IMPLICATIONS OF LITERACY RELATED TO COMPREHENSION OF ENVIRONMENTAL HEALTH MATERIALS

by

Martha Ann Lindsey

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A Dissertation Submitted to the Faculty of the

SCHOOL OF INFORMATION RESOURCES AND LIBRARY SCIENCE

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2010
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ACKNOWLEDGEMENTS

Dr. Cheryl K. Malone has been the ideal dissertation supervisor. Her excellent guidance, helpful suggestions, sage advice, insightful criticisms, and patient encouragement aided the writing of this dissertation in countless ways. Her long time support through the steps of my doctoral program is appreciated more than can be expressed.

I would also like to thank Dr. Don Fallis for his inquisitiveness, Dr. Patti M. Overall for her attention to detail and long time support, and Dr. Lynda Bergsma for provoking me to trust my findings and clarify my thoughts about understanding adult reading of health materials.

I would like to acknowledge the instruction and guidance of Dr. Martin Fricke and the initial impetus to study from Dr. Judith A. Effken. The abstract of this dissertation includes reprints of the previously published Newest Vital Sign material. Therefore, I would like to acknowledge the work of Dr. Barry Weiss, M.D. and all the others who have studied health literacy in the past, most especially Dr. Andrew Pleasant.

I would also like to acknowledge the support and assistance given me by many librarians at the University of Arizona, Pat Auflick, Annabelle Nunez, Mari Stoddard, and Alexandra Rivera. Finally, I would like to acknowledge the friendship of Linda Don, without whose support I would not have been able to persevere.
DEDICATION

This dissertation is dedicated to my husband, Mike Lindsey. I thank him for his love, support, humor, and encouragement. I could not have completed this effort without his assistance, tolerance, and enthusiasm.

I also dedicate this dissertation to my daughter, Dr. Erica Lindsey, M.D. There is no doubt in my mind that without her example, continued support and counsel I could not have completed this process.

Finally, I dedicate this dissertation to my mother, whose example and pride in my accomplishments is greatly appreciated.

Each, in his or her own way, taught me that even the largest task can be accomplished if it is done one step at a time.

The Doctoral process began with spiritual inspiration, which has sustained me in moments of doubt and success alike. For that I thank Baha'u'llah and bear witness to the oneness of God in the Dayspring of His Revelation. He has taught me, “Knowledge is as wings to man’s life, and a ladder for his ascent. … In truth, knowledge is a veritable treasure for man, and a source of glory, of bounty, of joy, of exaltation, of cheer and gladness unto him” (Baha’u’llah, Tablets of Baha’u’llah, pp. 51-52).
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ABSTRACT

Health literacy involves basic reading and numeracy, which allow a person to function as a health care consumer, by reading, understanding, evaluating and using information in health documents. For thirty years, the gap between the reading level of most of the public, eighth grade, and the reading level of most written health information, above the tenth grade, has been perceived to prevent people from comprehending health instructions or educating themselves about health conditions.

This study examined comprehension of health materials, using print environmental public health information about relatively obscure aspects of arsenic and ultraviolet light contamination. Specifically the research question was “to what extent are print materials for environmental health promotion comprehensible by the target audience of readers at the eighth grade reading level?” This study tested a hypothesis that materials written at the seventh grade level would be more comprehensible than those written at the twelfth grade level for individuals with an average reading level.

Materials were located, assessed for reading level, rewritten to the seventh grade reading level, and vetted by environmental health experts. The mean reading level of the participants was eighth grade. The study was conducted with a pretest / posttest design with follow up interviews to assess some participants’ perception of the reading materials and test. Data was analyzed using repeat measures ANOVA and content analysis.

Contrary to anticipated results, the study showed that when people with average reading ability read twelfth grade material, they were able to comprehend it as well as they did seventh-grade material. Two follow-up interviews provided anecdotal evidence
indicating people with an average reading level would not voluntarily choose to read the twelfth grade material.

Although the results of this small exploratory study found individuals, with average reading levels, can read and comprehend written information about environmental health topics, health literacy professionals cannot stop being concerned about the perceived mismatch between the reading levels of American adults and reading levels of environmental health information. It is important to undertake additional studies to better understand how much of an encumbrance hard-to-read information may be placing on individuals with a need to know about environmental hazards and their health.
CHAPTER ONE – INTRODUCTION

Statement of the Problem

While it has been known for many years (Baker, 2006; Davis, Crouch, Wills, Miller, & Abdehou, 1990; Nielsen-Bohlman, Panzer, & Kindig, 2004) that the American public reads at levels lower than most disseminated health materials (Rudd, Moeykens, & Colton, 2005), very little has been done to learn the best reading level for health information, including environmental health information.

The problem has been viewed as a public deficiency, requiring literacy testing in clinical settings, and as a public health problem for health professionals to address with well written, easy to read materials (Baker, 1999, 2006; Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005; Rudd, Kaphingst, Colton, Gregoire, & Hyde, 2004; Whitehurst, Rudd, Schillinger, Baker, & Pignone, 2006). However an acceptable reading level for health information has not been determined and some argue to write materials at lower reading levels would mean loss of content or over-simplification of inherently complicated medical or environmental health science.

Research Questions and Design

This study examined health literacy by focusing on the effectiveness of public environmental health print information. Specifically the research question was “to what extent are print materials for environmental health promotion comprehensible by a target audience of readers at the eighth grade reading level?” This study tested a hypothesis that materials written at the seventh grade level would be more comprehensible than those written at the twelfth grade level to individuals with an average reading level.
The study (a) located information, from reputable sources, about environmental health promotion concerning arsenic and ultraviolet exposure, (b) assessed the reading level of those print materials, (c) rewrote found materials to seventh grade reading level, (d) vetted the rewritten materials with subject experts, (e) created the pretest / posttest tool, (f) administered a health literacy test, using the Newest Vital Sign, (g) administered the pretest, (h) oversaw subjects reading study materials, (i) administered a posttest, (j) analyzed the resulting data, (k) conducted follow-up interviews with individual participants, (l) analyzed the content of the transcripts of those interviews, (m) reported findings, (n) discussed further areas for research, and (o) made suggestions based on the findings. The study used a sample recruited from a local agency that trains direct-care givers because each student is screened for reading level upon entering the program and must have a reading score no lower than the seventh grade reading level.

An understanding of study concepts--low literacy prevalence, the gap between reading level of the majority of Americans and the reading level of most health and environmental health information, and the lack of understanding of the problem among health and environmental health communicators--began at a videoconference in 2003 sponsored by the Medical Library Association (Medical Library Association, 2003). It addressed the depth and complexity of the problem of low health literacy and suggested health materials should be assessed for readability to provide quality consumer health and patient education information services. The Medical Library Association has a comprehensive health literacy endeavor that suggests health information providers become active in assessing and providing health information in formats that make the
information available to all people to foster the ability of people to read, understand and act on health information (Medical Library Association, 2008). The association promotes the expressed need for research related to improving health information accessibility (Medical Library Association, 2007).

**Literacy in America**

Literacy is conventionally defined as a person’s ability to read and write. It is also broadly understood to mean a person can make and communicate meaning from and by the use of a variety of symbols, such as words, letters, and numbers (UNESCO, 2002). The components of literacy addressed in this study concerned the ability to read and to understand written communication.

Low literacy is common in the United States, according to an Agency for Healthcare Research and Quality report titled *Literacy and Health Outcomes* (Berkman, et al., 2004). The more than 90 million adults in the United States are affected by low literacy and are unable to perform the most basic, simple and concrete literacy skills, identify, understand, interpret, create, communicate, and compute. At best they can perform undemanding and everyday literacy activities and recognize printed words on a fourth- to fifth-grade level (Kirsch, Jungeblut, Jenkins, & Kolstad, 2002). Low literacy can be the reason people may not understand or get their needs met in health care. It may affect people’s ability to communicate with health care providers including nurses, physicians, pharmacists and therapists, and with health care educators, health promotion professionals, and librarians. Individuals with low literacy are often unable to comprehend health related instructions. They may be unable to educate themselves about
health conditions because they cannot read the material disseminated (Berkman, et al., 2004). They are also thought to be unable to protect themselves from environmental hazards or to participate in effective way to improve the environment within their communities (Zarcadoolas, 2006).

The Literacy and Health Outcomes report relied on the 1992 National Adult Literacy Survey (NALS) for its description of the prevalence of low literacy among American adults. The NALS survey was conducted after Congress passed the National Literacy Act of 1991 (Irwin, 1991), which set a goal of improving adult literacy by 2000 and provided for services, on state and national levels, to improve the adult literacy nationwide. A second survey, the National Assessment of Adult Literacy (NAAL), was conducted in 2003 with more than 19,000 adults, age 16 and older participating, representing adults from all 50 states and the District of Columbia (National Center for Education Statistics, 2003c).

The NAAL, which included an assessment of health literacy, is “a nationally representative and continuing assessment of English language literacy skills of American Adults (National Center for Education Statistics, 2003c)“. Findings concerning the 1992 NALS and the subsequent 2003 NAAL are reported online by the National Center for Education Statistics (NCES), a center of the Institute of Education Sciences at the US Department of Education, at http://nces.ed.gov/naal/index.asp.

The NALS established a definition of literacy as “the ability to use printed and written information to function in society, to achieve one's goals, and to develop one's
knowledge and potential” (National Center for Education Statistics, 2003a). The NALS survey assessed adults across the county for three types of literacy:

1. **Prose** - the knowledge and skills needed to search, comprehend, and use continuous texts such as editorials, news stories, brochures, and instructional materials:

2. **Document** - knowledge and skills needed to perform to search, comprehend, and use non-continuous texts such as job applications, payroll forms, transportation schedules, maps, tables, and drug or food labels; and

3. **Quantitative** - knowledge and skills required to identify and perform computations, either alone or sequentially, using numbers embedded in printed materials, such as balancing a checkbook, figuring out a tip, completing an order form or determining the amount (National Center for Education Statistics, 2003b).

The National Center for Education Statistics, established four levels of literacy:

1. **Below Basic**: no more than the most simple and concrete literacy skills,

2. **Basic**: can perform simple and everyday literacy activities,

3. **Intermediate**: can perform moderately challenging literacy activities, and

4. **Proficient**: can perform complex and challenging literacy activities (National Center for Education Statistics, 2003a).

A comparison of results from 1992 and to 2003 shows little progress in adult literacy in the United States (National Center for Education Statistics, 2010) as seen in Figure 1: Percentage of Adults in Each Literacy Category, comparing 1992 to 2003.
The little progress shown seems to be at the low end of the scales, with fewer people being classified at a Below Basic literacy level with document and quantitative literacy. However, there was a decline in the number of Americans Proficient with prose and document literacy. Overall the number of people classified as Intermediate readers showed a small increase over the eleven-year time frame and the number of people with Basic literacy skills remained about the same.

The National Center for Education Statistics (NCES) produced estimates of the percentage of adults lacking Basic Prose Literacy Skills using statistical models based on results from the 1992 National Adult Literacy Survey and the 2003 National Assessment of Adult Literacy (Comprehensive Adult Student Assessment Systems, 1996). Based on these models, NCES derived Basic Prose Literacy Skills
(BPLS) estimates for all states and counties in the United States and produced user-friendly tables to compare literacy estimates across states or counties and across years. Estimates are reported at https://www.casas.org/lit/litcode/Search.cfm, including Mean Literacy Proficiency scores and percentages of adults reading at Below Basic and Below Basic. The Comprehensive Adult Student Assessment System, a nonprofit organization, partners with a national consortium of state and local agencies to provide these literacy assessments for states, counties, and cities. These scores do not reflect grade level equivalent reading levels as “the NCES does not plan to establish grade-level equivalents because they are unsuitable for characterizing adult reading skills, who often have uneven skills across different literacy areas” (National Center for Education Statistics, 2005).

Health Literacy

The Health Literacy of America’s Adults (Kutner, 2006), the first publication of NAAL health literacy results, presented four performance levels: Below Basic, Basic, Intermediate, and Proficient. The majority of adults, 53%, had Intermediate health literacy. About 36% were likely to have difficulties with health related documents, as 22% had Basic and 14% had Below Basic health literacy. The 2003 National Assessment of Adult Literacy estimated more than 89 million American adults have limited health literacy skills (Kutner, 2006). Therefore low health literacy can still be viewed as a pervasive and an under-recognized problem in health care (Williams, Davis, Parker, & Weiss, 2002). Problems with health literacy can include trouble with basic reading and
numerical skills, which are needed for a person to function effectively as a consumer in the health care environment (Safeer & Keenan, 2005).

Health literacy is defined as “the ability to obtain, process and understand basic health information and services needed to make appropriate health decisions” by Healthy People 2010 (Department of Health and Human Services, 2000, p. 16). This definition is also used by the Institutes of Medicine (Nielsen-Bohlman, et al., 2004). The American Medical Association (American Medical Association, 2007) recognized and began to address the problem of low health literacy in 1998. Concerns addressed by the American Medical Association included those identified above with additional concentration on: (a) patients’ inability to follow instructions for treatment, (b) high medical expenses incurred by patients with limited health literacy, which can be up to four times greater than patients with adequate literacy skills, and (c) compounding problem of patients hiding their misunderstanding from health care workers because they are too ashamed to ask for help.

Health literacy is a complicated concept, which depends in part on an individual’s capacity to read and can be confounded by the complexity of health care information often provided by the health care system (Baker, 2006). While many health literacy definitions (American Medical Association, 2007; Berkman, et al., 2004; Medical Library Association, 2008) focus on the ability of individuals to acquire and use health information provided by the health care system, Baker (2006) stresses the complexity of the information provided by the health care system as a problem for people with limited health literacy.
Plimpton & Root (1994) identified a gap between the reading level of most adults, approximately eighth grade, and the reading level of health materials, most often above the tenth grade. If an individual’s literacy is limited, then their health literacy is also most likely to be inadequate (Spadaro, 1980). A person with adequate reading comprehension is not necessarily able to understand print health materials, especially if they lack background understandings needed to process the information provided by those resources (Baker, 2006).

While several authors (Gemoets, Rosemblat, Tse, & Logan, 2004; Horner, Surratt, & Juliusson, 2000; Mumford, 1997; Rutledge & Donaldson, 1998; Zarcadoolas, Timm, & Bibeault, 2001) have suggested patient education material should be written between fifth and eighth grade reading levels, Baker (2006) pointed out little research has tested this assumption or gives clear guidance about which reading level is appropriate for print health information for the public.

**Understanding Environmental Health Literacy and Promotion**

Environmental health literacy is defined by the Society for Public Health Education as "the ability to read, understand and act on information regarding the environment." It incorporates concepts from health literacy, such as "the ability to understand, evaluate, and act on oral, written, and visual health information in order to mitigate risk and live healthier lives" (Society for Public Health Education, 2007).

Environmental health concerns both human health and human behavior related to preservation or contamination of the environment. Environmental health problems addressed in this study include cellular responses to ultraviolet light exposure and arsenic
contamination of the drinking water. Individuals and agencies in environmental health promotion invest in the creation of print materials, but there is little knowledge regarding whether or not their target audiences comprehend those materials.

The aim of environmental health promotion is to improve public health by addressing various aspects of social processes and/or physical environments (Schulz & Northridge, 2004). A person’s health status is influenced by their genetic susceptibility and lifestyle as well as their social, economic and environmental circumstances (Nutbeam, 2000). Therefore, it is important for environmental health materials to be written in such a way as to be understandable to the general public. Easily read materials are important to inform people about environmental health issues in order for them to meaningfully involve themselves in the process of planning for solutions to hazardous exposures (Zarcadoolas, Pleasant, & Greer, 2005). For almost twenty years the National Institute of Environmental Health Sciences (NIEHS) and other federal agencies, including the U.S. Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease Registry (ATSDR), have sought to inform the public about effects of environmental hazards on human health. One component of these efforts has been development of consumer level public health materials (Hood, 2006). Problematic characteristics of such print materials include difficult language presented without definitions or explanations, complex sentence structures, and assumed knowledge (Zarcadoolas, et al., 2005).
Conclusion

The prevalence of low literacy, low health literacy, and low environmental health literacy is important for librarians to understand because up to half of all library users might be deemed as having low literacy (National Center for Education Statistics, 2010). Libraries are in a position to work with other community organizations, health care providers, and environmental health promoters to improve accessibility of materials and to collaborate in health literacy promotion efforts (Burnham & Peterson, 2005). Librarians and other information professionals and providers who understand the prevalence of the problem can play an important role in delivering understandable health information.

The gap, identified for thirty years, between the reading level of the average adult and the reading level of the majority of health materials seems to point to a need of lowering the reading level of health materials. Recommendations have been to write in plain language and easy to read text. However, most of the information disseminated continues to be written at upper high school or college reading levels (Baker, 2006; Peerson & Saunders, 2009; Srinivasan & Dearly, 2004). The long held assumption has been the average reader could not comprehend information written at these higher levels.

The current study sought to understand this reading level gap in an environmental health context, aimed to provide suggestions about the reading level of materials to be disseminated to the public, by federal agencies and environmental health professionals, and to address how those materials may be constructed. Findings of this study indicate
the mismatch problem may be overstated. There may be reasons people do not read disseminated materials other than difficulties with comprehension.
CHAPTER TWO – LITERATURE REVIEW

Low Literacy

Literacy capacity is more than the ability to decode words on a page. It entails an individual’s ability to also understand words and concepts described by those words (Department of Health and Human Services, 2000). Low literacy is a pervasive and under-recognized problem in health care. Almost half of American adults have deficient literacy skills, with approximately 21% being functionally illiterate, and another 27% having marginal literacy skills (Williams, Weiss, Davis, Michielutte, & Askov, 1998). The match or mismatch between an individual’s reading fluency, vocabulary, background knowledge, and their written communication requirements would be a measure of an individual’s total literacy in a given situation.

Health Literacy

Written health literacy is a set of skills and abilities a person has to effectively navigate health information, health care personnel, and the health care system, which depends upon an individual’s health-related reading fluency, health-related vocabulary, and familiarity with health concepts presented in materials (Department of Health and Human Services, 2000).

The 1993 National Adult Literacy Survey reported 44 million adult Americans could not read or write well enough to meet the needs of everyday living and working and suggested low literacy may be a barrier to receiving adequate healthcare (Kirsch, Jungeblut, Jenkins, & Kolstad, 2002). An improvement in literacy was not shown with the 2003 National Assessment of Adult Literacy (National Center for Education...
Statistics, 2010). Only twenty-eight million American adults, or 13%, read at a Proficient level in both assessments, which is equivalent to or below the level of most health materials (National Center for Education Statistics, 2010). Davis and his associates (Davis, et al., 1990) indicated patient education materials required at least high school reading level, which was a confirmation of earlier work by Spadaro (1980).

According to the American Medical Association (2007), health literacy includes reading and numerical tasks needed to function in health settings. According to the Institutes of Medicine even very literate people may have trouble obtaining, understanding, and using health information because it is difficult to grasp complex vocabulary and compound complex sentences typical in such information (Nielsen-Bohlman, et al., 2004).

Examples of other ways low literacy influence health outcomes include, individuals having difficulty reading and understanding (a) hospital discharge instructions, (b) medication labels, (c) patient education materials, (d) consent forms, and (e) health surveys (Baker, et al., 2002). In clinical settings inadequate health literacy contributes to poor compliance, uncontrolled chronic disease, and rising health care costs. A 2004 report on health literacy by the Agency for Healthcare Research and Quality concluded low reading skills and poor health are clearly related (Berkman, et al.). The public health profession promotes improving health literacy related to reducing inequities and improving health by empowering both individuals and communities to make informed decisions about their health (Pleasant & Kuruvilla, 2008).

Zarcadoolas and Pleasant (2005) describe four domains of health literacy. These
are fundamental literacy, science literacy, civic literacy, and cultural literacy. The first domain includes: fundamental literacy, concerns reading, writing, speaking and numeracy, which includes the ability to understand written words and concepts implied by the words. The remaining three domains take the concept of health literacy beyond reading. The science literacy domain includes knowledge of fundamental scientific concepts and understanding science including awareness of the process of science. The civic domain is related to the power relationship between the health provider and the patient or receiver of health information. It also relates to the ability of citizens to become aware of public issues and to become involved in both private and public decision-making processes. The concept of cultural literacy, taken from Kreps and Kunimoto (1994), refers to the ability to recognize and use collective beliefs, customs, world-view and social identity in order to interpret and act on health information.

Nutbeam (1998a) identified improved health literacy as an outcome of effective health promotion and health education. He describes health literacy competencies as going beyond the ability to break the written code, to making meaning, using the text to understand the world, and critiquing text for its applicability to an individual life and society. He proposed that health education should develop health literacy in three ways, communication about health information, development of personal health related skills, and empowerment to improve personal and community health.

A health literacy baseline was established with the 2003 NAAL, the first large-scale national assessment in the United States to measure health literacy. Health literacy is defined as the “ability to use literacy skills to read and understand written health-
related information encountered in everyday life” (National Center for Education Statistics, 2006) in the NAAL. As can been seen from Figure 2: Percentage of Adults in each Health Literacy Level, the majority of adults, 53%, had Intermediate health literacy. About 22% had Basic, 14% had Below Basic, and 12% of adults had Proficient health literacy“ (Kutner, 2006, p. v).

Figure 2: Percentage of Adults in each Health Literacy Level (Department of Health and Human Services, 2008)

Highest concerns have been for the 14% of the American public who had a health literacy level of Below Basic because they can do no more than the most simple and concrete literacy skills (National Center for Education Statistics, 2010), similar to fourth or fifth grade reading level. For example they can read a set of short instructions, and identify what is permissible to drink before a medical test (Office of Disease Prevention and Health Promotion, 2008). Groups at risk for health literacy problems are the poor, the
elderly, those who had not completed high school, and without health insurance.

Concerns are also for those whose health literacy levels are Basic and Intermediate, over 74% of the population, because neither of these groups were thought to comprehend health information easily because of the high reading level of such materials. People with Basic health literacy can read and understand information in short, commonplace texts, and simple documents, and to solve simple, one-step problems when the arithmetic operation is specified or easily inferred. While people with Intermediate health literacy can read and understand moderately dense, less commonplace texts, as well as summarize, make simple inferences, determine cause and effect, and recognize the author’s purpose, and can use it to solve mathematical problems that are more complex, they can only make simple inferences about the information, thus continuing to interfere with their ability to make use of the information to understand or improve their health or prevent health problems (Kutner, 2006).

Although the recommendation for literacy assessments to be done by physicians was first introduced in 1990 (Davis, et al.) comprehensive direct measurement of health literacy is impractical for most clinical and health information settings or health promotion projects (Pleasant & Kurtz-Rossi, 2005). However, in a research setting, it is possible to measure individuals’ health reading fluency and vocabulary using established tools such as the Newest Vital Sign (Weiss, et al., 2005). Their health knowledge regarding a specific health topic can be tested as well. It is also possible to measure the complexity, reading level, and difficulty of written health materials regarding the same topic, using established methods such
as the Flesh-Kincaid or Flesch Reading Ease Scores (RFP Evaluation Centers, 2010a, 2010b).

**Public and Environmental Health Literacy**

Healthy People: 2010 (Department of Health and Human Services, 2000; Spengler & Falk, 2002) describes environmental health disparities as related to low health literacy because difficulties in the ability to read and understand health and environmental materials is related to personal health, navigating the health system, and understanding effects of environmental hazards on individual health (Agency for Toxic Substances and Disease Registry, Center for Disease Control and Prevention, & National Institute of Environmental Health Sciences, 2000). Improving environmental health literacy concerns improving health and reducing inequities by empowering both individuals and communities to make informed decisions about their health and the health of their communities and environments.

Pleasant & Kuruvilla (2008) address the importance of health literacy to understanding problems of public health, which underlies much of the burden of disease and which is charged with promoting global health, including environmental health. With any public health information it is important to reach a general audience at a level that promotes their understanding, while not hindering better informed or educated people (Pleasant & Kuruvilla, 2008). This is especially true of environmental public health information because it is disseminated broadly and usually not to a specific audience (Zarcadoolas, 2006; Zarcadoolas, et al., 2005).

According to Nutbeam (2000) public health interventions that have relied
primarily on print communication have failed to achieve substantial and sustained results in terms of behavior change (p. 260) because of the simplicity of previous approaches. He describes efforts needed to create more sophisticated health promotion campaigns to target both individual behaviors as well as public policy and underlying social and environmental determinants of that behavior, which influence behavior indirectly. He gives the example of reduction of tobacco use through efforts to communicate risks associated with tobacco use and benefits of avoiding its consumption alongside strategies to reduce demand through restrictions on promotion and increases in price, to reduce supply by restrictions, especially to minors and to create social unacceptability through environmental bans (p. 261).

Nutbeam (2000) describes healthy environments as those that consist of environmental, economic and social conditions that can both directly impact health as well as support healthy lifestyles. He suggests health promotion outcomes represent personal, social, and structural factors that can be modified in order to change determinants of health, one of which is health literacy. From this perspective, health literacy can both be a determinant of health or a result of health promotion and includes personal, cognitive, and social skills that determine an individual’s ability to gain access to, understand and use information to promote and maintain good personal and community/environmental health. Outcomes of health literacy can include improved knowledge, changed motivations, and improved health effectiveness related to health education activities (p. 263). For Nutbeam, health literacy includes functional literacy as well as the ability to communicate and interact with, as well as critically evaluate
information from the health system. He proposes strong alliances between educational and health elements of society to improve health literacy.

Policy suggestions from the Office of Disease Prevention and Health Promotion (2008) include: (a) Setting universal guidelines about information access and design, (b) changing the way health information is designed and delivered, and (c) encouraging professional health care provider organizations to distribute understandable materials for their members to use with their patients and families.

**Materials for Print Health Literacy**

Characteristics of text that create reading ease are labeled as plain language. The World Health Organization suggests open and transparent communication is crucial process in health promotion activities because social mobilization for health promotion needs effective communication strategies (World Health Organization, 2006). Plain language refers to communication that engages and is accessible to the intended audience (Stableford & Mettger, 2007). "For text-based information, it means using evidence-based standards in structuring, writing, and designing to create reading ease" (p. 77). Writing at accessible reading levels, which have yet to be determined, is only one of the approaches needed to make sure materials are easy to read and understand. There remain misunderstandings about what plain language is and how to write in ways that contribute to effective communication.

Plain language writers decide on key messages to include, and delete unnecessary descriptive, bureaucratic, or jargon-filled language. They use words that are commonly understood, rather than difficult abstract terms and concepts. A friendly, conversational tone is used to engage the reader, rather than a formal,
scholarly tone that distances the reader. Skilled plain language writers strike a balance between scientific information and the consumer’s needs and interests. They work closely with content specialists to ensure that the accuracy of the scientific information is retained (Stableford & Mettger, 2007, p. 79).

The need to write or re-write health materials into plain language is addressed by Rudd and colleagues (2004). They suggest (a) assessing consumer's understanding of materials, (b) modifying them based on the results of the assessment, (c) using a twelve step process rewrite materials assessed to be written at too high a level, and (d) to reassess health promotion documents with members of the intended audience (Rudd, Comings, & Hyde, 2003). Their findings also suggest public health professionals need to focus more research on health literacy and that core public health instruction should include health communication and literacy ideas, concepts and skills (Rudd, et al., 2004).

Instead of writing in plain language the early focus was on developing methods for assessing patients with informal and formal methods of screening for reading and comprehension in English and Spanish include the Rapid Estimate of Adult Literacy in Medicine, the Wide Range Achievement Test-3, the Cloze procedure, the Test of Functional Health Literacy in Adults, and others. However, such tools are time consuming to administer and can be intrusive to patients (Baker, 2006; Williams, et al., 1998).

While there is a need to coalesce different perspectives, clinical, public health, and adult education and to develop guidelines to help professionals successfully and ethically address both public health and clinical concerns (Pleasant & Kuruvilla, 2008),
the method to bring these perspectives together is not yet established.

**Baker Model of Health Literacy**

David Baker (1999, 2002, 2006) proposes that health literacy depends on characteristics of both individuals and the health care system. He describes the difficulty people have understanding health and public health professionals and suggests a “universal precaution” of a single, standard recommended reading level for materials (Baker, 2006). Universal precautions are infection control techniques to be followed with every patient, by treating them as if they are infected and therefore precautions are taken to minimize risk. Essentially, universal precautions are good hygiene habits, such as hand washing and use of gloves and other barriers, correct sharps handling, and aseptic techniques. Baker extends the concept of universal precautions by suggesting an alternative to formal literacy screening, for health professions to “assume that all patients experience some degree of difficulty in understanding health information,” (Baker, 2006, p. 881) and use plain language and multimedia communication tools to improve communication with patients.

The Baker model of health literacy (2006, p. 879), Figure 3, Baker Health Literacy Model, presents a conceptual framework for understanding domains of health literacy and the relationship of health literacy to health outcomes, suggesting terms to describe these domains. Baker’s view of health literacy is dynamic. The model describes verbal and written domains and influences on individuals from their culture, their education and their relationship to change, which might influence their ability to use new information to improve their health. The model has a written domain, addressed in this
study and a verbal health literacies domain, which is beyond the scope of this study.

Baker (2006) describes the interaction between an individual and the health care system and professionals as falling into two zones: individual capacity and complexity of materials. The latter zone concerns the capacity of the health system to clearly express information about health conditions. Baker identifies two sub-domains of an individual’s print health literacy capacity. The first, reading fluency, the ability to mentally ally process written materials and form new knowledge, allows an individual to expand his or her vocabulary and to gain conceptual knowledge. The second, prior health knowledge, having existing information before reading health-related materials, includes vocabulary and conceptual understanding of health and health care. This knowledge is a resource a person has, which facilitates health literacy but does not in itself constitute health

Figure 3: Baker Health Literacy Model (Baker, 2006, p879)
According to the Web of Science, the 2006 Baker article, “The meaning and the measure of health literacy,” has been cited fifty one times with six articles addressing the issues identified in the model of health literacy. Each article addresses concepts concerning relationships among individual capacities, health-related print and oral literacy, and health outcomes. These articles can be broadly categorized as supporting and adding to the Baker model, including expanding the domain of individual capacity and discussing implications of health literacy to public health, which address issues of complexity and difficulty of health related materials produced by the health system. All the articles suggest additional research is needed to identify which characteristics of low-literate patients influence the ability to learn health information.

Cho and colleagues (Cho, Lee, Arozullah, & Crittenden, 2008) support connections between literacy and health. They indicate improving health literacy may lead to a reduction in the use of expensive hospital and emergency room services among elderly patients, which Baker addressed in earlier work (Baker, et al., 2002).

Andrulis & Brach (2007) found strategies to improve health literacy for low-literate individuals are distinct from strategies for helping people from other cultures and those who have limited English proficiency. This distinction is important because it recognizes the difference between not being able to read well and not sharing cultural or linguistic backgrounds. The former concerns helping people who cannot read and the latter does not assume people from other cultures cannot read, just that they have little or no experience with reading English.
One research group (Pandit, et al., 2009) found low health literacy had a direct negative impact on information seeking and an association between health literacy and self-efficacy. Their findings suggest additional challenges to developing accessible and effective health promotion materials related to self-esteem, motivation, and desire to get new information.

The Kandula group (2009) suggests a third domain of health related multimedia literacy to health related print and oral health literacies. Their findings support combining the multimedia education programs with other education methods and suggest this approach may improve comprehension and learning among those with low literacy.

Nutbeam (2008), who has written extensively about health literacy (Nutbeam, 1998a, 1998b, 2000, 2008; Nutbeam & Kickbusch, 2000), expanding the domain of individual capacity by describing two distinctive concepts that reflect health literacy on an individual basis, as a clinical risk or a personal asset, thus adding a new aspect, asset, as a health literacy domain, proposing a change in physician perspective from individual’s deficiencies to focusing on their proficiencies? This simple change may help some in clinical practice view their patients differently.

**Lindsey Adaptation of the Baker Model of Health Literacy**

For this study, the Baker model was adapted to expand upon the section of the model titled “Complexity and Difficulty of Printed Messages, “ the gray highlighted zone of the Baker Model in Figure 3: Baker Health Literacy Model, which addresses the capacity of the health care system to communicate clearly.
The adaptation of the Baker model, Figure 4: Lindsey Adaptation of Baker Model, stresses contributions of the health care system to difficulties people have with information created by health care and health promotion professionals. The adapted and expanded model describes steps to minimize communication difficulties. The lightest gray components are elements from the original Baker model. The mid gray components were added to the model to identify Baker’s suggestion for a universal precaution. The darkest gray components are elements added for this study to expand the model by describing approaches to take, compiled from the literature, to write or rewrite content into plain language. These augmentations define universal precautions as writing or rewriting text into plain language, with (a) uncomplicated sentences, (b) short paragraphs,
(c) minimal technical terms, and (d) a small glossary of technical terms the author could not simplify, (e) while addressing only the most important aspects of the subject matter.

**Written Health Communication**

Complicated text makes health information difficult to understand for even some well-educated people (Office of Disease Prevention and Health Promotion, 2008). Even people with strong literacy skills can face health literacy challenges such as when they: are not familiar with medical terms or how their bodies work, have to interpret numbers or risks to make a health care decision, are diagnosed with a serious illness and are scared or confused, or have complex conditions that require complicated self-care. Aspects of a health material, the literature indicates contribute to the comprehension problem, are: (a) complex text, (b) with long sentences and (c) few or no definitions of scientific terms. The model in Figure 4: Lindsey Adaptation of Baker Model, describes a method of accomplishing universal precautions to increase the probability that individuals will be able to read and comprehend health materials and gain and apply new knowledge.

There are several lines of reasoning against translation of health and scientific information to a “universal precaution”. They are:

1. It is difficult, it is time consuming, and it costs too much (Smith, 1992).
2. Mumford (1997) says the cost associated with writing materials at an easy to read level is an expensive waste of resources.
3. Others bemoan the erosion of science (Hargreaves & Ferguson, 2000), and call such efforts the “dumbing down of materials” (Ernst, 2005).
4. Still others state that health writers do not understand the need nor do they know how to translate complicated information (Plimpton & Root, 1994).

5. Some are afraid there may be legal consequences of not using the most precise and comprehensive language to communicate concepts (Doak, Doak, & Root, 1996).

6. Finally, there are challenges to health providers to simplify their words and yet produce something that does not sound belittling or condescending (Mumford, 1997).

The argument in favor of translating environmental health materials to a universal precaution or reading level compatible with reading abilities of average American adults includes a number of factors:

1. There are ethical considerations of the need to inform patients and the public (Mumford, 1997) in language they can understand. This comes under the concept of the public’s right to know health information needed to make decisions that affect their health and the community’s well being.

2. Another argument concerns reducing the reading level to reduce information overload (Ernst, 2005). As Dubay (2004) indicates, if sentences are shorter, people are more likely to read the material disseminated.

3. The finding that low literacy is the single biggest risk factor for poor health outcomes and is related to limited success of health programs (Berkman, et al., 2004) is a powerful argument for writing health promotion materials at a level that the majority of people can understand.
4. Finally, the mismatch between documents available and the public’s ability to read those documents has reduced respect for scientists and medical professionals (Stableford, 2000). This lack of respect may lead to the public not following recommendations from doctors and public health professionals, including environmental health scientists.

Writing easy-to-read materials does not mean writing in a childish way. It means using an adult format while making the information as easy to understand as possible. This would include not using formats, illustrations, and words usually associated with children’s information. It does include using readability formulas because if the material is not readable, with too dense, with long sentences and technical words then it is useless (Root & Stableford, 1999). Easy-to-read materials help people understand what they need to know and what they need to do to get the care they need (Root & Stableford, 1999). Such materials should be developed and tested with members of the target audience (Rudd, 2004, 2005, Zarcadoolas, 2001).

Proponents of science literacy are also dealing with the gap between scientists and the general public (Bybee, 1991, 1995). They are concerned with people’s ability to build an understanding of concepts from a scientific point of view, their ability to comprehend big ideas of science, and to understand, discuss, persuade others and to take action based on scientific information. “Science literacy cannot be viewed as stacked facts, skills and attitudes but rather as interacting related dimensions of abilities, habits of mind, knowledge and communication” (Hand, Lawrence, & Yore, 1999). Suggestions about constructing meaning and
promoting critical thinking can form scaffolding for creating meaningful environmental health pieces.

**Environmental Health Literacy Promotion**

Diseases associated with environmental exposure are often chronic, such as asthma and lead poisoning. Environmental pollution disproportionately impacts poor communities and communities of color in the United States (Scorecard, 2005). The U.S. Department of Health and Human Services describes environmental health in Healthy People 2010 (Agency for Toxic Substances and Disease Registry, et al., 2000; Spengler & Falk, 2002) as those aspects of human health, disease, and injury that are determined or influenced by factors in the environment.

Environmental health science includes the study of direct pathological effects of various chemical, physical, and biological agents as well as effects on health of the broad physical and social environment, which includes housing, urban development, land-use and transportation, industry, agriculture and pesticide exposure, as well as the air and water pollution and soil contamination resulting from those factors (Morrone, 2003, 2006; Morrone, Tres, & Aronin, 2005; Srinivasan & Dearry, 2004).

Environmental health effects are the end result of a complex set of factors, necessitating treatment of individual cases, reducing human exposures, and long-term societal action directed at reducing driving forces that generate toxicological threats. Public awareness of environmental health problems and understandable environmental public health messages are important for creating the community's
will to work on environmental problems over time (Corvalan, Kjellstrom, & Smith, 1999).

A basic tenet of environmental public health is the "Precautionary Principle" (Foster, Vecchia, & Repacholi, 2000; Kriebel, et al., 2008), which prescribes creating policy and taking action in the face of uncertain risk, shifting the burden of proof to the proponent of the potentially harmful activity, exploring alternatives to possibly harmful actions, and participatory decision-making methods with the public. The precautionary principle takes the life cycle of products or chemicals into account and adds proactive steps of pre-market analysis of environmental harm (Green & Kreuter, 1999; Homsted, 2007; Kreuter, De Rosa, Howze, & Baldwin, 2004). Environmental health professionals promote healthy communities by teaching the precautionary principle and by creating materials for public understanding of environmental hazards. If the public does not read informational materials they cannot effectively participate in public policy or in activities, which oversee environmental cleanup.

Differences in susceptibility to environmental hazards may be attributable to age, gender, previous concomitant exposure, economic status, race/ethnicity, or genetic endowment. Through identification of individuals and groups at greater risk, environmental public health professionals can use primary and secondary prevention activities to protect susceptible individuals and communities from adverse exposures and environmentally related disease (Chalupka, 2005). Understanding one’s personal susceptibilities is important in making decisions
about personal behavior. Some environmental public health promotional campaigns target susceptible groups or gives messages to help people understand their personal risk. If messages are not understood they do not have the possibility of helping people change behavior.

The collective response to an environmental exposure can either reduce or exacerbate that hazard’s impact on health. Specific actions to strengthen community capacity include: (a) increasing access to accurate science; (b) building strong relationships among communities, environmental health researchers, and local health departments; and (c) supporting political reforms that level the playing field for communities seeking to challenge corporate or government practices (Freudenberg, 2004). Strategies for environmental health education involve multi-tiered training approaches that include (a) community residents, (b) parent education, (c) direct education of children, and (d) community education through professional counselors. Through train-the-trainer approaches community members can learn and be involved with (a) research design, (b) data collection and analysis, and (c) dissemination of results in order to make intervention strategies more effective (Claudio, Torres, Sanjurjo, Sherman, & Landrigan, 1998). Effective print materials are needed to inform the public and policy makers about all these aspects of environmental health science.

Environmental health promotion can be defined as any planned process employing comprehensive health promotion approaches to assess, correct, control, and prevent those factors in the environment that can potentially harm the health
and quality of life of present and future generations (Howze, et al., 2004). Srinivasan and Darry (2004) describe five main features of environmental health promotion efforts, which require effective communication tools: (a) Enhancing community capacity by bridging the communication gap between community members and researchers, (b) Creating community-university partnerships to address environmental health problems, (c) Increasing community member awareness about environmental health issues, (d) Using innovative techniques in intervention design and when assessing intervention effectiveness, and (e) Advocating for change in public health policy (Srinivasan & Darry, 2004, p. 529).

Environmental health problems are addressed on two levels, individual and community. Disciplines of sociology and epidemiology suggest conceptual frameworks for understanding disparate environmental exposures, health inequalities, and strategies for environmental health promotion (Schulz & Northridge, 2004). Each of the following theories suggest ways to understand how individuals, communities, and environmental health professionals might understand how environmental health issues affect them and how to develop programs to deal with problems.

McLeroy and colleagues (1988) describes an ecological framework of five individual and environmental factors that can influence behavior and health: (a) Intrapersonal / individual - knowledge, attitudes, and behaviors, (b) Interpersonal - family, social networks, (c) Institutional - voluntary organization, workplace, (d) Community - relationships between organizations, institutions, and informal networks,
and (e) Public policy - local, state, and national laws and policies (McLeroy, Bibeau D, Steckler A, & K, 1988, p. 355).

Designing interventions simultaneously at all levels within an ecological framework is daunting and may be logistically unrealistic. Robert Goodman and his colleagues (1998) suggest designing activities to meet long-term environmental health promotion goals by focusing on high impact factors that are most problematical and/or will lead to the most likely success. One example of such an approach is to target topics by the time of year, asthma and allergies in the spring, sun safety in the summer and carbon monoxide poisoning awareness in the winter, when space heaters are used.

The Stress Process Model focuses attention on stressors. Environmental demands can tax or exceed the adaptive capacity of an organism, which result in psychological and biological changes that may place persons at risk of disease (Cohen, Kessler, & Gordon, 1997). The Ecological Stress Process Model for Environmental Health Promotion suggests there are five categories of stressors: (a) ambient environment, (b) major life events, (c) daily hassles, (d) chronic strains, and (e) cataclysmic events (Parker, Baldwin, Israel, & Salinas, 2004). The presence of environmental toxins and hazards can lead to any of these stresses.

Health promotion intervention strategies need to target a range of outcomes and occur at multiple levels using a social ecological framework (Howze, Baldwin, & Kegler, 2004; Parker, et al., 2004). Easy-to-read literature, for low literacy readers, is needed to promote environmental health for individuals and communities (Kegler & Miner, 2004; McDermott, et al., 2003; Morrone, et al., 2005) especially as
environmental health disparities often affect people who have inadequate literacy, including minorities and the poor.

A significant part of the work of an environmental health professional is communication of information to clients, customers, patients, family members, and the public in the context of safety and health promotion or as an adjunct to enforcement activities. While a wide range of communication methods is available today, printed material is still an important communications medium for environmental health departments and environmental quality professionals. Harvey and Fleming (2003) demonstrate a mismatch between the estimated reading level of target audiences and the reading level of printed brochures and suggest an ongoing need for better tools for environmental health departments seeking to maximize their effectiveness.

Ken and Yetta Goodman (Dombey, 2005) describe reading as the active interaction with written words, connecting new information with past knowledge, with inference and guesswork at its heart, and ongoing monitoring to make sense from the words. They also indicate individuals in an encounter with challenging text must look more closely, with a sharper focus on the meaning. In addition, the interactive process of reading can be assisted by graphical and color references that cue the reader about the sections of text (Goodman & Buck, 1997).

Morrone (2003) suggests there is a perceptual gap, lack of understanding of the importance of environmental problems to human health, among policy makers, public health professionals, and the general public, which is hindering the use of
preventive approaches to eliminate disease. This gap is one reason there is a compelling need for the environmental health community to develop and disseminate more effective messages (Morrone, 2003; Morrone, et al., 2005).

Zarcadoolas and her partners (2001) suggest a method of developing environmental health information pieces called, “Cooperative Composing”, which promotes meaningful community environmental health professionals collaborations to learn the types of information the community wants, the language level and graphics that are appropriate to inform the public, and to activate community members to bring about greater quality and collaboration in environmental planning (Zarcadoolas, et al., 2001).

Summary

The problem of low literacy in America has been known for over thirty years and was clearly documented in 1992 with the National Adult Literacy Survey and again in 2003 with the National Assessment of Adult Literacy, which also documented difficulties the majority of Americans experience with health information and with navigating the health system.

A gap exists between the reading level of print health and environmental health materials and the average reading level of health information consumers. Health and public health professionals and promoters have stressed the importance of addressing the problem of the clear mismatch between people and information for both individual health improvement and for the health of entire communities.
The National Institute of Environmental Health Sciences has promoted public education around environmental health issues for over fifteen years. One environmental health literacy project, *Environmental Health Literacy for Low Literate Groups* (Waishwell, 2006), has been awarded research funds jointly by the National Institutes of Health and the National Institute of Environmental Health Science. To date no publications have arisen from the grant.

This current study explored issue of health literacy in the context of environmental health to empirically investigate the gap between the reading level of materials and that of people reading at the average level of adults in the United States.
CHAPTER THREE – METHODS AND MATERIALS

Introduction

This study investigated health literacy reading comprehension, analyzed by gain scores between a pretest and a posttest, identified as PrePost, about two environmental health topics, ultraviolet light and arsenic exposure, by two groups of average readers randomly assigned to read the materials at either a seventh grade (Appendix A: Environmental Health Reading A - Seventh Grade Reading Level - Blue Paper) or twelfth grade (Appendix B: Environmental Health Reading B - Twelfth Grade Reading Level - Green Paper) in an individual interview.

The study materials covered relatively obscure information, concerning arsenic contamination of drinking water and cellular responses to ultraviolet light exposure, to avoid participants receiving high pretest scores based on preexisting knowledge of the topics. Resources were located and selected from authoritative sources to assure their validity, assessed for their original reading level, rewritten to the seventh grade reading level, and vetted by environmental health experts.

Multiple choice questions (Appendix C: Pretest / Posttest - Arsenic and UV Light Exposure) were written from the seventh grade reading materials and compiled into a test which was given to all participants before reading and after reading the assigned materials. The participants were recruited from an agency that tests the reading level of its students in the admission process, to assure the read at least at seventh grade. The resulting data, both within subjects and between groups, was analyzed using the ANOVA technique. Individuals were asked questions (Appendix
D: Questions for Interviews) about the reading materials and the test. The content of the transcribed notes from the interviews was analyzed and used to supplement the quantitative data gathered from test results.

The research was conducted in late 2009 and the first half of 2010. The timeline for its completion is shown in Table 1: Research Timeline. The research began with selecting a study site location. Next were the identification, selection, and analysis of environmental health information materials. The original identified and selected materials were analyzed using Flesch-Kincaid Reading Levels and Flesch Reading Ease Scores and assessed to be written at the twelfth grade reading level. Then the materials were rewritten to a seventh grade reading level. Environmental health research scientists, studying arsenic and ultraviolet light exposure, vetted the selected and rewritten materials before multiple choice questions were written for the pretest / posttest. The wording for the pretest / posttest was selected from the seventh grade reading materials to provide impartiality and for all participants to experience identical tests. The reading materials and pretest / posttest were piloted to ensure correctness and clarity of wording.

Participants were recruited in three class sessions at the selected agency. They were randomly assigned to study groups, which were labeled “Control” for the group that read the original twelfth-grade-level materials and “Treatment” for the group that read the rewritten seventh-grade-level materials. Study sessions were scheduled in collaboration with the agency to be most convenient to participants.
and in an effort to assure few dropouts. Each study session consisted of consenting participants, collecting demographic data, and administering a health literacy assessment using the Newest Vital Sign (NVS) before participants took the pretest, read materials, and took the posttest.

The study was conducted in five study sessions and, after the initial data analysis was completed, by two individual interviews. Statistical analysis was conducted to quantify demographic data of participants and to compare pretest and posttest scores, assessing the impact of the reading level of the materials, participant reading level, and other variables on the difference between the pretest and posttest scores.

Participants for the interviews were recruited by phone and email with seven agreeing to be interviewed leading to three individual interviews being scheduled and two completed interviews. Participant answers to the interview questions were analyzed for patterns of comments and statements.

The remainder of this chapter presents key terms and discusses the overall design of the study, the rationale for site and participant selection, selection and creation of study instrumentation, the pretest / posttest and interview methodologies, and how the study sessions and interviews were conducted.
Table 1

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Research Component</th>
<th>Research Activity</th>
<th>Notes</th>
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<tbody>
<tr>
<td>April 2009</td>
<td>Proposal Approval</td>
<td>Meet with Committee</td>
<td></td>
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<tr>
<td>September 2009</td>
<td>Study site approved by the agency</td>
<td>Meet with the research site administrators</td>
<td></td>
</tr>
<tr>
<td>October 2009</td>
<td>Select and Rewrite Environmental Health Promotion Texts</td>
<td>* Locate materials and reformat the text to be consistent&lt;br&gt;* Rewrite the selected materials to seventh grade reading level&lt;br&gt;* Vet materials with environmental health scientists</td>
<td>Materials located from recognized sources, US Environmental Protection Agency and National Institute of Environmental Health Studies, and vetted with experts in arsenic and ultraviolet light exposure from the Southwest Environmental Health Sciences Center for accuracy of the rewritten materials.</td>
</tr>
<tr>
<td>November 2009</td>
<td>Create and pilot the pretest / posttest</td>
<td>* Create the content pretest / posttest&lt;br&gt;* Pilot the reading materials and pretest / posttest</td>
<td>For pretest / posttest with questions reflecting the reading level of rewritten materials</td>
</tr>
<tr>
<td>December 2009</td>
<td>University of Arizona IRB approval</td>
<td>Study approved by the Institutional Review Board, including permission to re-contact subjects for interviews</td>
<td></td>
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<tr>
<td>December 2009 and January 2010</td>
<td>Individuals who read the texts</td>
<td>Recruit participants, randomly assign to groups and schedule study sessions</td>
<td>Control group read the found material&lt;br&gt;The treatment group read the rewritten material</td>
</tr>
<tr>
<td>January 2010</td>
<td>Conduct study sessions</td>
<td>Administer a pretest</td>
<td>Before pretest consent participants, collect Participant Demographic</td>
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Table 1: Research Timeline

<table>
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<tr>
<th>Date Range</th>
<th>Activity</th>
<th>Description</th>
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<tr>
<td>February and March 2010</td>
<td>Data Analysis</td>
<td>Evaluate the resulting data</td>
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<tr>
<td>May 2010</td>
<td>Individual Interviews</td>
<td>Interview selected subjects</td>
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<tr>
<td>May 2010</td>
<td>Data Analysis</td>
<td>Evaluate the resulting data</td>
</tr>
<tr>
<td>July 2010</td>
<td>Dissertation Defense</td>
<td>Report Study, Findings, and Conclusion</td>
</tr>
</tbody>
</table>

Key Terms

In addition to environmental health, this study addresses arsenic contamination, ultraviolet light exposure, readability formulas, and characteristics of the study reading levels.

Environmental Health

The World Health Organization defines environmental health as the field of study that “addresses all the physical, chemical, and biological factors external to a person, encompassing the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments” (World Health Organization, 2007).

Arsenic

According to the Agency for Toxic Substances and Disease Registry, “exposure to higher than average levels of arsenic occur mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. At high levels,
inorganic arsenic can cause death” (Agency for Toxic Substances and Disease Registry, 2007),

Arsenic is a semi-metal element in the periodic table. It is odorless and tasteless. It enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices. Non-cancer effects can include thickening and discoloration of the skin, stomach pain, nausea, vomiting; diarrhea; numbness in hands and feet; partial paralysis; and blindness. Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. EPA has set the arsenic standard for drinking water at .010 parts per million (10 parts per billion) to protect consumers served by public water systems from the effects of long-term, chronic exposure to arsenic. (Environmental Protection Agency, 2006).

Ultraviolet Light

The sun naturally generates ultraviolet light. A tanning bed emits ultraviolet radiation, with a proportion of 95% UVA and 5% UVB. There are benefits of ultraviolet light but they are not the focus of this research. The American Cancer Society stresses, “too much exposure to UV radiation is thought to be the biggest risk factor for most melanomas. People with high levels of exposure to UV light are at greater risk for all types of skin cancer” (American Cancer Society, 2010).

Ultraviolet (UV) light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays. Sources emitting radiation with wavelengths longer than 200 nm are serious health hazards. Since UV radiation
has such low penetrating power, the effects are confined mainly to the eyes and the skin. The effects on skin are two types, acute and chronic. Acute effects appear within a few hours of exposure while chronic effects are long lasting, cumulative and may not appear for years. Acute effects of ultraviolet radiation are similar to sunburn; the redness of the skin called erythema. Chronic effects include accelerated skin aging and skin cancer” (Akram & Rubock, 2005).

**Readability Formulas**

There are many factors affecting success in reading. Ease-of-reading is the result of the interaction between the text and the reader. When texts exceed the reading ability of readers, they usually stop reading (DuBay, 2004). Readability can be described as able to be read easily. For the reader, factors affecting readability are (a) prior knowledge, (b) reading skill, (c) interest, and (d) motivation. In the text itself, factors include (a) content, (b) style, (c) design, and (d) structure (Gray & Leary, 1935). Readability formulas are widely used to match texts with the reading level of the audience. The readability formulas, when used properly, help increase the chances of successful reading (DuBay, 2004). Readability formulas only address a portion of the issue of readability. For purposes of this study they codify the reading level of the text to compare with the reading ability of the participants. The Flesch-Kincaid Grade Level readability score, used in this study, analyzes and rates text on a U.S. grade-school level based on the average number of syllables per word and words per sentence.

**Reading Levels**
While adults cannot be compared with children in terms of maturity and ability to understand adult concepts it is possible to compare the reading level of adults to the expected reading ability of people with a seventh grade reading level by using educational standards of Arizona for reading. Standards are still a great tool because they focus on underlying skills students develop (Arizona Department of Education, 2003).

People who read at a seventh grade reading level should be able to: (a) Restate the main idea and supporting details in expository text, (b) Summarize the main idea and critical details of expository text, maintaining chronological, sequential, or logical order, (c) Distinguish fact from opinion in expository text, providing supporting evidence from text, (d) Identify the author's stated or implied purpose(s) for writing expository text, (e) Locate specific information by using organizational features in expository text, (f) Apply knowledge of organizational structures of expository text to aid comprehension, (g) Make relevant inferences about expository text, supported by text evidence, and (h) Compare and contrast the central ideas and concepts from selected readings on a specific topic (Arizona Department of Education, 2003).

In addition to all of the above, people who read at the eighth grade reading level should be able to: (a) Locate appropriate print and electronic reference sources, (b) Differentiate between primary and secondary source materials, and (c) Explain how authors use elements of expository text to achieve their purposes (Arizona Department of Education, 2003).
In addition to all of the above, people who read at a twelfth grade reading level should be able to: (a) Critique the effectiveness of the organization of expository text, (b) Determine the accuracy and truthfulness of one source of information by examining evidence offered in the material itself and by referencing and comparing the evidence with information available from multiple sources, (c) Evaluate the evidence used to support the author’s perspective contained within both primary and secondary sources, (d) Compare and contrast readings on the same topic, by explaining how authors reach the same or different conclusions based upon differences in evidence, reasoning, assumptions, purposes, beliefs, biases, and argument., and (e) Identify an author's implicit and stated assumptions about a subject, based upon evidence in the selection (Arizona Department of Education, 2003)

**Overall Study Design**

The design for this study included quantitative and follow-up interview phases. In the quantitative phase participants were randomly assigned to two conditions, where they read environmental health piece at either the seventh or twelfth grade reading level. Two testing measurements were taken, one before and one after participants read their assigned piece, to evaluate if there were differences between the two measurements and if so to attempt to pinpoint the reason for any differences observed. In the follow-up interview phase of the study, participants were asked questions about their general perceptions about the materials and the
test, to gain an understanding about elements that were clear, confusing, missing, or new to the participants.

Three categories of variables describe characteristics of the study participants in the quantitative phase: independent (IV), dependent (DV), and controlled-for variables (CV). The independent or manipulated variable was the random group assignment for the study session, indicating the reading level of study instrument the participant read. Dependent variables measured in this study are characteristics the investigator observed about the participants’ involvement in the study. The dependent variables are each participant’s: (a) pretest score, (b) posttest score, (c) the PrePost, a measurement of the interaction between the reading level of the materials and the pretest and posttest scores.

The following are the controlled-for variables. They describe the demographics of the sample and address the characteristics the investigator kept the same by randomizing the assignment to the independent variable. The controlled-for variables are: (a) family income level, (b) language(s) spoken at home, (c) age range of the participant, (d) race of the participant, (e) ethnicity of the participant, (f) gender of the participant, (g) participant Newest Vital Sign Score of health literacy, (viii) participant reading level, and (h) the maximum educational level achieved by the participant.

The independent variable for the interview phase of the study was the random selection of participants to be recruited to the interviews and the
dependant variable was the responses to the interview questions, which are discussed in the methodology section.

**Independent Variables**

Independent variables were manipulated by the investigator and were random assignment of the participants to groups, control, treatment, and interviews. The group that read the twelfth grade materials (N=17) was considered the “Control” group because they read materials as they are usually disseminated, as discussed in the literature review (Ross, Moore, Earnest, Wittevrongel, & Lin, 2004). The group that read the seventh grade reading piece (N=18) was considered the “Treatment” group, as they read materials rewritten to match more closely the reading level of the participants (see section on literacy levels below). All of the participants (N=35) were randomly assigned to read either the seventh grade reading materials or the twelfth grade reading materials.

The investigator recruited a selection of three participants to be interviewed. Initially a randomization was performed on line at True Random Number Service (Haahr, 1998). However this randomization procedure was abandoned as the investigator needed to contact all most all of the original participants to recruit three. Of those three, only two completed the interview.

**Dependent Variables**

The first dependent variable was the participants’ pretest scores. The maximum possible score for the pretest / posttest was twenty. The second dependent variable was the participants’ posttest scores. The content of the posttest
was identical to that of the pretest, therefore the maximum score was twenty. The third dependent variable was the effect of the reading level of the materials read on the difference between the pretest score and the posttest score.

**Controlled-for Variables**

Most of the controlled-for variables are straightforward demographic characteristics of the participant sample; (a) family income level, (b) language(s) spoken at home, (c) age range of the participant, (d) race of the participant, (e) ethnicity of the participant, (f) gender of the participant, and (g) the maximum educational level achieved by the participant. Two controlled-for variables require additional explanation of the nature of the assessment method. They are the Curry method the agency, where the participants were students, uses to assess reading level and the Newest Vital Sign (NVS) assessment of health literacy. The agency screens for the reading level, when students enter the training program, using a reading ability test called the “Curry.” It is a brief achievement test measuring reading comprehension and the ability to follow instructions, related to washing hands (Schram, 2010). Students must achieve at least a 7th grade reading level to be accepted to the agencies program, which is measured by a score of 9 on the Curry. The top Curry score is an 11, which measures an 8.5th grade reading level. The participants scored higher reading scores than anticipated with an overall mean Curry reading score of 10.42, equivalent to an 8.1st reading grade level.

**Newest Vital Sign**
Participants’ health literacy ability was assessed, during the study, using the Newest Vital Sign (Appendix E: Newest Vital Sign Score Sheet Form, Appendix F: Newest Vital Sign Answer Sheet, and Appendix G: Newest Vital Sign Nutrition Label). It is considered appropriate for quickly screening for limited health literacy, has been found to be reliable, and to be an accurate measure for identifying persons with limited literacy (Weiss, et al., 2005). The NVS compares favorably to other tests of health literacy in identifying people with limited literacy skills (Osborn, et al., 2007), such as the Short Test of Functional Health Literacy in Adults (S-TOFHLA) and the Rapid Estimate of Adult Literacy in Medicine (REALM). However, the NVS may wrongly label those with adequate literacy when tested by other assessment tools (Osborn, et al., 2007).

The REALM is a word-recognition test that records basic reading decoding skills but does not measure comprehension, which the investigator decided was a weakness because the study was going to measure comprehension. The TOFHLA does measure comprehension but even the short version S-TOFHLA takes over eight minutes to administer. According to Barry D. Weiss, M.D., Professor, Family and Community Medicine, University of Arizona College of Medicine, the instrument’s creator, the NVS measures reading and interpretation skills, general literacy, reasoning, and the ability to use numbers, as applied to material with health content, rather than all aspects of health literacy (Weiss, et al., 2005). Weiss stated in an email on December 9, 2008, “The NVS is a screening instrument designed to estimate if someone has low or adequate literacy. It is not meant to provide a
definitive assessment of a person's literacy skills. The analogy would be a mammogram. It gives an estimate of whether someone might have breast cancer, but you need a more definitive test to be sure.”

The NVS measures reading and interpretation skills (i.e., general literacy, reasoning, and the ability to use numbers) as applied to material with health content, rather than all aspects of health literacy. The purpose of the health literacy assessment was to determine which participants had the probability of having low health literacy rather than to assess their pre-existing level of health information. Therefore, the NVS was chosen as the most expedient and least intrusive assessment and because it assesses for the likelihood of a person having health literacy difficulties, is freely available, has been validated, and was designed to be easy to use (Weiss, et al., 2005).

A score of four or more correct responses are unlikely to have low literacy, whereas fewer than three correct answers indicate the possibility of limited literacy. The investigator performed the assessment in less than three minutes per participant. The NCVS steps are to give participants an ice cream nutrition label (Appendix G: Newest Vital Sign Nutrition Label), to request them to look it over and then to ask questions from the Newest Vital Score Sheet.

**Rationale for Site and Participant Selection**

This study uses a convenience sample, which includes “individuals that are easy to reach” (Simon, 2007). Consequently, the sample for this study was not selected to be representative of the entire population. Participants were recruited at
a local agency that trains certified nursing assistants. Reading scores for the students of the agency were readily available, at least reading at a seventh grade reading level, the national average for adults in the United States. Agency leaders thought the subject of health literacy was very important and they were agreeable to the study design. They took an active role in developing the recruitment and study session schedules. A possible limitation with this pool of participants was their identified interest and probable background information about health related topics. The environmental health topics addressed in this study were sufficiently obscure to mitigate the possibility the participants would have high pre-existing knowledge.

Potential participants were recruited at the orientation session of the upcoming classes of the agency. The investigator recruited participants verbally, with a short speech, see Appendix I: Recruitment Speech, with an accompanying handout, Appendix J: Participant Information Sheet. The investigator introduced herself and her project, gave an overview of her work background, introduced the subjects of environmental health and health literacy and invited them to take part in the study, giving reasons to participate, the number of people who will be in the study, why she chose the agency, and stressing the voluntary nature of their involvement. The activities of the study were enumerated, along with the time requested, risks they would be subjected to, of not knowing the answers, and the modest compensation was explained. In addition the consent process was explained. The potential participants were able to follow the presentation with their
handout, Appendix J: Participant Information Sheet. Students indicated interest in participating in the study by completing and returning the contact information requested on the third page of the handout. The recruitment took place in three sessions. Students were not required to participate by the instructional staff. An administrative staff member introduced the investigator at the recruitment sessions and was available in the offices to assist the investigator with logistical issues. Thus, the participants’ privacy was protected and there was no coercion of their involvement with the study.

All information associated with an individual participant—the health literacy assessment, the pretest and posttest, demographic information, and reading scores—was anonymized with the use of I.D. numbers for the participants, and only the investigator has access to the key correlating participant names to I.D. numbers. Twenty-eight participants were recruited during these sessions. When the study sessions were scheduled the students talked among themselves and an additional twelve participants participated, for a total of forty. Four people who dropped out of the agency classes did not participate in the study. One person was unable to come to any of the scheduled sessions, leaving a total sample of thirty-five participants.

Dates for the study sessions were chosen with the leadership of the agency in order to not interfere with participants’ education or the day-to-day operations of the agency. Thus it was decided to hold sessions on the day of and an hour before cooking classes. Potential participants were contacted by email and then by phone to discuss the possible study session dates. Because of the lack of response to
emails the investigator made phone calls, which yielded good results. During phone calls potential participants were reminded of the recruitment session and the objectives and procedures, reading level disclosure, health literacy test, pretest, posttest, and interviews, of the study, the timeline, the risk, the benefits, the voluntary nature of participation, and that compensation was being offered, a Target gift card, and would be given at the completion of the study.

**Study Sessions**

Study sessions were conducted in four parts after they consented to participate; (a) the health literacy assessment with the Newest Vital Sign, (b) completion of the demographic data sheet and pretest; (c) reading the study materials; and (d) taking the posttest. The study activities took place in the classrooms of the offices of the agency where participants were taking classes, had been recruited and which convenient for participants. The space has provided free of charge to the study. None of the leaders of the agency were present for either the recruitment or the study sessions. Participants consented to participate in the study, Appendix K: Informed Consent - Implications of Literacy Related to Comprehension of Environmental Health Print Materials. The investigator repeated the information and asked the participants to sign the form and bring it to her for her signature. Copies of the document were provided. The six questions of the Newest Vital Sign were asked to individuals or small groups, no larger than five. Each participant had a copy of the ice cream nutrition label and they wrote their answers on an answer sheet. When they completed the NVS they turned it into the investigator and were
given the participant data sheet and the pretest. The participants also completed participant data sheet before taking the pretest.

The participants were instructed to complete the pretest to the best of their ability and to not be dismayed if they did not know the answers. After they completed the participant data sheet and the pretest, they returned them to the investigator and were given the reading materials for their assigned study group. No time limit was set for the time they could take to read the materials. However, a thirty-minute time was anticipated for the entire process and with only one exception the estimate was appropriate. After reading the materials they completed the content posttest. This was an “open book” test with the participants retaining their reading during the test, because that process most closely corresponded to the natural environment of environmental public health outreach activities, where materials are shared and discussed in an open forum, rather than being similar to a classroom with a formal test.

**Study Instrumentation**

The study employed three instruments; (a) to collect demographic data, (b) the reading materials, (c) the reading materials, and a multiple choice test of participants’ knowledge before and after reading.

**Demographic Data**

The demographic data addressed in the Controlled-for Variables section was collected via the Participant Demographics Data Sheet (Appendix. H: Participant Demographics Data Sheet). The information gathered included: contact information,
highest level of education the participant had acquired, their tested reading level, family income level, language(s) spoken at home, age (in small ranges), gender, race, and ethnicity.

**Environmental Health Reading Materials**

The environmental health subjects addressed in this study, arsenic contamination and mechanisms of skin damage from ultraviolet light, were planned to be sufficiently obscure to allay the possibility the participants had high pre-existing knowledge, and therefore a high pretest score. A high pretest score might make the intervention of reading the materials meaningless. Another issue to consider with environmental health information is preconceived notions about the topic, which might interfere with learning from the information in the materials and interfering with the information gained from reading comprehension tests (Johnston, 1984). The materials were developed in several steps; original content was located and selected. The original materials were in the format of a pamphlet and a fact sheet. The text from those materials was processed into a Microsoft Word document, assessed for reading level, rewritten to the seventh grade reading level, vetted by environmental health scientists and pilot tested to assess readability and comprehension. The reading material used in this study was developed from authentic materials located from trustworthy sources for accuracy, with a recent copyright date, 2000 or later, to assure the information was current. The arsenic piece, “Just The Facts For Consumers-Arsenic in Your Drinking Water,” (Environmental Protection Agency, 2007) was taken from the US Environmental
Protection Agency (EPA) and the ultraviolet piece, “UV Light / Reactive Carbonyl and Oxygen Species-Solar UV photons: environmental carcinogens,” (Wondrak, 2005) was taken from the Southwest Environmental Health Sciences Center (SWEHSC), which is supported by the National Institute of Environmental Health Sciences. From experience as an outreach professional, the investigator has come to understand that these topics are not well understood by the general public and did not anticipate the study participants would have a high preexisting knowledge about the subjects. The text of the materials was extracted from the Acrobat files and converted into Word format, exclusive of any graphics from the original documents. They were then formatted to be as close to identical as feasible, except for the reading level, using a 12 pt Times New Roman, a serif font, to reduce confounding the study with variables other than reading level of study materials. Serif font was used because it is more easily read in print (Arditi & Cho, 2005).

The reading level of the materials was determined electronically with the tools available in Microsoft Word, Flesch Reading Ease scores and the Flesch-Kincaid Reading Levels (Rudolph Flesch, 1948; Kincaid, 1975). They were chosen because they are readily available to writers of health and environmental health information who use Microsoft Word. These readability formulas are suggested by Friedman and Hoffman-Goetz (Friedman & Hoffman-Goetz), whose study concluded “readability formulas were found to correlate reasonably well with each other, having high concurrent validity” (Friedman & Hoffman-Goetz, 2006, p. 366). The Flesch Reading Ease Formula is considered as one of the oldest and most accurate
readability measures. Rudolph Flesch, an author, writing consultant, and a supporter of the Plain English Movement, developed this formula in 1948 (Rudolph Flesch, 1948; RFP Evaluation Centers, 2010a). The Flesch Reading Ease Formula is a simple approach to assess the grade level of the reader. It is one of the best-known readability scores, measuring how easily an adult can read and understand a text. Readability statistics are good predictors of the level of difficulty of documents, particularly technical ones (RFP Evaluation Centers, 2010a). Flesch rates text on a 100-point scale based on the average number of syllables per word and words per sentence. The higher the Flesch Reading Ease score, the easier it is to understand the document. Fortunately Microsoft Word calculates the formula for the Flesch Reading Ease (FRE) score, which takes into consideration the average number of words in a sentence and the average syllables per words. Reading ease is described on a scale where fewer words in a sentence and fewer syllables in the words means the piece gets a higher score and is considered easier to read. The scale of the Flesch Scores shown in Table 2: Understanding Flesch Scores from the RFP is an adaptation of one from Evaluation Centers (2010a). The investigator added the Approximate Grade Level column for purposes of this study. The table compares the Flesch Score, with a textual description of the level of ease of reading and an approximate grade level equivalent for that score. The Flesch-Kincaid Grade Level readability score analyzes and rates text on a U.S. grade-school level based on the average number of syllables per word and words per sentence, with a score of 8.0 meaning the text would be understood by an eighth grader (RFP Evaluation Centers, 2010b).
Table 2

Understanding Flesch Scores, Adapted

<table>
<thead>
<tr>
<th>Flesch Reading Ease Score</th>
<th>Indicates Readability Level</th>
<th>Indicates Approximate Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 29</td>
<td>⇒ Very difficult</td>
<td>⇒</td>
</tr>
<tr>
<td>30-49</td>
<td>⇒ Difficult</td>
<td>⇒ 12th+</td>
</tr>
<tr>
<td>50-59</td>
<td>⇒ Fairly difficult</td>
<td>⇒</td>
</tr>
<tr>
<td>60-69</td>
<td>⇒ Standard</td>
<td>⇒ 7th / 8th</td>
</tr>
<tr>
<td>70-79</td>
<td>⇒ Fairly easy</td>
<td>⇒</td>
</tr>
<tr>
<td>80-89</td>
<td>⇒ Easy</td>
<td>⇒</td>
</tr>
<tr>
<td>90-100</td>
<td>⇒ Very easy</td>
<td>⇒ 5th</td>
</tr>
</tbody>
</table>

Note: Approximate Grade Levels were added to provide more descriptions of each Flesch Reading Ease Score level.

Table 2: Understanding Flesch Ease Scores (RFP Evaluation Centers, 2010a)

The Flesch-Kincaid Grade Level test was created by Rudolf Flesch in the 1940’s, and later enhanced by John P. Kincaid (1975). Also known as the Flesch Grade Level readability formula, it takes into consideration (a) the total number of words, (b) the number syllables, and (c) the total number of sentences (My Byline Media, 2008).

Microsoft Word includes a built-in tool to display Flesch-Kincaid Readability scores. Each paragraph must be assessed individually to get a true Flesch-Kincaid readability score and the user should be aware of the semicolons in the piece, as they might make the score artificially low if many are used in the piece. This is because the read out for the Flesch-Kincaid readability score is likely for the last paragraph processed rather than for the entire document. The test in Microsoft Word also treats semicolons as breaks between sentences, like periods, thus a piece
with many semicolons might have a report of a lower reading level than it would have had with other punctuation (Perles, 2009).

The Flesch-Kincaid scores formula has been used in other health literacy studies to assess reading materials. Freda (2005) used the tool to evaluate the readability of American Academy of Pediatrics patient education brochures. As a result of the study, Freda suggests professional associations that develop and market patient education materials should test for readability and publish those readability levels on each piece of patient education so health care providers will know if materials are appropriate for their patients. The Trifiletti study (Trifiletti, Shields, McDonald, Walker, & Gielen, 2006) also used the Flesch-Kincaid Grade Level assessment tool to develop and evaluate written injury-prevention materials for people they assessed to have low literacy skills and concluded that readability is an essential concept for patient education materials.

The original ultraviolet light reading piece was very difficult to read, with a low Flesch Reading Ease score and a high Flesch-Kincaid Grade Level. It was assessed to have an overall Flesch Reading Ease score of 7.1 and a Flesch-Kincaid Grade Level of 12.0. The original arsenic reading piece had a Flesch Reading Ease score of 42.1 and a Flesch-Kincaid Grade Level of 11.5. They two pieces were put into one document, so participants would have only one document to read. It started with the arsenic information and the ultraviolet light information was second. When they were combined into one reading piece, they had a combined Flesch Reading Ease score of 31.5 and a Flesch-Kincaid Grade Level of 12.0, when evaluated by
paragraphs and the reading levels and reading ease scores were averaged.

Reading materials were rewritten from the original twelfth grade reading level to seventh grade reading level, while maintaining the same content. The rewriting of materials was accomplished in an iterative fashion, paragraph by paragraph, with repeated rewrites until the readability of the overall piece was reduced to a Flesch-Kincaid reading level of 7.0 and a Flesch Reading Ease of 65. Perles (2009) suggests the first step to lower the grade level of the text is to break sentences into two whenever possible, replace longer words with shorter ones, and insert additional one syllable word string. Other suggestions (Medline-Plus, 2009) include: (a) use a clear topic sentence at the beginning of each paragraph, (b) follow the topic sentence with details and examples, (c) use the "you" attitude because personalization helps the reader understand what he or she is supposed to do, (d) structure the material logically as some users prefer step-by-step instructions and others may find concepts arranged from the general to the specific easier to understand, (e) emphasize benefits of adopting the desired behavior, (f) make no assumptions about people who read at a low level, (g) maintain an adult perspective, and (h) find alternatives for complex words, medical jargon, abbreviations, and acronyms. When no alternatives are available, (i) spell complex terms and abbreviations phonetically and give clear definitions, (j) keep most sentences short and simple, but use varied sentence length to make them interesting, (k) use the active voice and vivid verbs, and (l) say things positively, not negatively.
Figure 5: 12 Steps for Re-Writing Complex Text to Plain Language (Rudd, et al., 2004)

In addition to following the Perles and Medline-Plus suggestions, the investigator followed steps one through six and nine through twelve of the Rudd and her collaborators describe a (2004) twelve-step process for rewriting public health information in Figure 5: 12 Steps for Re-Writing Complex Text to Plain Language. Steps one through six direct the writer to conduct an initial readability assessment for a base line, highlight and develop options or complex vocabulary, substitute everyday words for multi-syllabic and unusual terms, rewrite all complex sentences and, where needed, substitute two or three sentences, and to rewrite all sentences in an active voice. Because all graphics were removed from the documents and there were no tables in the originals, steps seven and eight were not
necessary. Steps nine to twelve tell the writer to conduct a readability assessment of
the text with each rewrite, to field test: engage panels of reviewers, include
members of the intended audience as key reviewers, and to modify the report as
needed to meet the needs and suggestions of members of the intended audience and
other reviewers. The final step is to avoid the temptation to re-insert jargon or
unusual words. The drafts were iteratively reassessed for readability until the
seventh grade reading level was achieved.

The process of rewriting was sentence-by-sentence and paragraph-by-
paragraph; because of the way Microsoft Word reports the Flesch Reading Ease
scores and the Flesch-Kincaid Reading Levels. The process ended with two versions
of the arsenic and ultraviolet environmental health information reading piece, one,
the original, at twelfth grade reading level and the other, the rewritten, at the
seventh grade reading level. After field-testing, the final revision was used in the
study.

**Pretest / Posttest**

Multiple choice questions (Appendix C: Pretest / Posttest - Arsenic and UV
Light Exposure) were written from the seventh grade reading materials and
compiled into a test given to all participants before reading and after reading the
assigned materials.

**Vetting and Pilot Testing**

The investigator vetted the materials to assure the two versions provided the
same information. University of Arizona Southwest Environmental Health Sciences
Center researchers vetted the materials. One has studied arsenic contamination for over thirty years. The other, who wrote the ultraviolet essay, has studied the effects of ultraviolet light on skin for close to twenty years. Both regularly communicate their research findings to the public and are aware of the difficulty many people have reading highly scientific environmental health materials. Some suggestions were made and followed to improve the text. After revisions, they both agreed the final drafts represented the same information contained in the originals. They also approved the additional revisions to the text after the field-testing of the reading materials.

The researcher conducted a pilot study of study materials, both reading and testing, before they were used in the investigation. It was done with six administrative staff members of the College of Pharmacy, University of Arizona because these people were deemed to be similar in educational level (non college graduates) to the actual study participants. People familiar with the topics were not chosen. Three field test participants read the seventh grade version of the reading materials and three read the twelfth grade version. All took both the pretest and the posttest. The text and test questions were discussed with each of the field test participants. An analysis of the questions was also done to locate ones that were confusing or poorly written. All field testers missed one question. It was rewritten to be more understandable in collaboration with field test participants. With their input some wording changes were made to the reading materials, which were approved by the researcher vetting the materials.
Research Methodologies

The study was conducted with two methodologies, a pretest/posttest methodology to explore the effect of a reading piece on participant performance on a test of knowledge gained, and individual interviews to learn what was clear on the materials and the testing instrument and what wasn’t.

Pretest / Posttest Methodology

This study conducted a randomized pretest /posttest research project comparing two groups and measuring change with pretest and posttest data. The same individuals were asked the same questions twice, before and after reading the study materials. “With a randomized control-group pretest-posttest design, all conditions are the same for both the experimental and control groups, with the exception that the experimental group is exposed to a treatment, whereas the control group is not” (Dimitrov, 2003). This study employed the simplest case of the pretest /posttest comparison group design because it has one treatment group and one comparison group. In this study one group received a new treatment, reading materials written at seventh grade reading level, and the other group receives a treatment that has been used previously, reading materials written at the twelfth grade reading level. The purpose of this design is to allow the investigator to evaluate the new treatment relative to the previously used treatment.

Pretest / posttest designs are widely used in behavioral research, primarily for the purpose of comparing groups and/or measuring changes individuals experience resulting from experimental treatments (Bonate, 2000). This study does
both; compares individuals’ knowledge before and after reading the environmental health promotional materials, and compares a group of participants reading materials at the twelfth grade reading level (Group A) and another group reading materials written at seventh grade reading level (Group B).

The purpose of the pretest is to gain an understanding of the subject’s pre-existing knowledge to be compared with the knowledge identified after the texts are read (Gliner, Morgan, & Harmon, 2003). This design provided quantitative data for measuring comprehension (Kintsch, 1988) from reading selected texts. The premise is participants are able to answer questions on the posttest more accurately than on the pretest based on their reading. A randomized, controlled trial is considered the most reliable and impartial method of determining what interventions work the best. Prior to the pretest, participants were randomly assigned to groups. Random assignment is an important feature of the pretest / posttest comparison group design because the goal of randomization is to produce comparable groups in terms of general participant characteristics that might affect the probable outcome of the research. Randomizing the assignment of participants to two groups is intended to ensure they are as comparable as possible at the start of the study. If at the end of the study, one group had a better outcome than the other, the investigator would have been able to conclude with some confidence that one intervention is better than the other.

The pretest / posttest measurement of change (PrePost) was taken with a multiple-choice reading comprehension test. In such tests participants were asked
to select the best possible answer (or answers) out of the choices from a list. Such tests are widely used by educators to determine how well students are learning (Farr, Pritchard, & Smitten, 1990) and to study reading comprehension (Friedman & Hoffman-Goetz, 2006).

The pretest / posttest was created to reflect the content of the reading materials (Moravcsik & Kintsch, 1993), using the seventh grade text as a source. The format was five true/false and fifteen multiple-choice questions. Half of the questions concerned arsenic contamination and half the questions concerned ultraviolet light exposure. The test was assessed to be at the seventh grade reading level, using the Flesch-Kincaid assessment tool. The questions were field tested with College of Pharmacy administrative employees as describe in the section concerning study instrumentation below.

**Individual Interviews**

Questions used in the individual interviews (Appendix D: Questions For Interview) asked participants about the comprehensibility and utility of the materials for learning about environmental health topics, using a heuristic approach. A heuristic provides a "rule of thumb" based on an educated judgment about the procedure to follow. Established questions served as a heuristic or an aid to the investigator, to guide the discovery about issues related to the materials and to the test, with the objectives of understanding participants’ general perception of the materials and the pretest/posttest. They provided a structure for some follow up questions to more deeply query about the participants’ impressions about
materials. The questions, in plain language, were based on established categories, using plain language, of public health promotion materials (Plimpton & Root, 1994), seeking to learn about: (a) Information overload, (b) Core message not clear, desired behaviors not emphasized, (c) Too many long words and complex sentences, (d) Technical language or jargon, or both, (e) Uninviting tone, and (f) Inappropriate for target audience either in culture or language.

The interviews were conducted in public places, convenient to the participants, and began with a few minutes of conversation to help the participant become comfortable with the situation. The first phase of the interview was an explanation of the purpose of the interview. Next the interviewees read the materials, the twelfth grade first and then the seventh grade. Then each question was asked in order. The interviews were recorded using the AnnoTape software, which turns your computer into a voice recorder (AnnoTape, 2010). The interviews ended with a few minutes of conversation. Both interviews took about an hour from beginning to end. Both participants were enthusiastic about the opportunity to discuss the materials and the test. As one of the interview participants said, “Of course I want to participate, it is really interesting.” Thus the participant interviewees became personally involved in the process and in educating herself about environmental health.

**Data Analysis**

This study used a pretest / posttest methodology to compare the difference between pretest and posttest scores, labeled PrePost. These scores were derived
from identical tests, administered both before and after reading print environmental health materials. Participants were randomly assigned to read either a text written at the twelfth grade reading level or a text written at the seventh grade reading level. This pretest / posttest method allowed for both a within subjects analysis and a between subjects analysis of the gain of posttest score over that of the pretest score and analysis of covariate variables, the controlled variables. A positive relative change score indicates that the posttest score was greater than the pretest score, whereas a negative relative change score indicates that the posttest score was less than the pre-test scores (Carmines & Zeller, 1979).

**Analysis of Variance – ANOVA**

ANOVA is a general methodology used to identify and measure the various sources of variation within a collection of data, for partitioning the total variation of a data collection into its component parts among the controlled variables, and for exploring differences in mean values of a dependant variable, which are associated with different values of the independent variable (Kachigan, 1991). The procedure is used for identifying if observations are independent of one another, if there are relationships or interactions among variables, whether those relationships are experimental or correlational in nature, when the investigator is interested in uncovering the fact that two variables are related (Kachigan, 1991). Initially it was thought the effect of reading level, health literacy level, educational level, age, race, ethnicity, income level and gender might affect the results of the PrePost scores. These were tested using ANOVA to evaluate if there was a significant effect of these
variables as covariates and they were found to be non significant and were not included in subsequent analysis.

**Content Analysis**

Content analysis of the interview transcripts was performed, using a text mining approach with HyperResearch software (ResearchWare, 1997a), which derives high-quality information from text.

**Summary**

This research study measured the comprehension of two groups randomly assigned to read materials. The readings concerned two environmental health topics, arsenic contamination of drinking water and ultraviolet light exposure from authoritative sources to assure their validity. The learning was measured with multiple choice questions written from the seventh grade reading materials and compiled into a test that was given to all participants before reading and after reading assigned materials, a PrePost design. Thirty-five participants were recruited from a local agency that tests the reading level of students it teaches to assure they can read adequately, defined as at least the seventh grade reading level. One group of eighteen participants was assigned to read environmental health materials assessed to be written at the seventh grade reading level, labeled the treatment. The other group of seventeen participants was assigned to read materials with the same content written at the twelfth grade reading level.
Two of the participants also discussed the reading materials and the test in one-to-one interviews with the investigator by reading both sets of materials and being asked a prescribed set of questions.

The data resulting from the pretest / posttest was analyzed using the ANOVA technique, both for the difference between individual scores and to compare the two groups, which is addressed in Chapter 4: Data Analysis and Findings, which also discusses the analysis of the transcribed notes from the individual interviews.
CHAPTER FOUR – DATA ANALYSIS

The current study investigates one aspect of health literacy, the impact of fundamental literacy, reading, writing, speaking and numeracy (Zarcadoolas, et al., 2005), on comprehension of environmental health materials about arsenic and ultraviolet exposure. The investigation measured the extent to which individuals with average reading skills comprehend environmental health information by conducting a pretest / posttest study and by interviewing some participants to gain their comments about the research tools.

Introduction

The investigation conducted a mixed between and within subjects ANOVA using a General Linear Model Repeat Measures, with SPSS software, to analyze the quantitative data of this study. The between subjects variables were the reading level of assigned materials and the within subjects variables were the scores on an identical pretest and posttest. The test measured a significant effect between the pretest scores and posttest scores of individual participants. However it did not measure a significant effect between the group who read seventh grade reading materials and the group that read the twelfth grade reading materials.

Content analysis of the interview transcripts was performed, using a text mining approach with HyperResearch software (ResearchWare, 1997a), which derives high-quality information from text. Examination was conducted on interview transcripts to analyze the content of the transcripts. The interviewees clearly described the seventh grade reading level piece as more readable than the
twelfth grade reading level piece.

Description of Participants

Characteristics of the Study Sample

The details of the distribution of characteristics of controlled variables of the participant sample are identified in Table 4: Characteristics of the Study Sample Participants; family income, language spoken at home, age range, race, ethnicity, gender, reading level, health literacy level, and maximum education level attained.

The participants were primarily low income, with 77.1% having a family income less than $20,000, 14.3% having a family income between $20,000 and $30,000 and 5.7% having a family income above $30,000. All the participants spoke English at home with 25.7% also speaking Spanish at home and 2.9% speaking English, Spanish, and French at home. Most (80.1%) of the participants were under the age of 45. The largest age group (22.9%) was between 26 and 30 year old. Three age groups had 14.3% of the participants, 18 to 20, 36 to 40 and 41 to 45. Six participants (19.9%) were between the ages of 46 and 65. The majority classified themselves as white (60%) and there were black participants (8.6%) and American Indian participants (5.7%), with 25.7% not classifying their race. Ethnically 34.3% were non-Hispanic, 42.9% were Hispanic-Mexican and 5.7% were another category of Hispanic (one Caribbean and two from South America), with 17.1% not answering the ethnicity question. The group of participants was primarily women (85.7%) with 11.4% men and 2.9% not answering the gender question.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories of the Variable</th>
<th>Variable Code</th>
<th>Frequency of the Variable</th>
<th>Percentage of each Category of the Variable</th>
<th>Missing Data Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 (2.9%)</td>
</tr>
<tr>
<td>10-20K</td>
<td>1</td>
<td>27</td>
<td>77.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-30K</td>
<td>2</td>
<td>5</td>
<td>14.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-40K</td>
<td>3</td>
<td>2</td>
<td>5.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Language(s) Spoken at Home</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Only</td>
<td>1</td>
<td>25</td>
<td>71.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English and Spanish</td>
<td>2</td>
<td>9</td>
<td>25.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English, Spanish &amp; French</td>
<td>3</td>
<td>1</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age Range of Participants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 (2.9%)</td>
</tr>
<tr>
<td>18-20</td>
<td>1</td>
<td>5</td>
<td>14.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-25</td>
<td>2</td>
<td>3</td>
<td>8.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26-30</td>
<td>3</td>
<td>8</td>
<td>22.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31-35</td>
<td>4</td>
<td>2</td>
<td>5.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36-40</td>
<td>5</td>
<td>5</td>
<td>14.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41-45</td>
<td>6</td>
<td>5</td>
<td>14.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>46-50</td>
<td>7</td>
<td>3</td>
<td>8.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51-55</td>
<td>8</td>
<td>1</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56-60</td>
<td>9</td>
<td>1</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61-65</td>
<td>10</td>
<td>1</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Race of Participants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9 (25.7%)</td>
</tr>
<tr>
<td>White</td>
<td>1</td>
<td>21</td>
<td>60.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>2</td>
<td>3</td>
<td>8.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian</td>
<td>3</td>
<td>2</td>
<td>5.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethnicity of Participants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 (17.1%)</td>
</tr>
<tr>
<td>Not Hispanic</td>
<td>1</td>
<td>12</td>
<td>34.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic – Mexican</td>
<td>2</td>
<td>15</td>
<td>42.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic – Other</td>
<td>3</td>
<td>2</td>
<td>5.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender of Participants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 (2.9%)</td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td>30</td>
<td>85.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2</td>
<td>4</td>
<td>11.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maximum Educational Level Achieved</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th &amp; GED</td>
<td>1</td>
<td>3</td>
<td>8.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11th &amp; GED</td>
<td>2</td>
<td>1</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12th &amp; GED</td>
<td>3</td>
<td>2</td>
<td>5.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School Grad</td>
<td>4</td>
<td>8</td>
<td>22.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some</td>
<td>5</td>
<td>16</td>
<td>45.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tested Reading Level</td>
<td>5.5th grade</td>
<td>7</td>
<td>1</td>
<td>2.9%</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
<td>---</td>
<td>---</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>6.25th grade</td>
<td>8</td>
<td>1</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th grade</td>
<td>9</td>
<td>3</td>
<td>8.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.75th grade</td>
<td>10</td>
<td>6</td>
<td>17.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.5th grade</td>
<td>11</td>
<td>22</td>
<td>62.9%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Newest Vital Sign Score of Health Literacy</th>
<th>2</th>
<th>2</th>
<th>1</th>
<th>2.9%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>8</td>
<td>22.9%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>9</td>
<td>25.7%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>12</td>
<td>34.3%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>5</td>
<td>14.3%</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3: Characteristics of Sample Participants**

The participants were required by the agency, where they were students, to have at least a high school education or its equivalent. Almost 23% of the participants were high school graduates, 17.2% had General Education Diplomas (GEDs), 45.7% had some college and 14.3% had graduated from college or junior college. Thirty of the 35 participants (88.6%) read at seventh grade or above as seen in Figure 6: Tested Reading Levels of Participants. The majority of the study participants (74.3%) were unlikely to have inadequate health literacy, as the mean Newest Vital Sign (NVS) score was 4.34 out of a possible 6, as shown in Figure 7: Tested Health Literacy Levels of Participant. Fewer than three correct answers indicate the possibility of limited literacy and 4 or more suggests it is unlikely to have low literacy (Weiss, et al., 2005). Almost 26% of the participants are likely to have trouble with health literacy as their scores were below 4, which is more than expected from national statistics, shown in Figure 8: Percentage of Adults in Each Health Literacy Level.
Figure 6: Tested Reading Levels of Participants

Figure 7: Tested Health Literacy Levels of Participants
The two study groups were compared for similarity to assess the randomization of the groups, which is important for drawing inferences from the study. From the comparison, shown in Figure 9: Reading Level Comparison of Study Groups, Table 5: Comparison of Treatment and Control Groups, Figure 10: Comparison of Study Groups’ Demographics, and Figure 11: Percentage of Adults in Each Health Literacy Level, it is clear the randomization was effective in producing two groups of similar characteristics.
Figure 9: Reading Level Comparison of Study Groups

The two pretest / posttest groups were very close in size, with the Control group (N=18) being 51.43% of the total of the participants and the Treatment group (N=17) being 48.57%. The two groups had slightly different mean reading levels, but the difference was not significant. The mean reading level of Group A: Control was 7.9844 and the mean reading level of Group B: Treatment was 8.1471, with a total mean of 8.0682 as seen in Figure 7: Reading Level Comparison of Study Groups. The similarities between the two groups are presented in Table 5: Comparison of Treatment and Control Groups and Figure 9: Comparison of Study Groups’ Demographics.
Concerning family income the control group had a mean of 1.33 and the treatment group had a mean of 1.19, where the assigned variable of 1 was
equivalent to between $10,000 and $20,000. Regarding languages spoken at home the comparison was a mean of 1.39 for the control group and 1.24 for the treatment group, where the assigned variable of 1 was equivalent to English only and 2 was English and Spanish. Regarding the race of the participants, the mean for the control group was 1.25 and for the treatment group the mean was 1.29, where the variable assigned to 1 was white. In terms of ethnicity, the means were 1.73 for control and 1.57 for the treatment, where 1 was the variable for non-Hispanic and 2 was the variable for Hispanic/Mexican. The two groups were identical in terms of gender, with a mean of 1.12, where 1 was the assigned variable for female. The analysis of the age ranges of the two groups indicated there was no significant difference between the groups. The mean for the control group was 4.65 and for the treatment group was 3.94, where four was the assigned value for the age range of 31 to 35.

**Study Results**

The distribution of pretest and posttest scores was relatively normal as seen in Figure 11: Comparison of Pretest and Posttest Scores by Study Group. The range of pretest scores was between five and sixteen out of a possible twenty. The overall mean pretest score was 12.14. The range of posttest scores was twelve to nineteen. The overall mean posttest score was 16.23. The mean pretest score for Group A, Control group, was 11.83 and the mean posttest score was 15.78. For Group B, Treatment group, the mean pretest score was 12.47 and the mean posttest score was 16.71.
Figure 11: Comparison of Pretest and Posttest Scores by Study Group

<table>
<thead>
<tr>
<th></th>
<th>Testing Group</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Score</td>
<td>Group A - Control</td>
<td>11.83</td>
<td>2.956</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Group B - Treatment</td>
<td>12.47</td>
<td>2.154</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>12.14</td>
<td>2.580</td>
<td>35</td>
</tr>
<tr>
<td>Posttest Score</td>
<td>Group A - Control</td>
<td>15.78</td>
<td>2.045</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Group B - Treatment</td>
<td>16.71</td>
<td>1.572</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>16.23</td>
<td>1.864</td>
<td>35</td>
</tr>
</tbody>
</table>

Table 5: Descriptive Statistics for Mean Pretest and Posttest Scores by Group

The results describe a positive relative change (Carmines & Zeller, 1979) because the mean posttest scores were greater than the mean pretest scores, as seen in Table 6: Descriptive Statistics for Mean Pretest and Posttest Scores by...
Testing Groups.

**Data Analysis of Pretest/posttest Results**

Basic to data analysis is testing the means of two groups to determine if the difference between them is statistically significant. ANOVA, conducted with SPSS software, extends that procedure by comparing means of more than two groups on a variable of interest (Hall, 2010). SPSS has been among the most widely used programs for statistical analysis in social science since 1968 when it was first released. Market researchers, health researchers, survey companies, government, education researchers, marketing organizations and others use it. In addition to statistical analysis, data management and data documentation are features of the software (Data Center, 2010).

Quantitative analysis was conducted, to analyze the relative change of scores from the pretest to the posttest, using an analysis of variance test (ANOVA), with Repeated Measures. The ANOVA test was selected to determine differences among group averages because there were two important variables of interest, pretest and posttest scores within participants and the reading material assigned to the two study groups. They either read materials at the reading level of those customarily disseminated for public education, twelfth grade, or those who read the materials at the re-written level, seventh grade. The outcomes or variables of interest, in this case, were the gain score between the pretest and posttest and the reading levels of participants in each group.
The Repeated Measures Analysis of Variance test is used when members of a sample are measured under different conditions, such as this study. Using standard ANOVA is not appropriate because it fails to take into account correlation between the repeated measures, violating the assumption of independence (Cann, 2009). When an analysis has both within-subjects factors and between-subjects factors, it is called repeated measures ANOVA with between-subjects factors. If any repeated factor is present, then repeated measures ANOVA should be used (Academic Technology Services, 1997). Repeated measures ANOVA can also be used when sample members have been matched according to some important characteristic. Matched sets of sample members are generated, with each set having the same number of members and each member of a set being exposed to a different random level of a factor or set of factors (Academic Technology Services, 1997), such as the random assignment to two groups, which read different reading level materials. When sample members are matched, measurements across conditions are treated like repeated measures in repeated measures ANOVA. The within-subjects factor was the repeated measures taken on the dependent variable, pretest/posttest gain score, which was taken for all participants across a set of conditions, the controlled variables. The between-subjects factor was the measurement of the dependent variable on two independent groups, the control and the treatment, where each group was exposed to a different conditions, in this case the control read the unaltered materials and the treatment group read the rewritten materials.
Standardized measures of effect are used within the context of ANOVA to describe the degree of relationship between a predictor or set of predictors and the dependent variable; effect size of the relationship, statistical significance, and the F ratio. An ANOVA determines whether these means are statistically significant, meaning the differences are likely not by chance occurrence. Effect size estimates are reported to allow researchers to compare findings in studies and across disciplines (Toriningen, 2010).

Fundamental to the ANOVA technique is the F ratio, which is defined in terms of the variance, allows the investigator to draw conclusions about the larger population from which the sample was taken. The F Score is the actual test statistic, which is the ratio of explained variance to unexplained variance. The F-ratio can be thought of as a measure of how different the means are relative to the variability within each sample. The larger this value, the greater the likelihood the differences between the means are due to something other than chance alone, namely real effects. If the difference between the means is due only to chance, that is, there are no real effects, then the expected value of the F-ratio would be one (1.00) (Stockburger, 1996). ANOVA puts all the data into one number \( F \) and gives us one p (Kirkman, 1996). A large F value yields a correspondingly small p value.

The p value is examined to determine if it meets the criterion for an acceptable level of alpha error. A significance level of 0.05 or less indicates statistically significant differences among the means, which was the value selected for this data analysis. The significance level (labeled "Sig.") interprets the p value. A
0.05 significance level means a 95% certainty (the norm among statisticians) that the differences among the means are meaningful and not the result of random chance. A significance level of 0.06 to 0.99 indicates no statistical significance and that any apparent differences may be due only to chance (Hall, 2010).

**Analysis of Variance - ANOVA**

A between-within subjects analysis of variance was conducted to assess the impact of interventions (Reading at 7th grade, Reading at 12th grade) on participants’ scores on the test across two time periods, before the reading --pretest and after the reading --posttest. Three issues were examined to understand the effect of reading on the posttest results, (a) Within-Subjects Main Effect, (b) Between-Subjects Main Effects, and the (c) Interaction Effect of the first two.

Steps for the ANOVA data analysis are: Step 1: State the research question(s), Step 2: Check assumptions, Step 3: Calculate test statistic, Step 4: Evaluate the result, and Step 5: Interpret the result (Carmines & Zeller, 1979). Steps 1 and 2 were reported above. This section addresses Step 3 - General Linear Model: Repeated Measures and Steps 4 - see Table 6: ANOVA Table: General Linear Model - Pretest / Posttest by Group - Repeated Measures and Figure 10: General Linear Model - Pretest / Posttest by Group - Repeated Measures, and Step 5 will be reported in Chapter 5.

**ANOVA Results**

1. There was a substantial main effect for PrePost, F (1, 33) = 52.172, p < .000, partial eta squared = .613, with both groups showing an increase in posttest
scores over the pretest scores, suggesting reading the Arsenic and Ultraviolet Light piece did have an effect on the results of the posttest.

2. However, there was no significant interaction between Reading level of the reading piece and PrePost scores, F (1, 33) = 2.38, p = .132, partial eta squared = .067. There was no significant effect between reading at 7th grade and reading at 12th grade, F (1, 33) = .066, p = .799, partial eta squared = .002, suggesting no difference in the effectiveness of the two reading level approaches.

The test was found to be effective for measuring the difference between the pretest score and the posttest score, as can be seen in the ANOVA Table 6: ANOVA Table: General Linear Model - Repeat Measures - Pretest - Posttest by Groups. The large F value and the significance level of .000 show that there was a significant difference between the mean pretest and mean posttest scores. The small F value and the significance level of .132 show that the effect of the pretest /posttest difference was no significant between the subjects in the two testing groups. Therefore, the reading level of the materials the participants read between the pretest and the posttest did not have an effect on the difference between the pretest scores and the posttest scores. These same findings are shown by the parallel lines in Figure 12: General Linear Model - Pretest / Posttest by Group - Repeated Measures, the chart generated by the ANOVA repeat measures test. To show a significant difference between subjects and intersection of the lines was anticipated.
Table 6

ANOVA Table: General Linear Model - Repeat Measures - Pretest - Posttest by Groups

<table>
<thead>
<tr>
<th>Tests of</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PrePost</td>
<td>292.484</td>
<td>1</td>
<td>292.484</td>
<td>52.172</td>
<td>.000</td>
<td>0.613</td>
</tr>
<tr>
<td>PrePost * Group</td>
<td>0.370</td>
<td>1</td>
<td>0.370</td>
<td>0.066</td>
<td>.799</td>
<td>0.002</td>
</tr>
<tr>
<td>Error (PrePost)</td>
<td>185.002</td>
<td>33</td>
<td>5.606</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between-Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>10.712</td>
<td>1</td>
<td>10.712</td>
<td>2.382</td>
<td>.132</td>
<td>0.067</td>
</tr>
<tr>
<td>Error</td>
<td>148.34</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: ANOVA Table: General Linear Model - Repeat Measures - Pretest - Posttest by Groups

Figure 12: General Linear Model - Repeat Measures - Pretest Posttest by Group
Content Analysis of Interview Transcripts

Interview audio files were transcribed using HyperTranscribe software (ResearchWare, 1997b), which created text files. Data was extracted from the transcriptions by creating an outline of the transcript, which was based on the questions asked. The next step was to remove articles, conjunctions, passive verbs, conversational terms and other extraneous words. Meaningful text strings remained in an outline format with five subtitles for the reading materials: general, confusing, clear, missing, and new; and three subtitles for the tests: general, confusing and clear. There was also an additional subtitle for general comments about the environmental health topics. The text was analyzed for keywords, keyword density, summaries of the comments in each interview, and by creating summaries of each section of the data.

Keywords were extracted from online documents to summarize the essence of the comments from the interviews were captured in strings of text in an outline. Html files were created and put on the Internet, to conduct the keyword mining and keyword density analysis, as there are many powerful tools online to do keyword extraction. The Google keyword extractor (Google, 2007) produced 199 keywords from the transcripts of two interviews. Nineteen keywords had a density or frequency of more than one and 11 among the more dense keywords were on the lists of both interviewees. Those 19 were assessed to be important in providing a key to the content of the interviews and are identified in Table 8: Keywords Extracted from Interview Transcripts.
Table 7

**Keywords Extracted from Interview Transcripts**

<table>
<thead>
<tr>
<th>Word</th>
<th>Count</th>
<th>Word</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>7</td>
<td>Words</td>
<td>3</td>
</tr>
<tr>
<td>Water</td>
<td>7</td>
<td>Paragraph</td>
<td>3</td>
</tr>
<tr>
<td>Arsenic</td>
<td>5</td>
<td>Technical</td>
<td>3</td>
</tr>
<tr>
<td>Cancer</td>
<td>5</td>
<td>New</td>
<td>2</td>
</tr>
<tr>
<td>Skin</td>
<td>5</td>
<td>Sun</td>
<td>2</td>
</tr>
<tr>
<td>Easier</td>
<td>5</td>
<td>Understand</td>
<td>2</td>
</tr>
<tr>
<td>Read</td>
<td>4</td>
<td>Order</td>
<td>2</td>
</tr>
<tr>
<td>Blue</td>
<td>3</td>
<td>Solution</td>
<td>2</td>
</tr>
<tr>
<td>MCL</td>
<td>3</td>
<td>Abbreviation</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 7: Keywords Extracted from Interview Transcripts*

The green and blue on Table 8: Keywords Extracted from Interview Transcripts, refer to the color of the materials, as the interviewees did not know the reading level of the two pieces. Six terms applied to the subject matter of the reading pieces, water, arsenic, MCL, cancer, skin, and sun. Eleven terms applied to either clear or confusing aspects of the reading materials or the test. From the keyword analysis it can be observed that the interviewees compared the reading documents and focused on both subject matter and format of the pieces.

To more fully understand the essence of the comments from the interviews, a summary report was created using the “AutoSummarize” tool in Microsoft word files. The summaries, Table 9: Summaries of Two Interviews, show similar patterns of focus on both the content and the structure of the materials and provide more detail about what the interviewees considered to be important.
Table 8

<table>
<thead>
<tr>
<th>Summaries of Two Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interview #1</strong></td>
</tr>
<tr>
<td>1. Skin cancer the biggest cancer especially for people with fair skin</td>
</tr>
<tr>
<td>2. Reading explained how arsenic gets into drinking water</td>
</tr>
<tr>
<td>3. Skin cancer part green one unreadable</td>
</tr>
<tr>
<td>4. Green copy kinda choppy</td>
</tr>
<tr>
<td>5. Green copy bad grammar</td>
</tr>
<tr>
<td>6. People short attention span</td>
</tr>
<tr>
<td>7. Green one too long to read</td>
</tr>
<tr>
<td>8. Green one gigantic paragraphs</td>
</tr>
<tr>
<td>9. Blue version less technical terms</td>
</tr>
<tr>
<td>10. Blue one easier to read bout the UV light</td>
</tr>
<tr>
<td>11. Blue one has solutions</td>
</tr>
<tr>
<td>12. Blue one easier to read than the green one</td>
</tr>
<tr>
<td>13. Blue one paragraphs are shorter</td>
</tr>
<tr>
<td>14. Test short only 20 questions</td>
</tr>
<tr>
<td>15. Test straight forward</td>
</tr>
<tr>
<td><strong>Interview #2</strong></td>
</tr>
<tr>
<td>1. Didn’t realize arsenic in the water</td>
</tr>
<tr>
<td>2. Arsenic occurs naturally</td>
</tr>
<tr>
<td>3. That much in my drinking water</td>
</tr>
<tr>
<td>4. Skin cancer stuff scary serious</td>
</tr>
<tr>
<td>5. Interesting ppb of arsenic</td>
</tr>
<tr>
<td>6. Green one used big long words</td>
</tr>
<tr>
<td>7. Green one jargon</td>
</tr>
<tr>
<td>8. Green one technical words</td>
</tr>
<tr>
<td>9. I never use really big words</td>
</tr>
<tr>
<td>10. Skin cancer part was kinda hard</td>
</tr>
<tr>
<td>11. Blue one more valuable</td>
</tr>
<tr>
<td>12. Blue one works better</td>
</tr>
<tr>
<td>13. Blue one was clearer</td>
</tr>
<tr>
<td>14. Blue one big numbers explained</td>
</tr>
</tbody>
</table>

*Table 8: Summaries of Two Interviews*
Both interviewees had more difficulty with the ultraviolet light section, which they both called the skin cancer section, than the arsenic section. One referred to the “skin cancer part was kinda (sp) hard” and the other stated, “skin cancer part green one unreadable.” Although one of the interviewees said “they had covered skin in their class just before” the study, an analysis of the scores on the test questions concerning skin did not show a pattern of high pretest scores,

The comments about the subject matter illustrated the two interviewees learned some points made in the environmental health promotion materials:

1. Comments about the arsenic contamination included: not realizing arsenic can be found in the water, it occurs naturally, in some cases a lot can be found in drinking water and it is measured in ppb. Both also commented that the reading explained how arsenic gets into drinking water.

2. Comments about ultraviolet light exposure lead to comments about skin cancer, which included: skin cancer being the biggest (most common) cancer, especially for Caucasian people or people with fair skin and that skin cancer stuff scary and serious.

Comments concerning differences between the two reading materials addressed the difficulties with the piece written at the twelfth grade (referred to as green in the interview as that was the color it was printed onto) and the ease of the seventh grade (referred to as blue). In discussing the difficulties with the green piece, one interviewee said, “sure makes you want to kinda (sp) skip it.”

1. Comments concerning the “green copy” included that it was: "kinda (sp) choppy”, had bad grammar, too long to read, with gigantic paragraphs, big long words,
jargon, and technical words. One interviewee commented, “people have too short of attention spans” to be able to read the green one.

2. Comments concerning the blue one generally stated it was “easier to read than the green one”, including: it used less technical terms, it was easier to read about the UV light, has solutions, the paragraphs are shorter, was more valuable, works better, was clearer, and that the big numbers were explained.

Comments about the test were largely positive, such as it was short, with only 20 questions, it was straightforward, fair, and followed the reading, which made it easier to answer.

Content of strings of text, based on the entire interview transcripts, were analyzed for distillation of prevailing themes (Lobdell, Gilboa, Mendola, & Hesse, 2005) using HyperResearch (ResearchWare, 1997a), which codes-and-retrieves qualitative data analysis program. The coding system was based on the keywords extracted. Figure 13: Relationships Among Interview Comments was created by HyperResearch software, summing up the comments. “Wording” and “structure” were added to the codes as they summed up of many of the comments. There are four main elements of Figure 13: Relationships Among Interview Comments, showing the following types of information (a) relationships among comments, and comments about (b) the subject matter, (c) the test, and (d) the differences between the green (7th grade reading) and blue (12th grade reading).
As for subject matter, water was used in conjunction with arsenic multiple times and skin was used more frequently than UV light, the term both interviewees used for ultraviolet light. The comments about the test aggregated around straightforward, followed the reading, and fair.

The types of comments about the two readings were different. Both interviewees were able to describe specific characteristics about the green (twelfth grade reading level), which were coded wording, structure, and grammar. However, neither was able to give specifics about the blue (seventh grade reading level) one that made it more readable. Rather they described it in more general terms, one of the codes applied. The other two codes for the blue version were structure and
wording. It is very interesting to note that both thought the blue copy was shorter than the green, when the opposite was true. One interviewee said the blue one had solutions to the problems and only after she re-read the green one did she see the solutions and said they were too vague, when the meaning was very similar but not stated in a straightforward fashion.

Content Analysis Results

It was clear from the interviews that the seventh grade-reading piece was easier for the participants to read than the twelfth grade-reading piece. The length of the paragraphs and sentences, the fewer technical words, and the explanations of complicated terms and numbers were the reasons the interviewees reported the seventh grade reading piece was easier to read. While the interviewees did not discuss the reading pieces in terms of reading level, the qualities that they reported made the pieces easier to read are those that are manipulated to change the reading level of written materials.

Summary

The two randomly assigned groups of participants were very similar in demographics and educational levels. They took identical pretests and posttests before and after reading environmental health materials. The test measured a significant effect between pretest scores and posttest scores of individual participants. However it did not measure a significant effect between the group who read seventh grade reading materials and the group that read the twelfth grade reading materials.
Two participants were interviewed and both described important differences between the two reading materials, which included, wording, structural, grammatical and general variations. They clearly described the seventh grade reading level piece as more readable than the twelfth grade reading level piece. They described differences, which illustrated the characteristics of differentiation between reading levels. However, neither describes the difference in terms of reading level. One indicated that she would “skip” the twelfth grade reading level piece.
CHAPTER FIVE – SUMMARY

Development of the Study

For thirty years, health literacy professionals have suggested the establishment of a grade-equivalent reading level for health materials, to assure most people are able to comprehend the information. Investigators in the field of health literacy have suggested reading levels from fifth to ninth grade. However, a single level has yet to be recognized by the health literacy community of researchers, health practitioners, public health professionals, health educators, librarians and others concerned with people’s ability to read, understand, evaluate and act upon health information.

I learned about the suggestion to write or rewrite health information to the reading level of average American adults, to address the mismatch between the average adult reading level and the customary reading level of health information, at a 2003 teleconference: Reading Between the Lines: Focusing on Health Information Literacy hosted by the Medical Library Association (Medical Library Association, 2003). The goal of the teleconference was to “enhance the knowledge of information professionals about the concepts of health information literacy and to highlight opportunities for using these principles in the provision of quality consumer health and patient education information services” (Medical Library Association, 2003). From the presentations, the importance of writing or rewriting health materials to a lower reading level seemed to be a proven concept (Boilard, Fisher, Harwood, & Petty, 2003). Subsequent study of health literacy literature supported that understanding and suggested an important research study would be address establishing one reading level to which health information should be
written or rewritten.

This was a particularly important subject to me because professionally I convert environmental health science information into environmental public health information in collaboration with scientists and community partners. The materials thus developed are provided to the public in a variety of venues including health fairs. At such fairs, in 2004 and 2005, large amounts of the information was thrown into trashcans before participants left the site. This was disturbing because time and treasure went into materials development and printing. New materials were developed, rewriting technical language, simplifying sentences, and writing shorter paragraphs. Included were definitions of technical terms without simple synonyms. The text was revised until it was assessed to be between seventh and eighth grade reading levels, calculated with Flesch-Kincaid Reading Level and Flesch Reading Ease tools, which are readily available in Microsoft Word. Anecdotally, by 2007 fewer materials went into the trash at the end of events.

Consequently, this exploratory study was conceived to understand to what extent print materials for environmental health promotion written at the seventh and twelfth grade reading levels were comprehensible by a target audience of readers at the eighth grade reading level. The study was designed to begin an investigation concerning a universal precautionary reading level by comparing how well average readers, at eighth grade, could comprehend environmental health information written at the customary dissemination reading level, twelfth grade, and rewritten to an average recommended reading level of seventh grade. The literature suggested study participants would comprehend the seventh grade material better. The evidence of better comprehension
would have been a significant difference in the pretest and posttest scores between the group of participants who read the seventh grade material and those who read the twelfth grade material. This study tested the hypothesis that materials written at the seventh grade level would be more comprehensible than those written at the twelfth grade level. The results indicate there was no significant difference in comprehension between the two participant groups, thus rejecting the hypothesis.

Although two follow-up interviews with individual participants provide some anecdotal evidence indicating people with an average reading level would not voluntarily choose to read the twelfth grade material, study results show that when people do read the harder material, they are able to comprehend it.

Results of this study call into question the recommendation regarding improving comprehension by reducing the grade level of health information materials. A subsequent consideration of the key studies, in light of these findings, underscores that the recommendation was based on educational, governmental, and journalistic findings and not tested in health settings. It is an assumption health literacy research has rested upon rather than an empirically established principle.

**Health Literacy Background**

One of the first to make the assertion of the need for writing more simply, because of the difficulty of health materials, was Pyrczak (1979) concerning pharmacists’ patient package inserts (PPI). He suggested the use of readability formulas to test materials for their reading level and “matching the reading difficulty with the reading skills of the intended audience” (p. 125). His suggestion was based on readability work in journalism.
designed to increase circulation by lowering reading levels of newspapers, and governmental mandates of plain language for tax and insurance documents. He made a suggestion to provide reading tests with pharmaceutical information. He also considered issues that might increase patient motivation to read materials such as interesting titles and inviting first paragraphs. He was writing for the purpose of reviewing “some of the issues and findings in readability research and to indicate their implications for writing labels and brochures” (p. 126) for drugs. He used examples from patient package insert for oestrogens to make his points. While he suggested a comprehension test for package inserts he did not test his materials for improved comprehension. It is important to mention this oversight as much health literacy work stems from his untested assertions.

For example, Spadaro, Robinson and Smith (1980) continued in the same vein with a large assessment of PPIs. Their assertion, “comprehension is influenced by the difficulty of reading materials” (p. 216), was based on almost thirty years of educational readability research, extrapolating knowledge gained from children’s reading to adults. The study found only 50% of the PPIs reviewed were written at or below the eighth grade level. While the authors acknowledged many Americans read below eighth grade, including many who only read at the fourth grade level, they chose eighth grade as the appropriate level because it was the “standard reading level for the overall population” (Spadaro, et al., 1980, p. 218). Their recommendation was based on Flesch (1974), who indicated eighth grade was the upper limit of desirable readability because it was the reading level where the average high school student could learn without reading difficulty. Spadaro’s claims promoted the assumption that high reading level caused
difficulties in comprehension of content based on a comparison of adults’ reading to that of children and adolescents. This assumption does not take into consideration pre-existing health information adults might have, which children and adolescents might not. In addition, there was no testing of health materials developed based on their recommendations.

The term health literacy, as a concept separate from literacy, was not used until the late 1990s. Davis and his colleagues (Davis, et al., 1990) were among the early researchers in health literacy, describing a gap between tested patient reading abilities and tested readability of patient education materials, indicating patients read at levels far below the reading level at which health materials were written.

Their study of one hundred fifty one clinic patients was one of the first to test the reading comprehension of patients, which was reported as grade level equivalents, ranging broadly from the public clinics to private practice, with an average of fifth grade fourth month in the community clinic and an average of from sixth grade eighth month to tenth grade eighth month in the private practice. They also indicated that more than 60% of patients read three or more grade levels below the last grade they attended (Davis, et al., 1990, p. 537), implying that health practitioners should provide information at much lower than the highest academic achievement of patients, clients and intended audiences.

Using computer programs, current at the time but no longer in use, the project tested and produced readability scores for one hundred fifty materials and forms provided at the clinics as well as newspaper articles concerning health topics. They indicated patient education materials required a reading level between eleventh and fourteenth
grade and reported virtually none of the materials they assessed were written below ninth grade level.

Highlighting this difference, Davis et al. (1990) strongly suggested a need to develop materials for people with low literacy using simple words, short sentences, specific concepts and graphic illustrations. They went further to suggest patient reading levels be established as part of the clinical record, health materials be labeled with readability levels, and appropriate materials be given to patients.

The Davis et al. (1990) study might lead some people interested in the prevalence of the low literacy problem to misconstrue the severity of the problem because the study identified 40% of public clinic patients as reading below a fifth grade level but did not point out that public clinic patients are largely drawn from people with lower incomes who predominantly have lower literacy levels as well. National data (National Center for Education Statistics, 2010) indicate people with lower incomes are also likely to have lower literacy rates. According to the National Assessment of Adult Literacy (National Center for Education Statistics, 2010) such very low literate adults, described as Below Basic, are about 14% of the population. Therefore, the Davis et al. (1990) study may have over-identified the severity of the health literacy problem.

The literature makes it apparent that conceptually the medical profession accepted the suggestion to test patients’ health literacy levels as a component of the care plan and to present information at the patient’s level. The literature also points out these practices have not been universally adopted. Several tools have been developed to assess health literacy; Rapid Estimate of Adult Literacy in Medicine, the Wide Range Achievement
Test-3, the Cloze procedure, the Test of Functional Health Literacy in Adults, and the Newest Vital Sign. There is no literature indicating the level of implementation of recommendations to test patients’ reading level or deliver information at either a compatible or an average level.

Baker (2006) suggested a universal precaution for health related information as an alternative to formal literacy screening. “Instead of screening, it may be better to assume that all patients experience some degree of difficulty in understanding health information, and we should adopt the perspective of universal precautions and use plain language” (Baker, 2006, p. 881). Baker gave no reading level suggestions for universal precautions for print health information. Rather, he suggested the need for research to be conducted to understand how to reduce the complexity and difficulty of print health information.

Among the other early investigators to use the term health literacy was DonNutbeam (1998), who identified improved health literacy as an outcome of effective health promotion and health education. His work is germane to this study because it arises from the public health perspective, not the pharmacy or clinical perspectives, since environmental health is a subset of public health. His article, Health Literacy as a Public Health Goal (Nutbeam, 2000), described health literacy as a resource critical for empowering individuals and communities to effect change in individual and collective lives. In this overview article, he developed an outcome model for health promotion using the Four Resources Model of Reading (Freebody & Luke, 1999) to describe health literacy competencies that go beyond the ability to break the written code, to making meaning, using the text to understand the world, and critiquing text for its applicability to
an individual life and society. He proposed that health education develops health literacy in three ways, communication about health information, development of personal health related skills, and empowerment to improve personal and community health. Although, once again no empirical research was done to validate the model or health literacy competencies, Nutbeams’s work is widely cited as foundational to health literacy research and practice, with 347 citations indicated on Google Scholar as of September 6, 2010.

Rima Rudd and her colleagues (Rudd, et al., 2004) have also promoted the use of plain language in developing and rewriting health information materials. They suggested and tested a process for developing such materials, using an example of lead poisoning information. They did not, however, test the comprehension of the materials they rewrote, suggesting the next steps would be to “… assess consumers’ understanding, to modify the report based on these results and then reassess the document with members of the intended audience” (Rudd, et al., 2004, p. 205).

Zarcadoolas and Shanahan (2003, p. 22) indicated that complexity of environmental health information is an obstacle to effective community engagement in environmental health research and promotion. The Zarcadoolas model, which includes fundamental literacy, science literacy, civic literacy and cultural literacy, was assessed using materials disseminated, by the Center for Disease Control and Prevention (CDC) during the anthrax episode in 2001. They asserted the CDC health promotion messages were not understood because of “complex vocabulary and embedded compound and complex sentences… and were not written at a level matching the fundamental literacy of
the majority of the public” (Zarcadoolas, et al., 2005, p. 198), leading to unintended negative consequences of over-prescribing Cipro, an antibiotic, as people sought to protect themselves. Their model demonstrates the prevalence of accepted assumption that materials need to be written at the average reading level of American adults.

Much of the work in health literacy has concerned developing models and assessment tools rather than empirical research studying the underlying assumptions of the models, assessing the usefulness of the tools, or the applicability of the models. Even as new assessment tools are being created by respected authors (Zarcadoolas, et al., 2005) it seems that more attention should be paid to empirical work. Environmental health problems affect all members of a community. In the short term, during an emergency, all must participate in preventive or clean up activities. Many environmental problems can impact all members of a community with long-term affects, requiring long-term solutions and public policies for change. Environmental health education, for the most part, takes place in groups or in the media, rather than with individuals. The educator cannot tailor messages to one person or one literacy level. The entire population must be considered and the information disseminated must be appropriate for a broad audience. Therefore, a universal precautionary approach seems appropriate for understanding the implications of health literacy for environmental health information dissemination.

**Current Health Literacy Study**

The current study addresses the underdeveloped issues of “complexity and difficulty of print health messages”, the solution to which Baker (2006) proposed a
universal precaution, giving no details beyond suggesting plain language for written materials.

For this study, the Baker model was expanded to describe steps to minimize these difficulties. The augmented model defines universal precautions in the following way: (a) writing or rewriting text into plain language, (b) with uncomplicated sentences, (c) short paragraphs, (d) minimal technical terms, and (e) a small glossary of technical terms the author could not simplify, while addressing only the most important aspects of the subject matter. The enhanced model is shown in Figure 14: Second Expansion of the Baker Model. The lightest gray components are elements from the original Baker model. The mid gray components were added to the model to identify Baker’s suggestion for a universal precaution. The dark gray components are elements added in the first expansion of model and describe approaches, compiled from the literature, to take to write or rewrite content into plain language. This adapted model was followed in developing the rewritten text for the study materials. Study results prompted new additions, which are the black elements with white writing, comprehension and willingness to read.

The hypothesis was the rewritten material, at the seventh grade, would be more comprehensible than the original material at the twelfth grade. This did not prove to be the case in this study. The results called into question the need for rewriting. However, interview participants indicated they had a negative response to the material they viewed as more difficult and would have skipped it if they were given that option. The need for rewriting to plain language may be indicated but for reasons of motivating people to read health materials rather than for improving comprehension.
Figure 14: Second Expansion of the Baker Model

The research was conducted in late 2009 and early 2010 to test this study’s hypothesis that materials written at the seventh grade level would be more comprehensible than those written at the twelfth grade level. The little known topics of arsenic contamination and the biochemical process of ultraviolet light exposure were selected to avoid participants having strong preexisting knowledge about them. Authoritative resources were located, assessed for readability, found to be written at twelfth grade, and rewritten to the seventh grade reading level using Flesch-Kincaid and
Flesch Reading Ease scores. Environmental health experts for both topics vetted the rewritten information. Multiple-choice questions were compiled into a test from the seventh grade version. The readings and pretest / posttest was adjusted based on a pilot test of the materials for clarity. Interview questions were formulated to understand the participant’s impressions about the understandability of the reading materials and the test. Participants were recruited from an agency that knows the reading level of its students and randomly assigned to read either the seventh or twelfth grade reading materials. The study was conducted in five pretest / posttest sessions and two individual interviews.

Statistical analysis was conducted including descriptive statistics regarding participant demographic data and repeat measures ANOVA to compare the pretest / posttest scores. The content of participant answers to the interview questions was analyzed to determine patterns and themes of comments and statements.

The hypothesis that materials written at the seventh grade level would be more comprehensible than those written at the twelfth grade level was rejected because there was no significant difference between the scores of the two participant groups. The results from the interviews produced a cautionary note that the participants might not have chosen to read the more difficult materials if they had been given the option to read the simpler materials.

**Framework for Understanding Study Results**

Comprehending health materials involves building sense from the text and relating new information to what is already known in a constructivist manner. The constructivist conceptual framework for understanding the results of this study brings
together concepts from literacy, information literacy, health literacy, and environmental literacy. People understand information in the context of their background, knowledge, culture, and values. Constructivism argues humans generate knowledge and meaning from their experiences through assimilating information into their awareness and accommodating their behavior to the new information (Lindsey, 2000).

Ken and Yetta Goodman (Dombey, 2005) suggested reading involves active interaction with the text, connecting new information to past knowledge about the subject matter. They describe an active process, with inference and guesswork at its heart and ongoing monitoring for sense. They also indicate individuals in an encounter with challenging text must look more closely, with a sharper focus on the meaning. Important to constructing meaning are people’s recognition of the need for information, the questions the person asks before and during the experience, and their tolerance for ambiguity, confusion and other points of view (Kuhlthau, 1991). Essentially, the reading process is an interaction of the reader with the author to construct his or her own understanding of the information. It is an opportunity for the reader to hear and interpret the author. Information should be offered to readers in a progressive manner, with simple materials first and progressively more complex information later, as the reader desires more information.

The various definitions of health literacy and environmental health literacy incorporate the ability to read with abilities to understand, evaluate and act upon health or environmental information to live healthier lives and mitigate risk. Thus, health literacy requires more than the mechanical retrieval of information but also an active engagement
of the reader to construct meaning from health materials. This requires more than identifying and decoding words in text.

Participants in this study were able to comprehend the written materials and show significant understanding on the test because they were motivated and were able to construct meaning from reading the materials, taking the test, and drawing upon past knowledge.

The current study suggests that the assumption/recommendation of the past thirty years regarding reducing the reading level of health materials to make them comprehensible may be incorrect. If that is the case then environmental health information can continue to be presented in the current forms. Other reasons will have to be found for the difficulties people experience with literature addressing environmental problems impacting human health and possible solutions to those problems, which usually require changes of behavior. Environmental health promoters will need to investigate other reasons for people’s misunderstandings about environmental health issues and lack of acceptance of environmental health findings and suggestions.

The assumption/recommendation regarding reducing the reading level of health materials to make them comprehensible may be correct, but not for the reasons of improving comprehension usually espoused. Possible reasons to continue to suggest plain language as a universal precaution may relate more to reducing barriers to reading and to motivating people to read than to comprehensibility of health materials. If materials are not read, they cannot be comprehended or affect people’s behavior and choices.
The current study results provoke questions, such as: Is there a reason to continue to suggest grade-reading levels for health information? And, what recommendations should be made concerning readability of health materials?

Based on the study findings that average readers learned from both the seventh and twelfth grade reading materials, it seems unwise to continue to advocate a universal precaution involving a single specific grade level in the absence of additional empirical studies.

It seems the best course to assure readability is to develop materials in collaboration with members of the intended audience and/or pilot test the materials with that audience. By doing so, the author can assess the understanding of the participants and revise until they comprehend well (Rudd, et al., 2004; Zarcadoolas, et al., 2001).

Because people understand information within the context of their background, knowledge, culture, and values, it will serve authors well to learn from local informants about the culture of their target audience with local informants in addition to gaining an academic understanding (Zarcadoolas, et al., 2001). The process of creating health information for the public can include engaging panels of reviewers, both from the target audience and subject matter experts. Including members of the intended audience in the process and modifying the materials to meet their desires and suggestions can inform the author of their needs and ways of understanding. Subject experts should vet common language materials for accuracy and the material should be modified from their suggestions as well. Collaboratively writing health information with health consumers and/or pilot testing and making meaningful changes may help authors build in helpful
elements that will improve the chances the material is read and acted upon.

None of the literature advocating writing with plain language does more than support good writing (CDC, 2010; Medline-Plus, 2009; National Institutes of Health, 2003; Rudd, et al., 2004; S Stableford & Mettger, 2007). Because there are no other empirical studies of the comprehension of rewritten materials it seems that there can be no claim of improved comprehension of health materials from writing with plain language.

Other features of well-written materials, not addressed in this study, are format, supplementing text with meaningful graphics, and motivational messages. Suggestions include taking into account the interactive process of reading is assisted with graphical and color references that cue the reader for each section (Goodman & Buck, 1997).

This study was designed as exploratory research to provide insights into and understanding of the effect of reading level on comprehension of environmental health materials. It was an effort to more clearly define the issue and develop a hypothesis about a recommended reading level. It was also intended to propose a research method to establish that reading level, including data collection methods and selection of future subjects.

Like some other exploratory studies this research concluded the perceived problem might not be real or it may not exist for reasons that have been supposed for thirty years. The need to lower the reading level of health materials to assure people can comprehend them is called into question by the results of this study.


Study Limitations

For several reasons the study results are not highly generalizable to all health materials. The subject matter limits the findings to environmental public health materials. The way the participants most likely were different from the population was their identified interest in health, based on their enrollment as nursing assistant students. This interest might have affected their preexisting information and their motivation to read about environmental health. Only two participants agreed to participate in the interview / follow up question component of the study. This small sample limits the insights that can be drawn from interview transcripts about the reading materials and the test.

The pretest / posttest was created for the study and therefore cannot be considered an established testing instrument. It was created from the seventh grade level reading material. Although there was an effort not to use the exact text, the final version of the test was very similar to the seventh grade reading piece. Because there was no significant difference between the two testing groups it is unlikely the reading level of the test influenced the testing outcome.

Pretest sensitization is an unlikely explanation for the significant difference between pretest and posttest scores, for the entire sample, because there was no significant difference between the two groups’ posttest scores. The hallmark of pretest sensitivity is participants receiving the treatment having a significantly higher mean posttest score (Bonate, 2000).

The study setting, in a classroom before class, may have had an undue influence on participants by influencing them to complete the reading and posttest when they might
have desired to stop. While there was no overt observable interaction among the participants, they were involved in the study with classmates and they may have sensed peer pressure to do their best. While there was no requirement to participate from the agency where the participants were students, the experiment was conducted in a classroom setting, with peers, and with an unspoken expectation of completing the tasks of taking the pretest, reading the environmental health information, and taking the posttest. These circumstances may have given the participants a compelling reason to finish the assignment.

Study instructions were given verbally. For the pretest, participants were able to guess on the questions and the posttest was open book. There was no significant difference among results from the five testing sessions. Variations on this methodology need to be performed, including written instructions, to evaluate if the instructions had an effect on the outcome.

Although there are problems with readability testing, it is an established tool available to assess materials and compare one text to another. Readability formulas do not guarantee people will learn from text. The investigator considered three reasons to use the formulas, including: their long standing use, their reputation for methodical accuracy for categorizing reading materials into grade levels, and the perceived notion of internal consistency within and between various formulas when determining reading levels (Meade & Smith, 1991). Over-reliance on readability testing might present a problem because factors other than sentence length and word difficulty, such as readers’ knowledge of the world and interest in the text, are involved in comprehending content.
Therefore, while readability formulas were used, the materials were vetted to assure technical accuracy and legibility was controlled with the size and font of the type.

The pretest / posttest results were unexpected. The reading level of the materials did not significantly affect the mean difference score between the group that read seventh grade material and the group that read twelfth grade material. The findings of this study seem to contradict the assumption of the need to reduce the reading level of health information to make it comprehensible, because the participants were able to make meaning, as evidenced by their significant difference scores between the pretest and posttest, from the twelfth grade text much as they were from the seventh grade text. The answer to the research question “to what extent are print materials for environmental health promotion, written at the seventh and twelfth grade reading levels, comprehensible by a target audience of readers at the eighth grade reading level?” seems to be people with an average reading level are able to comprehend health information written at either the seventh or twelfth grade reading level. Logically, they should be able to comprehend information written at the levels between seventh and twelfth as well.

Findings from the interviews, however, indicate there is a possibility people might not read text written at the higher level if they encountered it in a non-experimental setting. It was clear from interviews that the seventh grade-reading piece was perceived to be easier for the participants to read and understand than the twelfth grade-reading piece. The interviewees did not discuss the reading pieces in terms of reading level. The qualities reported about the seventh grade material that made the piece seem easier to
read are those manipulated to change the reading level of written materials. The length of the paragraphs and sentences, fewer technical words, and explanations of complicated terms and numbers were reasons interviewees reported the seventh grade reading piece seemed easier to read and understand. Given the choice, they would have preferred the material written at seventh grade reading level over that written at the twelfth grade or they would have “skipped” reading the twelfth grade material, if they encountered it in another setting.

Although the data from limited interviews should not be over-emphasized, it does seem to suggest adults can learn from complex health materials if they are obliged, compelled or motivated to do so but that they would rather read materials they do not perceive as difficult.

Based on answers to interview questions, it may be appropriate to continue to suggest health information be provided in plain language and to teach health professionals to use the above methods to create easily read text. Such education should be provided to all categories of health professionals in their preparation for health careers. It may also be provided as continuing education for nurses, doctors, pharmacists, public health professionals and others who create and provide health information to the public.

**Recommendations for Future Studies**

The study findings lead me to believe the concern for authors should not be writing or rewriting to a specific grade reading level. Rather it should be motivating people to read health materials, which may involve the use of plain language, and may include the way the information is presented on the page. The issue for clinical and public
health information providers is to motivate people to read health information by identifying compelling reasons to read and comprehend health materials.

Instead of suggesting a reading level hypothesis to test, I think more exploratory research needs to be done to study the characteristics of health materials that motivate participants to read or not to read. Research question might include:

3. Under what conditions would people avoid reading challenging materials?
4. Under what conditions would they voluntarily read challenging materials?
5. What are the characteristics of materials chosen to be read by participants?
6. Does plain language affect motivation to read health information?
7. Will people choose twelfth grade health materials after multiple exposures to materials on the same subject?
8. Do multimedia approaches help people voluntarily read challenging materials?

To continue to address the original research question concerning comprehension of health information, the current study should be repeated to validate the data. In addition, variations on the study could be done to explore how research procedures might have affected the outcome. Alternatives might include changing the instruction for the pretest to leave answers blank, not guessing, if the answer is unknown, using a posttest only method to study the effect of pretest sensitization, and interviewing participants immediately after the reading/testing session in order to increase the number of interviews.
Three other approaches to establishing recommendations concerning writing easy to read health materials could be:

1. Observe participants choosing or discarding health materials with immediate interviews or surveys for the purpose of participants answering explicit questions that related to readability - long paragraphs, complex vocabulary, complex sentences, formatting, use of color, etc.

2. Offering participants the option to choose materials of different complexities, with immediate interviews about their choice and a posttest for comprehension.

3. Combine a brief verbal presentation about the subject or an online tutorial with giving print materials, a posttest and an interview.

The data analysis for these research designs would be content analysis of interviews and t-tests for posttests, because there would be no repeat measures.

Another type of study would be comparing the pretest / posttest method with a posttest only. This research method could be used to assess materials in the real world context, where administering a pretest is impractical, due to time or context considerations. In a posttest only study, an experimental and a control group are used. The experimental group is introduced to the reading while the control is not. The test results are measured in both groups. Because there are no repeat measures the analysis would be conducted by T-test (Toriningen, 2010).

Continuing to explore the original question with a pretest / posttest method it may be important to do future studies with samples drawn from people who are not learning
about health related topics. Such a sample may reflect the health knowledge of the
general population more accurately than the current study sample. A screening test for
health literacy would have to be chosen for such a study because the reading level of a
broader audience will not be known. Use of the Newest Vital Sign might be reconsidered
as there is a likelihood the NVS will return false low literacy results (Osborn, et al.,
2007). The REALM, S-TOFHLA or Cloze methods should be considered.

Closing Remarks

Studies about providing health information to the general public are responsive to
the efforts by the Medical Library Association (2007) to promote using evidence to
improve the practice of health sciences librarians. According to the Research Policy
Statement of the Medical Library Association (Dalrymple, et al., 1995), despite advances,
the profession of librarianship has not yet developed a culture of research and assessment.
At present, much of the library literature is of little use to those wishing to engage in
evidence-based practice. Research concerning health literacy is important to assist in
resource selection and with reference services, not only in health or medical libraries but
also in public and school libraries.

Contexts for health information are changing. The example of this study is the
application of health literacy concepts in the environmental health context. Information is
readily available to the point of overload. The meaning of information, how information
is procured and used, how we learn and teach, and the options for scholarly
communication are changing quickly. New roles and spheres of influence for librarians,
as information professionals, are emerging (McKibbon, Peay, & Humphreys, 2007). This
is true in the study of health literacy, where health sciences librarians are taking leadership roles to improve the information available to the general public.

Health professionals and public health information providers cannot stop being concerned about the perceived mismatch between the reading levels of American adults and health information just because this small exploratory study found that people with average reading levels can read and comprehend written information about environmental health topics written at both the seventh and twelfth grade reading levels. It is important to undertake additional studies to better understand how much of an encumbrance or impediment hard-to-read information may be placing on individuals’ use of those materials. Of special concern should be people who need information but are perhaps burdened by their own, their family’s or their community’s health issues. We need to empirically investigate how to develop consumer health and patient education information that encourages people to read, understand, evaluate, and act on the information.
APPENDIX A: ENVIRONMENTAL HEALTH READING A – SEVENTH GRADE

READING LEVEL - BLUE PAPER

Arsenic

Arsenic is a toxic element. Arsenic occurs naturally in the environment. It is spread unevenly in the Earth’s crust in soil, rocks, and minerals. It can pollute drinking water. It gets into the water as a result of farming and industry. Or it can be in runoff into surface water sources. Arsenic is measured in parts per billion (ppb).

Congress passed the Safe Drinking Water Act in 1974. Because of this law the EPA has issued two types of rules. Cost of clean up, benefits to public health and the ability of public water systems to detect and remove pollutants are taken into consideration when the rules are set.

The first rule is called the maximum contaminant level (MCL). These must be obeyed and are about pollutants that may cause health problems. MCLs are set as close to the health goals as possible.

The second type of rules is called maximum contaminant level goals (MCLGs). They are rules that suggest health goals. The MCLG for arsenic is 0 parts per billion (ppb).

The EPA recently lowered the arsenic MCL. It was reduced from 50 ppb to 10 ppb. This was done to better protect people who drink public water from the health risks of long-term arsenic exposure. The 10 ppb arsenic standard relates to almost all water systems. 10 ppb of arsenic in the water is about the same as a few drops of ink in an Olympic-sized swimming pool.

Exposures to high doses of arsenic do not occur from public water supplies in the U.S. that obey with the arsenic MCL. In other countries some people drink water that has high arsenic levels for many years. They might develop health troubles as well. This is called chronic exposure to arsenic.

Health problems from arsenic effect many parts of the body:
• thickening and discoloration of the skin;
• stomach pain, nausea, vomiting, and diarrhea;
• heart and lung problems;
• reproductive problems;
• diabetes;
• neurological conditions such as numbness and partial paralysis;
• cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.

Water that comes from a water company is tested for arsenic every year. The community water systems send a water quality report listing any level of arsenic found. The EPA also requires all water systems to give a notice when the water supply breaks the arsenic standard. Customers will be told what is being done to correct the situation.
Ultraviolet Light

Light from the sun is a powerful cause of cancer for humans. How the sunlight causes skin damage is very well known. Skin cancers that are not melanomas (NMSC) are the most common cancers diagnosed in humans in the United States. NMSC come from the outer surface of the skin.

Melanoma is a cancer tumor that comes from the cells in the lower part of the skin. The cells are called melanocytes and they are the ones that produce skin pigment called melanin. Melanoma is very dangerous. Melanoma is more common in fair-skinned people across the world. Each year there are between 3% and 7% more cases of melanoma. It is increasing faster than any other cancer in the United States.

The causes of the photo damage are dependent on the length of the wavelength of the UV light. UV light has wavelengths shorter than visible light. Most of the sunlight that causes damage to skin comes from UVA light. UVB light is shorter than UVA light. UVC light does not reach the Earth’s surface. UVA light is less affected by environmental factors than UVB. UVA is longer and is able to go through cloud cover and glass windows. New tumors can develop from skin damage from UVA sunlight. UVA sunlight can make both melanoma and nonmelanoma skin cancers grow.

There are three layers in the skin; the epidermis, which provides waterproofing and serves as a barrier to infection; the dermis, which serves as a location for the hair, blood vessels and nerves of skin; and the hypodermis, which connects the skin to the muscles. The length of the light wave is associated with how far the light can penetrate into the skin. Up to half of the UVA light can reach far into the epidermis. Only 14% of the UVB can reach into the lower epidermis.

Photo biological researchers study how sunlight causes illness. They are working to understand how UVA affects skin health. They are also studying helpful UVA protection for the skin.

Constant exposure to the sun can lead to aging of the skin. The symptoms of aging skin include masses of cell, wrinkles, thinning skin, age spots and dryness. It might take longer to heal. It is important to understand that sunlight activates the cell surface growth factor. Growth factor is the feature that controls the growth and changes in cells.

Research findings tell us that damage to sun-exposed skin occurs in two ways. One is when the body is unable to get rid of toxins. The other is when the body is not able to fix damage caused by small molecules that contain oxygen. This problem is called reactive oxidative stress (ROS).

UV light creates ROS. This affects the enzymes that are part of the growth factor. The newest research about UV light tells us that ROS formation has an effect on the parts of the cell that give directions to other parts of the cell. These instructions are about cell growth, cell definition, cell death and the creation of cancers. UV created ROS is interferes with the cell’s ability to respond to stimuli from outside. It can lead to problems with transcription factors. These factors
control the transfer of genetic information inside the cell and allow the cell to duplicate itself.

UVB is thought to damage DNA in the epidermis. More than 90% of squamous-cell skin cancers have gene mutations. UVA causes little direct damage to DNA because DNA does not absorb UVA light. Skin damage from UVA is from agitation of other skin components. This makes skin sensitive to the sun.

Oxidative stress causes changes to the makeup and function of skin. The chemical changes begin with absorption of sunlight. Absorption of sunlight causes photo-excitation and leads to ROS. The ROS leads to structural and DNA damage and inflammation. These processes trigger aging of the skin and the formation of cancer.

University of Arizona scientists are looking for better methods to protect and treat skin damage. Recent research has created healing treatments by new molecules. Scientists are now testing possible treatments. Some treatments might upset the process of skin damage. Others may either alter or possibly reverse skin damage from sunlight.
Arsenic

Arsenic is a toxic chemical element. It is spread unevenly in the Earth’s crust in soil, rocks, and minerals. Arsenic occurs naturally in the environment. Human exposure to arsenic is largely a result of farming and industry. It can enter drinking water through the ground. Or it can be in runoff into surface water sources.

In 1974, Congress passed the Safe Drinking Water Act. Because of this law the EPA has to issue two types of rules. Cost of clean up, benefits to public health and the ability of public water systems to detect and remove contaminants using suitable treatment technologies are taken into consideration when the rules are set.

The first called maximum contaminant level (MCL). These must be obeyed and are about pollutants that may cause health problems. MCLs are set as close to the health goals as possible. Second are called maximum contaminant level goals (MCLGs). They are rules that suggest health goals. The MCLG for arsenic is 0 parts per billion (ppb).

The EPA recently lowered the arsenic MCL. It was reduced from 50 ppb to 10 ppb. This was done to better protect people who drink public water from the health risks of chronic long-term arsenic exposure. The 10 ppb arsenic standard applies to all community water systems. The standard also applies to non-transient, non-community water systems. 10 parts per billion (ppb) of arsenic in water means that there are 10 molecules of arsenic for every 999,999,990 molecules of water. That is roughly equivalent to a few drops of ink in an Olympic-sized swimming pool.

High doses are about a thousand times higher than the drinking water maximum contaminant level. Short-term exposures to high doses can cause bad health problems in some people. Exposures to high doses of arsenic do not occur from public water supplies in the U.S. that obey with the arsenic MCL. Some people, who drink water that has high arsenic levels for many years, might develop health troubles as well. This is called chronic exposure to arsenic.

Health effects might include problems with many parts of the body:

- thickening and discoloration of the skin;
- stomach pain, nausea, vomiting, diarrhea, and liver effects;
- heart and lung problems;
- problems with the immune and reproductive systems;
- endocrine problems such as diabetes;
- neurological conditions such as numbness and partial paralysis;
- cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.

If your water comes from a municipal system, they are already testing for arsenic in your water. Every year, your community water system sends you a consumer confidence report (sometimes called a water quality report), listing any levels of arsenic detected. EPA also requires all community and non-transient, non-
community water systems to give you public notice when their water supply violates the arsenic standard.

**Ultraviolet Light**

Solar radiation is a powerful environmental human carcinogen. The causative role of solar ultraviolet (UV) photons in skin photo damage is firmly established. Nonmelanoma skin cancers make up the majority of all human cancers diagnosed in the United States.

Melanoma is a highly invasive and metastatic tumor. It arises from melanocytes, cells in the lower epidermis that produce the skin pigment. Melanoma affects fair-skinned Caucasian populations worldwide with an annual increase in incidence rate between 3-7%. The incidence of malignant melanoma is increasing faster than any other cancer in the United States.

The mechanisms of solar UV-irradiation that cause skin photo damage are wavelength dependent. UV light has wavelengths shorter than visible light. Most of the sunlight that causes damage to skin comes from UVA light. UBV light is shorter than UVA light. UVC light does not reach the Earth’s surface. Longer-wavelength UVA radiation is less affected than UVB by environmental variables and easily penetrates cloud cover and glass windows.

There are three layers in the skin; the epidermis, which provides waterproofing and serves as a barrier to infection; the dermis, which serves as a location for the hair, blood vessels and nerves of skin; and the hypodermis, which connects the skin to the muscles. Skin photon penetration is positively correlated with wavelength. Up to 50% of UVA can reach the depth of melanocytes and the dermal compartment, whereas only 14% of UVB reaches the lower epidermis.

Photobiological research focuses the role of UVA and near visible solar irradiation in photodamage, photoaging, and carcinogenesis and the need for effective UVA skin photoprotection are now rapidly emerging as important areas of environmental health-related research.

Chronic photooxidative stress also leads to skin photoaging, characterized by accumulation of senescent dermal fibroblasts, extracellular matrix remodeling with collagen crosslinking, protease-dependent collagen breakdown, overexpression of dysfunctional elastin, and chronic inflammatory signaling.

UVB is thought to cause direct structural damage to DNA in the form of epidermal cyclobutane pyrimidine dimers (CPD) and pyrimidine 6-4 pyrimidone dimers.

These reactive intermediates then induce skin protein, lipid and DNA damage, and trigger alterations of redox and inflammatory signaling involved in photoaging and photocarcinogenesis. Chemical damage occurs by spontaneous chemical reactions and formation of protein-epitopes called advanced glycation endproducts (AGEs). AGEs accumulate on the collagen and elastin in skin, where they induce structural and functional alterations. Moreover, some AGEs are
established skin photosensitizers that produce ROS and photooxidative stress upon UVA-irradiation adding to the photooxidative burden of photoaged skin.

The structural and functional alterations that result from skin photooxidative stress depend on a cascade of chemical events started by skin solar photon absorption and formation of reactive photexcited states. Photo excited states of the skin leads to formation of reactive oxygen (ROS) by light-driven redox cycling.

Better molecules for skin photoprotection and treatment of skin photodamage are needed. Recent research on molecular targets involved in skin photodamage suggests the feasibility of therapeutic intervention by novel molecular antagonists. Prototype agents that effectively antagonize, modulate, and potentially reverse the increasingly transparent chemistry and cell biology that underlies skin photodamage are currently being tested for safety and chemopreventive performance.
APPENDIX C: PRETEST / POSTTEST - ARSENIC AND UV LIGHT EXPOSURE

1. What is arsenic?
   a. A toxic element
   b. A manmade chemical
   c. A good mineral

2. How does arsenic get into my drinking water?
   a. From farming
   b. In runoff into surface water sources
   c. From industry
   d. All of the above

3. How much is 10 ppb? Similar to:
   a. Like eating a can of tuna once a week
   b. A few drops of ink in an Olympic-sized swimming pool
   c. A teaspoon of food coloring in a gallon jug

4. Every year, your community water system sends you a water quality report. It lists any levels of arsenic found.
   a. True
   b. False

5. Long long-term arsenic exposure is not a problem so the EPA standard has stayed the same for many years
   a. True
   b. False

6. How is Arsenic measured by:
   a. Parts per trillion
   b. Parts per million
   c. Parts per billion

7. The maximum contaminant level (MCL) is different from the maximum contaminant level goals (MCLGs) because
   a. The MCLG must be obeyed and the MCL is a suggestion
   b. The MCL must be obeyed and the MCLG is a suggestion

8. Should people in the United States be aware about arsenic in their drinking water?
   a. Yes, Short-term exposures to high doses can cause bad health problems in some people.
   b. No, Exposures to high doses of arsenic do not occur from public water supplies in the U.S.

9. What parts of the body do not have health effects from Arsenic?
   a. Skin
   b. Stomach
   c. Bones
   d. Heart

10. Which is the most common form of cancer?
    a. Melanoma skin cancer
    b. Breast cancer
    c. Non Melanoma skin cancer
d. Lung cancer

11. Which of the following is about Melanoma?  _____
   a. Melanoma is a cancer tumor that comes from the upper part of the skin
   b. Forms in the melanocytes that produce skin pigment called melanin
   c. Melanoma is not very dangerous

12. Which group of people gets more melanoma?  _____
   a. Dark
   b. Fair

13. Most of the sunlight that causes damage to skin comes from UVA light.  _____
   a. True
   b. False

14. The dermis performs what function within the skin?  _____
   a. Connects the skin to the muscles
   b. Serves as a location for the hair, blood vessels and nerves of skin
   c. Provides waterproofing and serves as a barrier to infection

15. Skin damage from sun-exposure does not occur by?  _____
   a. Not being able to fix damage caused by small molecules which contain oxygen
   b. Not enough vitamin A
   c. The body being unable to get rid of toxins

16. What is reactive oxidative stress (ROS)?  _____
   a. Stress in the body from a reaction to oxygen
   b. Oxidation happens in the body
   c. Damage caused by small molecules that contain oxygen.

17. What damage does sunlight cause to skin?  _____
   a. Cancer
   b. Wrinkles
   c. Thickening of skin
   d. Age spots

18. The newest research about ROS formation tells us that it has an effect on directions inside the cell such as creation of cancers.  _____
   a. True
   a. False

19. Which UV light causes direct damage to DNA?  _____
   a. UVA
   b. UVC
   c. UVB

20. ROS comes from photo excitation and leads to structural damage and inflammation  _____
   a. True
   b. False
APPENDIX D: QUESTIONS FOR INTERVIEWS

Introductory statements:

1. I am seeking to learn what was clear on the materials and what wasn't.
2. I am also seeking comments about the pretest / posttest.

I will give you copies of the print materials and of the test to refresh their memory.

To initiate the discussions of the reading materials I asked:

- What are your general thoughts about the environmental health information materials?
- What was confusing about the information on the reading materials? please elaborate…
- What was especially clear? please elaborate…
- Was there new information on the brochure? please tell me more…
- To what extent you feel that you already knew all the information the brochure provided?
- What information do you think should have been on the reading materials?

To initiate discussions about the pretest / posttest I asked:

- What are your general thoughts about the tests?
- Were there questions that were confusing? please elaborate…
- Were there questions that were especially clear? please elaborate…
APPENDIX E: NEWEST VITAL SIGN SCORE SHEET

Score Sheet for the Newest Vital Sign Questions and Answers

READ TO SUBJECT: This information is on the back of a container of a pint of ice cream.

1. If you eat the entire container, how many calories will you eat?
   Answer:

2. If you are allowed to eat 60 grams of carbohydrates as a snack, how much ice cream could you have?
   Answer:

3. Your doctor advises you to reduce the amount of saturated fat in your diet. You usually have 42 g of saturated fat each day, which includes one serving of ice cream. If you stop eating ice cream, how many grams of saturated fat would you be consuming each day?
   Answer:

4. If you usually eat 2500 calories in a day, what percentage of your daily value of calories will you be eating if you eat one serving?
   Answer:

READ TO SUBJECT: Pretend that you are allergic to the following substances: Penicillin, peanuts, latex gloves, and bee stings.

5. Is it safe for you to eat this ice cream?
   Answer:

6. (Ask only if the patient responds "no" to question 5): Why not?
   Answer:

Number of correct answers:

Figure 15: Newest Vital Sign Score Sheet (Weiss, 2008)
APPENDIX F: NEWEST VITAL SIGN ANSWER SHEET

Score Sheet for the Newest Vital Sign Questions and Answers

READ TO SUBJECT: This information is on the back of a container of a pint of ice cream.

1. If you eat the entire container, how many calories will you eat?
   
   **Answer:** 1,000 is the only correct answer

2. If you are allowed to eat 60 grams of carbohydrates as a snack, how much ice cream could you have?
   
   **Answer:** Any of the following is correct: 1 cup (or any amount up to 1 cup), half the container. Note: if patient answers “two servings,” ask “How much ice cream would that be if you were to measure it into a bowl?”

3. Your doctor advises you to reduce the amount of saturated fat in your diet. You usually have 42 g of saturated fat each day, which includes one serving of ice cream. If you stop eating ice cream, how many grams of saturated fat would you be consuming each day?
   
   **Answer:** 33 is the only correct answer

4. If you usually eat 2500 calories in a day, what percentage of your daily value of calories will you be eating if you eat one serving?
   
   **Answer:** 10% is the only correct answer

READ TO SUBJECT: Pretend that you are allergic to the following substances: Penicillin, peanuts, latex gloves, and bee stings.

5. Is it safe for you to eat this ice cream?
   
   **Answer:** No

6. (Ask only if the patient responds “no” to question 5): Why not?
   
   **Answer:** Because it has peanut oil.

**Interpretation**

<table>
<thead>
<tr>
<th>Number of correct answers:</th>
</tr>
</thead>
</table>

Score of 0-1 suggests high likelihood (50% or more) of limited literacy.
Score of 2-3 indicates the possibility of limited literacy.
Score of 4-6 almost always indicates adequate literacy.

---

Figure 16: Newest Vital Sign Answer Sheet (Weiss, 2008)
### Nutrition Facts

<table>
<thead>
<tr>
<th>Serving Size</th>
<th>1/2 cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servings per container</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount per serving</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>250</td>
</tr>
<tr>
<td>Fat Cal</td>
<td>120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Fat</th>
<th>13g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat Fat</td>
<td>9g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>28mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>55mg</td>
</tr>
<tr>
<td>Total Carbohydrate</td>
<td>30g</td>
</tr>
<tr>
<td>Dietary Fiber</td>
<td>2g</td>
</tr>
<tr>
<td>Sugars</td>
<td>23g</td>
</tr>
<tr>
<td>Protein</td>
<td>4g</td>
</tr>
</tbody>
</table>

* Percent Daily Values (DV) are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

**Ingredients:** Cream, Skim Milk, Liquid Sugar, Water, Egg Yolks, Brown Sugar, Milkfat, Peanut Oil, Sugar, Butter, Salt, Carrageenan, Vanilla Extract.

*Figure 17: Newest Vital Sign Nutrition Label (Weiss, 2008)*
APPENDIX H: PARTICIPANT DEMOGRAPHIC DATA SHEET

Name: _______________________________________________________

Address: _____________________________________________________

Email: _______________________________________________________

Phone: _________________________________________________________

Education (check one): 9th □ 10th □ 11th □ 12th □ High School Graduate □ Some college □ Jr. College Graduate □ College Graduate □

Reading level from CareGiver Training Institute (if you know): ________

Income level range: 10,000 – 20,000 □ 20,000-30,000 □ 30,000-40,000 □

Language Spoken at Home (check primary):

- English □ Spanish □ Other: ________________________________

Age: 18-20 □ 21-25 □ 26-30 □ 31-35 □ 36-40 □ 41-45 □ 46-50 □ 51-55 □ 56-60 □ 61-65 □

Gender: Female □ Male □

Ethnicity & Race

- Spanish/Hispanic/Latino
  - No, not Spanish/Hispanic/Latino □
  - Yes, Mexican, Mexican American, Chicano □
  - Yes, Puerto Rican □
  - Yes, Cuban □
  - Yes, other Spanish/Hispanic/Latino (write in group)

- Ethnicity
  - White □
  - Black or African American □
  - American Indian or Alaska Native (write in tribe) □

- Other: _____________________________________________________
APPENDIX I: RECRUITMENT SPEECH

Hello, I am Marti Lindsey. I am a PhD student at the University of Arizona studying health information resources in the School of Information Resources and Library Science.

I used to be a hospital and nursing home social worker and taught social workers. I have also been a librarian. Now I teach high school students and the public about environmental health.

People who study environmental health are concerned about preventing disease and creating health-supportive environments. According to the World Health Organization, environmental health includes all the physical, chemical, and biological factors outside a person. It also includes the understanding and management of those environmental factors that can possibly affect health.

I am here today to invite you to take part in my environmental health literacy research study. Most health information is written at a college level. My research is about health literacy. Specifically, this study will examine problems with understanding health information by trying to determine if the general public better understands environmental health information if it is written at the seventh grade reading level.

Health literacy is defined in Health People 2010 as: "The degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions"

I am hoping that my study will benefit society from environmental health information being written in a more readable form.

I am looking for about 30 - 50 people to participate in the study.

You are being invited to participate because you are a student of the CareGiver Training Institute in Tucson.

Your participation in this study is completely voluntary, and a decision not to participate will have no adverse effect on your student status at the CareGiver Training Institute.

Participants will....

1. provide some information about themselves such as age, ethnicity, primary language, reading level from the test taken at the CareGiver Training Institute, and amount of education

2. take a health literacy test and a pre-test of their knowledge regarding the environmental health topics of the test materials
3. read print materials on environmental health topics. No time limit will be imposed for reading the materials

4. take a post-test that is a repeat of the pre-test when they finish reading.

I am asking you to give about 2 hours of your time will be needed to complete this study.

Aside from your time, there are *no costs* for taking part in the study.

You will receive a very modest compensation for your time in the form of a gift card.

A randomly selected group of participants will be interviewed later about their views about the environmental health materials.

Although we have tried to avoid risks, you may feel that some questions we ask you may be stressful or upsetting. If this occurs you can stop participating immediately.

We will make an audio recording during the interview portion of the study so that we can be certain that your responses are recorded accurately.

If you decide to take part in the study, you will be asked to sign this consent form. And you will receive a copy of the consent form for your records.

The information sheet has my telephone numbers and email address. You can call me at (520) 626-3692 or email me at mlindsey@email.arizona.edu.

The Human Subjects Protection office oversees research. If you have questions about your rights as a research subject you may contact them anonymously, at (520) 626-6721 or via their website [http://www.irb.arizona.edu/contact/](http://www.irb.arizona.edu/contact/).
APPENDIX J: PARTICIPANT INFORMATION SHEET

Implications of Literacy Related to Comprehension of Environmental Health Print Materials

You are being invited to take part in a health literacy research study.

Currently, most health information is written at a college level. Most people in the U.S.A. read at about the seventh grade reading level. This study looks into problems with health literacy by trying to understand if the general public better understands environmental health information if it is written at the seventh grade reading level.

Society may benefit from environmental health information written at a reading level that is closer to the reading level of the general public.

We are seeking approximately 30 – 50 people for the study. You are being invited to participate because you are a student of the CareGiver Training Institute in Tucson.

Participants will....

5. Provide some information about themselves; age, ethnicity, primary language, reading level from the test taken at the CareGiver Training Institute, and amount of education

6. Take a health literacy test and a pre‐test of their knowledge regarding the environmental health topics of the test materials

7. Read print materials on environmental health topics. No time limit will be imposed for reading the materials

8. Take a posttest that is a repeat of the pretest when they finish reading.

You are asked to give about 2 hours of your time to complete this study. Aside from your time, there are no costs for taking part in the study.

You will receive a very modest compensation for your time in the form of a gift card.

A randomly selected group of participants will be interviewed, in a focus group, later about their views about the environmental health materials.
Although we have tried to avoid risks, you may feel that some questions we ask you may be stressful or upsetting. If this occurs you can stop participating immediately.

We will make an audio recording during the interview portion of the study so that we can be certain that your responses are recorded accurately.

Your participation in this study is voluntary. You may decide to not begin or to stop the study at any time. Your refusing to participate will have no effect on your student status at the CareGiver Training Institute. You can discontinue your participation with no effect on your student status.

If you decide to take part in the study, you will be asked to sign this consent form. The form was passed out at the beginning of this presentation. Please indicate on the bottom of this form if you are willing to participate. If you decide to participate, you will receive a copy of this form.

You can call or email the Principal Investigator to tell her about a concern or complaint about this research study. She is Marti Lindsey, Ph.D. Candidate, and can be called at (520) 626-3692 or reached by email at mlindsey@email.arizona.edu.

If you have questions about your rights as a research subject you may call the University of Arizona Human Subjects Protection Program office anonymously, at (520) 626-6721 or via their website http://www.irb.arizona.edu/contact/.
I am willing to participate in the study.

I am not interested in participating in the study.
APPENDIX K: INFORMED CONSENT

Implications of Literacy Related to Comprehension of Environmental Health Print Materials

Introduction

You are being invited to take part in a research study. The information in this form is provided to help you decide whether or not to take part. Study personnel will be available to answer your questions and provide additional information. If you decide to take part in the study, you will be asked to sign this consent form. A copy of this form will be given to you.

What is the purpose of this research study?

Low literacy affects more than 90 million adults in the United States. They are unable to do the most basic, simple and everyday literacy skills. They have a difficult time reading text and math to understand health information. This study looks into problems with health literacy by trying to understand if the general public better understands environmental health information if it is written at the seventh grade reading level.

Why are you being asked to participate?

You are being invited because you are a student of the CareGiver Training Institute in Tucson. This group was chosen for the study because their group of students represents average readers in the U.S.A. We want to test the understandability of environmental health materials with participants who represent average readers in the United States.

How many people will be asked to participate in this study?

Approximately 30 – 50 people will be asked to participate in this study.

What will happen during this study?

Participants will take a health literacy test and a pre-test of their knowledge regarding the environmental health topics of the test materials. They will read print materials on environmental health topics. No time limit will be imposed for reading the materials. They will take a posttest that is a repeat of the pre-test when they finish reading. A randomly selected group of participants will be interviewed, either in a focus group interview or individually, later about their views about the environmental health materials.

How long will I be in this study?

About 2 hours of your time will be needed to complete this study.

Are there any risks to me?

The things that you will be doing have no more risk than a small possibility of a breach of confidentiality. If you are asked and agree to participate in the focus group interview, you will be asked to protect the confidentiality of the other members.
Although we have tried to avoid risks, you may feel that some questions we ask you may be stressful or upsetting. If this occurs you can stop participating immediately. We can give you information about individuals who may be able to help you with these problems.

**Are there any benefits to me?**

You will not receive any benefit from taking part in this study. As a result of this study society may benefit from environmental health information written to be more readable.

**What are the alternatives for participating in this study?**

The alternative is not to participate in this study.

**Will there be any costs to me?**

Aside from your time, there are *no costs* for taking part in the study.

**Will I be paid to participate in the study?**

You will receive a very modest compensation for your time in the form of a gift card.

**Will video or audio recordings be made of me during the study?**

We will make an audio recording during the interview portion of the study so that we can be certain that your responses are recorded accurately only if you check the first box below:

- [ ] I give my permission for audio recordings to be made of me during my participation in this research study if I am selected for the follow-up focus group or individual interview meeting.

- [ ] I do not give my permission for audio recordings to be made of me during my participation in this research study.

**Will the information that is obtained from me be kept confidential?**

The only persons who will know that you participated in this study will be the research team members: *Marti Lindsey, Principal Investigator*. Your records will be confidential. You will not be identified in any reports or publications resulting from the study. Representatives of regulatory agencies including The University of Arizona Human Subjects Protection Program may access your records.

**What if I am harmed by the study procedures?**

There is no risk of being harmed by the study procedures.

**May I change my mind about participating?**
Your participation in this study is voluntary. You may decide to not begin or to stop the study at any time. Your refusing to participate will have no effect on your student status at the CareGiver Training Institute. You can discontinue your participation with no effect on your student status. Also any new information discovered about the research will be provided to you. This information could affect your willingness to continue your participation.

**Whom can I contact for additional information?**

You can call the Principal Investigator to tell her about a concern or complaint about this research study. The Principal Investigator Marti Lindsey, doctoral candidate, can be called at (520) 626-3692. If you have questions about your rights as a research subject you may call the University of Arizona Human Subjects Protection Program office at (520) 626-6721.

If you have questions, complaints, or concerns about the research and cannot reach the Principal Investigator; or want to talk to someone other than the Investigator, you may call the University of Arizona Human Subjects Protection Program office. (If out of state use the toll-free number 1-866-278-1455.) If you would like to contact the Human Subjects Protection Program via the web (this can be anonymous), please visit [http://www.irb.arizona.edu/contact/](http://www.irb.arizona.edu/contact/).

**Your Signature**

By signing this form, I affirm that I have read the information contained in the form, that the study has been explained to me, that my questions have been answered and that I agree to take part in this study. I do not give up any of my legal rights by signing this form.

__________________________________
Name (Printed)

__________________________________
Participant’s Signature __________________ date signed

**Statement by person obtaining consent**

I certify that I have explained the research study to the person who has agreed to participate, and that he or she has been informed of the purpose, the procedures, the possible risks and potential benefits associated with participation in this study. Any questions raised have been answered to the participant’s satisfaction.

__________________________________
Name of study personnel

__________________________________
Study personnel Signature __________________ date signed
REFERENCES


Lindsey, M. (2000). *A constructivist study of developing curriculum to teach Internet information literacy to Navajo high school students*. Prescott College, Prescott, AZ.


ResearchWare. (1997a). HyperResearch cross-platform qualitative analysis software. Randolph, MA.


