family interventions, however, face the same barriers of community access, context, data collection and evaluation as encountered in Harlan County. Bell County is known to be economically deprived and affordability of and accessibility to recommended, nutrient-rich foods is an important consideration.

Russellville, Kentucky is a town with past PCB exposures and resolved litigation. This community may agree to anthropometric and clinical assessments. NDSR 24-hour dietary intake collection taken before and after nutrition education programming would provide valuable feedback on program effectiveness, as well as establish baseline data for nutrition and diet should clinical trials occur in the future.

Attempts to further understand the experience of individuals affected either directly or indirectly by Kentucky Superfund contaminants may be undertaken in the form of recorded, unstructured interviews. These would likely form a phenomenological study that could elucidate aspects of the human experience yet identified.

Last, research efforts will continue in Harlan County. Dietary intake data collection will continue quarterly, if agreed to by community members. Nutrition education programs would be developed and delivered on topics related to (1) the role of

nutrition in preventing and mitigating chronic disease states, and (2) the translation of research findings, when appropriate. Upon resolution of current litigation, efforts to engage residents of Dayhoit and Holiday Mobile Home Park may again be attempted. The success of past efforts to bond with Harlan County community members, however, assures continued involvement at this site.

Appendix A

Definition of Terms

BAT: Brown adipose tissue; deriving its color from the mitrochondria and blood vessels contained within; involved in heat and energy regulation, though considered to yield a minimal effect in adults (Nelms M, Sucher K, Long S, 2007).

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act, passed by Congress in 1980, granted the federal government authority to locate, investigate, and clean up the hazardous waste sites that threatened the health and safety of the public and environment; created a tax on chemical and petroleum industries that were held in trust ("Superfund") for cleanup operations. *National Institute of Environmental Health Sciences - National Institutes of Health, accessed April 28, 2008.* www.niehs.nih.gov/research/supported/sbrp/about/about4.cfm

Chloracne: An acne-like skin disorder caused by prolonged exposure to chlorinated hydrocarbons, developing primarily in areas where there is active secretion of sebum (Fischbein, et al, 1982).

Cholestyramine: A drug used to lower serum cholesterol levels and treat itching associated with jaundice through its ability to promote excretion of bile acids (Mutter, et al. 1988).

1,2-DCE: Refers to cis-1,2-dichloroethene, trans-1,2-dichloroethene, and total-1,2-dichloroethene, a volatile organic compound.

EPA/DHA: Eicosapentoic Acid/Docosahexanoic Acid; Omega-3 fatty acids of 20C (5 bonds of unsaturation) and 22C (6 bonds of unsaturation), respectively; primarily found in fatty fish, fish oils, and marine algae. (Chow CK, 2008).

HCB: Hexachlorobenzene; also called benzene hexachloride; a pesticide. Any of several stereoisomeric chlorine derivatives $C_6H_6Cl_6$ of cyclohexane, in which the chlorine atoms are all attached to different carbon atoms (Jandacek, et al. 2004).

IARC: International Agency for Research on Cancer. A part of the World Health Organization, their mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control. Retrieved December 14, 2006 from IARC website: http://www.iarc.fr/.

Lipophilic: Having an affinity for, tending to combine with, or capable of dissolving in lipids (Jandacek and Tso, 2007).

MUFA: Monounsaturated fatty acid; unsaturated fatty acids containing one double bond. (Chow CK, 2008).

NDSR: Nutrient Data System for Research, software version 2007; a comprehensive nutrient and food group serving count calculation research program; developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. NDSR 2007.

OC: Organochlorine compounds; a group of chlorinated hydrocarbons that are effective as solvents, pesticides, and heat transfer agents (PCBs). They are water insoluble, strongly associated with organic carbon, and have long half-lives. U.S. Geological Service; retrieved May 3, 2008. http://pubs.usgs.gov/circ/circ1171/html/organo.htm

Olestra: A blend of long-chain fatty acid esters of sucrose that have the physical properties of triacylglycerol, but are not hydrolyzed by pancreatic lipase. (Jandacek, et al. 2005, G292).

PCBs: Any of a family of industrial compounds produced by chlorination of biphenyl, noted primarily as an environmental pollutant that accumulates in animal tissue with resultant pathogenic and teratogenic effects. *The American Heritage® Dictionary of the English Language, Fourth Edition*. Retrieved December 14, 2006, from Dictionary.com website: http://dictionary.reference.com/browse/PCBs.

POPs: Persistent organic pollutants; a group of synthetic chemicals with shared properties of toxicity, persistence, bioaccumulation in body fat, and ability for long-range transport. **United States Environmental Protection Agency;** Retrieved April 28, 2008. http://www.epa.gov/oppfead1/international/pops.htm

PUFA: Polyunsaturated fatty acids; unsaturated fatty acids containing two or more double bonds. (Chow, CK, 2008)

Sucrose polyester: A complex synthetic compound of sucrose and fatty acids that the body is unable to digest or absorb (Mutter, et al. 1988).

SBRP: The Superfund Basic Research Program (SBRP) is a network of university grants that are designed to seek solutions to the complex health and environmental issues associated with the nation's hazardous waste sites. *National Institute of Environmental*

Health Sciences - National Institutes of Health website, accessed April 28, 2008. http://www.niehs.nih.gov/research/supported/sbrp/

SCAN: Superfund Community Action through Nutrition, the Community Outreach Core of the UK-SBRP (University of Kentucky website, accessed April 25, 2008; http://www.uky.edu/Research/Superfund/Communities.html).

TCDD: 2,3,7,8-tetrachlorodibenzo-*p*-dioxin

TCE: Trichloroethylene

VOCs: Volatile organic compounds; having a high vapor pressure and low water solubility; typically manufactured as industrial solvents, and are components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents. *U.S. Geological Survey website,* accessed April 28, 2008.

WAT: White adipose tissue, though appearing light yellow due to the presence of carotenoids; primarily composed of triglyceride, and involved in energy storage (Nelms M, Sucher K, Long S, 2007).

Appendix B

Community Member Comments

I just can't let you do that.

This was stated by a waitress at the Huddle House in the town of Harlan when, after a working lunch, a SCAN member (female) attempted to pay for the attorney's (male) meal.

You can make salad out of it or cover it with water and boil it, but you can't eat the berries. They're poisonous.

These comments were offered by a participant who lived directly across Old Route 119 from the NEC/Cooper Industries NPL site in reference to the *poke* plant (pokeweed) she had brought as a gift from the hillside behind her home.

A second participant brought frozen poke to give as a gift.

I fixed it for years, but you've got to know what you're doing.

This was stated by a program participant in reference to her job as a cook at a local diner and preparation of poke salad as a regular menu item. This woman shared her story of cancer "woven" around her thyroid, supposedly terminal, but she was cancer free at this time.

People are dropping like flies.

There is lots of cancer.

We're seeing unusual cancers.

These statements were made by three different participants during the first program, which was about cancer. The county health department nurse had demonstrated fruit smoothies as a healthy breakfast option and offered the comment, "We're seeing unusual cancers".

I listened to what you all said.

This was stated by a participant who adopted the fruit smoothie option for breakfast immediately after the first program. Two weeks later at the second program, she reported a two pound weight loss and increased daily walking. At the first spring program one year later, she reported a fifty pound weight loss.

In the Caywood district, there are often boil advisories and at one point an advisory of too much chlorine in the water.

There was a mercury alert in the water from the Cumberland area at one time, which flows down to Harlan; fish died.

Half of Caywood buys water to drink.

These comments were made during a lively discussion on water quality, as well as other environmental issues. One woman present at this discussion was put on the defensive as her husband worked for the water company. At the conclusion of the program as people were leaving, she stated to dietitian-researchers, "*People do not understand that my husband does take care of the water quality".*

Barrels were dumped at the airport.

My granddaughter and her family moved up the hollow and their dog kept losing all his hair. The vet said he was being exposed to something, so they moved and his hair grew back.

Several participants commented that they enjoyed having a chance to talk about local issues. They expressed interest in learning what to do nutritionally about exposure.

My granddaddy would take five poke berries a day for arthritis.

Too many poke berries were stated to be poisonous. Other shared arthritis treatments included 1 Tbsp. cider vinegar per day or 1 Tbsp. cider vinegar with 1 Tbsp. honey per day. Shared local food customs included creasey greens, hickory chickens (mushrooms), and persimmons. A bowl of persimmons was brought to the September 27, 2007 meeting as a gift with the explanation, "If the white part of the seed pod is shaped like a fork or "u", it means it will be a mild winter; if it is shaped like a shovel, it will be a cold winter".

He would come home with bleeding sores all up and down his arms.

The widow of a NEC/Cooper Industries employee told her story one evening. When the TCE-containing cistern was emptied, her husband would "go in there and scrub it out by hand. He would come home with bleeding sores all up and down his arms." He would fish in the Cumberland River by "noodling", which entailed hooking a line under a large rock and catching several fish at once. She reports they consumed a lot of fish from the Cumberland River.

You didn't talk down to us.

When are you coming back?

Researchers have been told that they were liked because (1) they learned names, (2) were interested in what residents had to say, and (3) didn't talk down to them. Routinely, researchers are asked, "When are you coming back?"

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Refereed Abstract

- Hofe C, Finnie M, Gaetke L. *A holistic approach to effective nutrition programs for affected Superfund communities* (Poster Presentation). NIEHS Superfund Basic Research Program Annual Meeting; Durham, NC, December 3-5, 2007.

Other Abstract

- Hofe C, Finnie M, Gaetke L. *Nutrition education provides outreach to improve health-related behaviors for Superfund Communities.* Kentucky Research Consortium for Energy and the Environment Technical Symposium, Lexington, KY, October 30-31, 2007.

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