EXTENDING THE DIFFUSION MODEL IN RISK COMMUNICATION: A CASE STUDY OF RISK IN A PUBLIC HEALTH CAMPAIGN

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

Kimberly Ann Beauchamp

In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Programs:
Mass Communication
Food Safety

March 2010

Fargo, North Dakota

North Dakota State University
Graduate School

Title

Extending the diffusion model in risk communication:

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

ABSTRACT

Beauchamp, Kimberly A., M.S., Mass Communications, College of Arts, Humanities and Social Sciences, Food Safety, College of Graduate and Interdisciplinary Studies, North Dakota State University, March 2010. Extending the Diffusion Model in Risk Communication: A Case Study of Risk in a Public Health Campaign. Major Professor: Dr. Robert S. Littlefield.

Everett Rogers' (2003) diffusion model provided a theoretical framework through which to measure change among publics. However, use of Rogers' diffusion model can lead to research shortcomings such as lack of consequence research, change agent tendencies, pro-innovation bias, and inadequate research methods. Through new model development, the current study introduced a specific data analysis process that distinctly measured and merged a relationship between communication, outreach, and scientific effects. The application of a public health campaign served to test the new model's ability to overcome previous diffusion research shortcomings. Using an integrated approach of diffusion and gap analysis, the study investigated and quantified effects of risk communication. This new model has value in that it supports the collaborative efforts of multi-disciplinary projects, while promoting and strengthening the position of each discipline through joint research. The model serves to help researchers seek, find, and work within a respected and common ground platform.

ACKNOWLEDGEMENTS

This thesis is a synthesis of my efforts and much support from many individuals. I am very fortunate to have Dr. Robert Littlefield as my professor, mentor, and friend. As your student, I have come to realize that your teaching style is second to none. I am thankful that you accepted the responsibility to serve as my advisor. As your advisee, I have gleaned much from your insight and expertise. The feedback you offer is always skillfully balanced with compliments and constructive suggestions. Quite often you have encouraged me to think outside the box, and for that I am extremely grateful. Much of my thesis resulted from your suggestions, attention-to-detail, and steadfast guidance. I am also thankful that you helped me find a stopping point in my thesis document. Otherwise, I might still be writing and adding to it today! You are the engine that kept me on track to thesis completion. Thank you for your words of motivation and encouragement.

Dr. Julie Garden-Robinson, thank you for having confidence in my ability to coordinate the North Dakota folic acid campaign. Without your statewide project, much of my thesis would not have evolved. You encouraged my creativity throughout the campaign design and implementation. I consider you a friend, as well as a mentor. You truly are a role model. You set the stage with a perfect blend of commitment, perseverance and a terrific sense of humor – all of which have helped me learn how to overcome project-related challenges that may come my way. Thank you for having faith in my ability.

I would also like to thank all of my committee members for entering my world of thought as presented in my lengthy document. Thank you for helping me reach the point of a completed thesis. I truly appreciated your guidance through the challenging moments of the defense. Your valuable suggestions served to greatly improve my thesis. A special

thank you goes to Dr. Paul Nelson for helping me realize that I was well-prepared to defend my thesis, a day that we have all waited for! Dr. Charlene Wolf-Hall, thank you for asking questions to test my boundaries and helping me realize areas for potential growth.

Additionally, I would also like to extend a special thank you to my former professor, Dr. Margaret Khaitsa. Your classes ignited my interest and enthusiasm for epidemiology. Thank you for your sharing your insight as I prepared my thesis. Without hesitation, you made time to review my data analysis and offer suggestions which greatly improved my thesis. It was your input that helped me solidify my conclusions with confidence. Your epidemiologic expertise is truly a Godsend for me.

My acknowledgement would not be complete without thanking my family. To my husband Jeffrey, thank you for supporting my educational pursuits. I am grateful that you always allow me to bounce my ideas your way. Without your feedback, much of my creative thinking would be stifled and never reach fruition. To my daughter Kerri, thank you for understanding when I need to miss a sporting event or am too busy to do the fun things we are used to doing on a regular basis. You always know when I need a hug! To my daughter Steffanie, thank you for believing that your mom can accomplish a goal of degree completion. You are quite the cheerleader! To my daughter Laura, thank you for publicly acknowledging that your mother was sitting in a desk near you, while we attended classes together at NDSU. Of my children, you are the only one who can say "I graduated with my mom!" Although it is the parent who is supposed to offer advice and support, I will always be grateful for your words of encouragement as we worked simultaneously to complete our theses. To my daughter Jessica and her wonderful family, thank you for supporting my dreams from a distance, and understanding when I am too busy to drive up

the interstate for a weekend visit. Jessica, your gift of positive conversation is always a highlight of my life. Without fail, you always have a story to share that can make me laugh until I cry, just when I need it the most. To my parents, thank you for encouraging me throughout life to pursue my dreams. I am as proud of my family, as they are of me and without the input from each one of them, I would not be where I am today. For them, I am truly grateful and thank God on a daily basis.

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INTRODUCTION

Risk messages can be designed to warn individuals about the potentiality of an unwanted, but possible event. Preventative public health campaigns often promote risk-centered messages that forewarn the public of negative consequences that are linked to unhealthy behavior. However, as Sellnow, Ulmer, Seeger, and Littlefield (2009) pointed out, exposure to information does not automatically translate into individual's level of understanding (p. 9). In order to reduce risk, a level of understanding of the message and potential risk needs to be ascertained, and eventually acted upon.

Because innovations are a type of communication message whose effects are relatively easy to isolate, diffusion research offers a useful theoretical framework through which to ascertain an understanding of change (Rogers, 2003, p. 104). Everett Rogers published a theory of the diffusion of innovation in 1962 (Berger, 2005). Diffusion researchers often use Rogers' (2003) general model to investigate the timing of decisions made by individuals or systems choosing to adopt or reject new ideas, products, or behaviors. Tichenor, Donohue, and Olien (1970) proposed a knowledge-gap hypothesis that predicted a growth in knowledge-based differentials between socioeconomic groups when information is infused into the environment (Gaziano & O'Leary, 1998, p. 29). Taken together, these two conceptual frameworks provide a foundation through which to ascertain how individuals understand a communicated message, how differences in levels of understanding contributes to gaps in levels of information richness among publics, and how levels of information richness can be measured, quantified and associated with risks related to adopting or changing behavior.

The purpose of this study is twofold. First, this study probes the limitations of diffusion research and investigates the possibility of a new approach to address shortcomings. More specifically, this study will explore a diffusion approach that addresses change agent tendencies and pro-innovation bias, and utilizes specific methodologies to measure the consequences of communication and scientific effects. Second, this study will explore the creation of a new research model that employs the conceptual frameworks of diffusion and gap analysis, and additionally incorporates specific statistical and epidemiologic methods to analyze data. Thus, Rogers' (2003) diffusion model and Tichenor and colleagues' (1970) gap paradigm will be incorporated into the process of new model development. The goals and purpose of this study are introduced in this chapter.

First, this chapter introduces the challenges that limit the growth of diffusion research and explores potential areas for research contribution. Because diffusion research seeks to ascertain an understanding of change, the chapter moves to a discussion of change assessment measures. Next, the chapter highlights the importance of using appropriately partitioned data to draw accurate conclusions. Finally, this chapter concludes with an overview of this study's purpose, and defines pertinent terms and acronyms.

Diffusion Research Challenges

Diffusion has made many contributions to the understanding of human behavior. However, the potential contribution would be far greater if it were not for certain shortcomings and biases of diffusion research (Rogers, 2003, p. 105). Rogers (2003) pointed out that the use of his diffusion model may result in shortcomings such as a lack of consequence research, the inclusion of change agent tendencies, an assumption of pro-innovation bias, and limitations of research methods.

An individual's innovativeness has been the main dependent variable of much past diffusion research. "*Innovativeness* is the degree to which an individual or unit of adoption is relatively earlier in adopting new ideas than the other members of a system" (Rogers, 2003, p. 22). Much of the past diffusion research has explored variables related to innovativeness. Most diffusion research stopped with an analysis of the *decision* to adopt a new idea, and ignored how the choice is implemented and with what consequences (Rogers, 2003, p. 440). Rogers (2003) classified innovation consequences as (1) desirable versus undesirable, (2) direct versus indirect, and (3) anticipated versus unanticipated (p. 470). Why have there not been more diffusion studies of consequences?

Rogers (2003) suggested deterrents to consequence research. Rogers (2003) pointed out that change agencies often sponsor diffusion research, and overemphasize adoption under the assumption that consequences related to an innovation will be positive (p. 440). However, negative consequences may exist. They may simply be unrevealed because of the lack of consequence research. Therefore, due to the deficiency of consequence research, the pro-innovation assumptions may not always be valid (Rogers, 2003, p. 440). Change agencies assume that an innovation is needed and desirable by individuals. These funding agencies tend to measure diffusion success of an innovation by its rate of adoption (Rogers, 2003, p. 440). This measurement of success ignores how the choice is implemented and with what consequences.

Usual survey methods tend to be most suitable for measuring innovativeness, rather than investigating consequences related to adoption or rejection. Diffusion researchers have relied most entirely on one-shot survey methods, which are inappropriate for investigating innovation effects (Rogers, 2003, p. 440). A study in which respondents are interviewed

before and after an innovation's introduction may yield information related to consequences. To date, only a small number of diffusion investigations have included field experiments where variables of knowledge, attitudes and rate of adoption (K-A-P) are analyzed for differences between benchmark and follow-up surveys (Rogers, 2003, p. 72).

Consequences of an innovation are difficult to determine in a precise manner because it is difficult to untangle the cause-and-effect relationship (Rogers, 2003, p. 442). Consequences of an innovation may be confounded by other effects. Ideally, consequences should be evaluated as the outcome of an innovation, and measured as the changes that would not have occurred if the innovation had not been introduced and adopted (Rogers, 2003, p. 443). For example, lung cancer is a potential outcome of cigarette smoking. The prevalence of lung cancer due to smoking would not have occurred among publics, had cigarettes not been introduced.

Change Assessment Measures

The impact of consequences among individuals or groups of individuals is dependent on the context in which an innovation diffuses, and may differently affect some population subsets more than others. The diffusion of innovations generally causes wider socioeconomic gaps within an audience and decreases the degree of equality in a social system (Rogers, 2003, p. 457). Thus, consequences of an innovation may be categorized by the degree to which they increase or decrease equality among members of society.

Communication effects measure changes in publics that result from diffusing an innovation. Communication effects among publics have been of great interest to diffusion scholars. Most past diffusion studies have explored communication effects by measuring aggregate changes in knowledge, attitudes or adoption behavior among individuals

(Rogers, 2003, pp. 457-458). Later, diffusion scholars began to explore the equality of communication effects by measuring changes among groups of publics (Rogers, 2003, pp. 459-460).

The study of communication effects on aggregate and differential change is often referred to as gap dimension research. Gap research is a form of research that focuses on assessing change among publics. Tichenor and colleagues (1970) proposed a useful paradigm to assess gap differentials through data collection at two or more points in time (Rogers, 2003, p. 460). Because data are collected at multiple points in time, the gap paradigm provides a richer analysis of changes that occur among different audiences during the innovation process. For example, individuals can be classified into categories as "ups" and "downs" or "haves" and "have nots" on the basis of specific attributes, such as race, age, and socioeconomic status. Individuals also can be categorized by their decision to adopt or reject an innovation. Regardless of how individuals are classified into categories such as "ups" and "downs," regularities related to equality-inequality in the consequences of diffusion are found (Rogers, 2003, p. 460). An analysis that incorporates aggregate and differential analysis will better evaluate the total impact of an innovation among publics.

Relevance of Partitioned Data

Data often are partitioned to serve the needs of special interest studies, and present a biased approach. For example, those who study population health increasingly partition their data along racial or social lines to make comparisons relevant to the issue of health disparity (Asch & Armstrong, 2007, p. 2117). An eagerness to identify racial disparities may drive the choice to partition data by race. A narrow focus limits stratification analysis and may result in statistical confounding (Asch & Armstrong, 2007, p. 2117). In other

words, data results may be exaggerated, or may overlook extraneous variables that influence results.

One needs to be aware of Simpson's Paradox, a form of bias that results from homogeneity in the data if not accounted for when aggregating data. In 1951, Edward Hugh Simpson published an interesting statistical result. The statistical paradox states that a summary table, consisting of two or more collapsed tables, may show a relationship that is different from those reflected in the original data tables (Simpson, 1951). Simpson's paradox is a phenomenon that occurs when an association between two dichotomous variables is similar within subgroups of a population, but changes in similarity if individuals of the subgroups are pooled without stratification (Rücker & Schumacher, 2008). Among the general lessons of Simpson's paradox is that the partitions of data can at times support conclusions contradictory to those of the data as a whole (Asch & Armstrong, 2007, p. 2118). Thus, inappropriately partitioned data presents a problem when less accurate findings are presented and used to draw conclusions.

Conclusions drawn from findings of scientific and communication studies often are often used in decision making processes that formulate public policies, such as was evident in the development of the United States food fortification program. Based on the United States (U.S.) Centers for Disease Control and Prevention (CDC) synthesis of conclusions drawn from findings of numerous studies and agency reports, scientists inferred that folic acid alone at levels of 400 mcg per day will reduce the risk of having a pregnancy affected by a neural tube birth defect (NTD) (Centers for Disease Control and Prevention [CDC], 1992). This scientific basis prompted a need to address the inability of public health efforts

to influence voluntary and timely folate consumption among women of childbearing age (Shane, 2003, p. 8).

The Food and Drug Administration (FDA) reviewed CDC reports regarding the relationship between folic acid intake and the prevalence of neural tube birth defects and proposed regulations for public review (Oakley, 2007, p. 367). After reviewing approaches to delivery of folic acid to women of childbearing age, the FDA issued a folic-acid fortification policy that required all manufacturers to comply beginning January 1998 (CDC, 2002b). The fortification program is a population-based program that targets the population subset, women of childbearing age. More specifically, the fortification program implements an aggregate approach to target a partitioned subset of the U.S. population. Rogers (2003) encouraged researchers to investigate the context in which an innovation diffuses, such as policy-related decisions that influence the decision to diffuse an innovation to members of society (p. 115).

This chapter has presented challenges that have slowed growth and contributions of diffusion research. In order to contribute to the growth of diffusion research, these challenges need to be acknowledged and addressed. How can these diffusion research limitations be properly addressed and overcome in a study design? How can improvements be made to the way in which data are gathered and analyzed in diffusion studies?

Rationale

One way to investigate the context in which an innovation diffuses, and overcome past research limitations is to explore alternative ways of methodologically revealing and analyzing data. Currently, the quantification of communication effects in diffusion research

is deficient. More specifically, the consequences of communication and scientific effects related to diffusion of innovations are not quantified.

A revised model that addresses shortcomings of past diffusion research has the potential to more accurately investigate and report data from which findings and conclusions will be drawn. In sum, the present study proposes a new diffusion model and uses the application of a statewide folic acid campaign to test the new model's potential to overcome research limitations. The new model will be evaluated for its ability to quantify health-related risks related to the adoption of daily folic acid supplementation. As such, a new diffusion approach may be helpful in classifying consequences related to folic acid awareness, knowledge and supplement behavior among publics at-risk.

In this paper, the researcher brings the consequences of communication and scientific effects together into a single, coordinated investigation using a data analysis model that incorporates mediation and epidemiologic approaches. Using epidemiologic methods to appropriately partition data sets, this study uniquely investigates two dimensions of communication effects, and explores potential health risks related to daily consumption of folic acid containing supplements. Awareness, understanding, information richness, and behavior are measured aggregately and differentially among North Dakota publics. An analytical approach that compares aggregate and differential effects among audience subsets will be incorporated to better reveal which publics were more or less affected by the innovation's diffusion. Appropriately identifying and understanding gaps among multiple publics will more accurately guide and support a remediation process.

Baron and Kenny (1986) suggest that a causal approach provides opportunities to probe more deeply into the nature of causal mechanisms and integrates seemingly

irreconcilable theoretical positions (p. 1173). Epidemiologic models of causation and statistical tests have been developed through the years in an attempt to explain causation of an outcome and the interrelationships of factors or exposures causing the outcome. Torrence (1997) points out that measuring the strength of association between a specific factor and the outcome allows its importance to be quantified (p. 135). Thus, the stronger the association, the more likely the exposing factor will influence the outcome.

In the present study, the strength of association is examined between information richness and health-related risks. Information richness is used to quantify communication effects related to the risk of NTD and colorectal adenoma development. Through epidemiologic means, it can be inferred that a portion of NTDs occurring in North Dakota can be attributed to information richness. Diffusion research has relevance for many disciplines. A diffusion approach provides a common conceptual ground that bridges divergent disciplines and methodologies (Rogers, 2003, pp. 103-104).

Definitions

The following definitions of terms are relevant to the application of the folic acid campaign in the present study.

Neural Tube Birth Defects

For more than 40 years, researchers have studied the relationship between folic acid intake and the prevalence of NTDs. Twenty-one types of birth defects, including anencephaly and spina bifida, have been tracked on U.S. birth certificates since 1989 (CDC, 2002b). NTDs are structural defects of the spinal cord and brain that form in the developing fetus during the first 17 to 30 days after conception (CDC, 1999b). Of the NTDs, anencephaly accounts for approximately 50% of the cases, in which the infant's

brain is completely or partially missing (CDC, 2001). Infants with anencephaly die before or shortly after birth. Spina bifida accounts for the other 50% of the NTD cases, in which a malformation of the spinal column causes the spinal cord to form outside the protective backbone (CDC, 2001). Babies born with spina bifida usually survive and experience life-long health consequences associated with spinal cord malformation.

Childbearing age

Women who are capable of becoming pregnant are considered of childbearing age. Monitoring agencies such as the National Health and Examination Surveys (NHANES), typically include reports of blood folate serum levels of women between the ages of 15 and 44 years. March of Dimes Birth Defects Foundation (MOD) surveys typically include reports of folic acid awareness, knowledge and behavior of women between the ages of 18 and 45 years.

Folic Acid

The timely and adequate consumption of folic acid or folate can help form a baby's brain and spine during early fetal development. Folic acid is a synthetic compound of the B vitamin folate. While folate is naturally found in food, folic acid is used in fortified food and dietary supplements (Committee on Genetics, 1999, p. 325).

Risk

Risk is defined as the absence of uncertainty, and how an individual perceives and manages risk has a profound impact on the quality of life (Sellnow et al., 2009, p. 3). Although additional risk factors exist, the main risk factor of having an NTD-affected pregnancy is inadequate dietary intake of folic acid among women of childbearing age, starting at least a month prior to conception. Based on a synthesis of information from

several studies, it was inferred that folic acid alone at 400 mcg per day will reduce the risk of NTDs (CDC, 1992). No one can predict which women will experience an NTD-affected pregnancy, so all remain at risk. Because most supplements contain 400 mcg per pill, increasing the use of vitamins containing folic acid remains a helpful component of NTD prevention (CDC, 1992).

United States Public Health Service Recommendation

Research findings demonstrate a relationship between timely and adequate folic acid intake and NTDs. In 1992, in an effort to reduce the prevalence of preventable NTDs, the United States Public Health Service (USPHS) recommended that all women of childbearing age in the United States who are capable of becoming pregnant should consume 400 mcg of folic acid per day for the purpose of reducing their risk of having a pregnancy affected by spina bifida or other NTDs (CDC, 1992). In partnership with the National Council on Folic Acid (NCFA), the CDC began promoting the USPHS recommendation through the *Ready or Not* public health campaign, in May 1999 (Hammond, Squires, & Treiman, 2000, p. 2).

Measurements

Medical tests often give results in micrograms (mcg) or nonograms (ng) per milliliter (mL). A microgram is one-millionth of a gram. A nanogram is one-billionth of a gram. The dietary folate equivalent (DFE) is a measure that accounts for differences in absorption of naturally occurring dietary folate and bioavailable synthetic folic acid (National Institute of Health [NIH], 2009).

Information Richness

From a communication perspective, information richness is yet another way to measure the equality of consequences that result from diffusing an innovation among publics. One way to ascertain an individual's level of information richness is to evaluate their understanding of the USPHS recommendation, through a multiple choice test.

Most multiple-choice tests use a number-right scoring method, and calculate a test score based on the number of correct answers (Muijtjens, van Mameren, Hoogenboom, Evers, & van der Vleuten, 1999, p. 267). In the classical testing approach, the observed score on a given test (e.g. number right) is made up of true score (e.g. knowledge) and noise (e.g. guessing) (Higham, 2007, p. 2). Thus, correct answers on the test may result from an individual's use of complete knowledge, partial understanding, or lucky guesses. However, the observed score becomes a better estimate of the true score, when the noise component (e.g. guessing) is removed or "corrected for" (Higham, 2007, p. 2).

As an alternative approach, a formula-scoring method can be used to correct for noise, when evaluating responses on an individual's multiple-choice test. Introduced more than 80 years ago, the method of formula scoring is used to reduce the influence of random guessing by an individual (Thurston, 1919, p. 235, Holzinger, 1924, p. 445). In a formula-scoring approach, an individual's test is graded for total correctness, where each correct response receives a positive point value, each incorrect response is penalized with a negative point value, and each "passing" response receives a no-penalty value of zero points. The Scholastic Aptitude Test (SAT) uses a formula-scoring method to evaluate tests taken by American high school seniors. Since 1953, the SAT test scores have been evaluated in the following manner: a correct response is scored with +1 points, an incorrect

response is penalized with -0.25 points, and an unanswered question counts as zero points (Higham, 2007, p. 2).

The formula-scoring method is an alternative approach that can be used to ascertain a better estimate of an individual's true knowledge regarding a topic, such as the USPHS folic acid recommendation. For example, the method of formula scoring can be used to reduce the influence of random guessing that may be present in an individual's test responses regarding folic acid knowledge. In turn, the scored points representing an individual's true understanding of the USPHS folic acid recommendation can be summed to create an individual's level of information richness. Finally, an individual's information-richness score can be comparatively measured as a continuous variable or dichotomized into categories such of "information rich" and "information poor."

Delimitations

Findings related to NTD-risk are limited to published scientific journal articles, CDC reports, and data provided from the agencies such as the National Center for Health Statistics (NCHS), NHANES, Pregnancy Risk Assessment Monitoring System (PRAMS), MOD, and the NCFA. The *Ready or Not* campaign is investigated for its role modeling potential, and is not compared to other folic acid campaigns that may also exist. The *Ready or Not* campaign and the current study's campaign are evaluated on the basis of campaign objective achievement, and are not fully evaluated for campaign effectiveness. Although individual information-richness scores are computed for each survey participant, aggregate and differential analysis of communication and scientific effects are not evaluated on an individual basis. Rather, such effects are measured within and between groups of publics.

Acronyms

Table 1.1 presents acronyms used throughout this thesis.

Table 1.1 Acronyms Defined

Acronym	Description	Page of first mention
AF	Attributable fraction	96
AFp	Population attributable fraction	96
CDC	Centers for Disease Control and Prevention	6
DFE	Dietary folate equivalent	11
DHHS	Department of Health and Human Services	24
FDA	Food and Drug Administration	7
FNP	Family Nutrition Program	56
FNS	Food and Nutrition Service	57
HNRCA	Human Nutrition Research Center on Aging	35
HP2010	Healthy People 2010	24
IRB	Institutional Review Board	83
K-A-P	Knowledge-attitudes-rate of adoption	4
Mcg	Micrograms	11
mL	Milliliter	11
MOD	March of Dimes Birth Defects Foundation	10
MRC	Medical Research Council	20
NBDPN	National Birth Defects Prevention Network	25
NCBDD	National Center on Birth Defects and Developmental Disabilities	25
NCFA	National Council on Folic Acid	11
NCHS	National Center for Health Statistics	13
NDBDMS	North Dakota Birth Defects Monitoring System	37
NDDH	North Dakota Department of Health	76
NDDHS	North Dakota Department of Human Services	78
NDSU	North Dakota State University	83
Ng	Nanogram	11
ng/mL	Nanograms per milliliter	24
NHANES	National Health and Examination Surveys	10
NRC	National Research Council	42
NIH	National Institute of Health	11
NTD	Neural tube birth defect	6
OR	Odds Ratio	95
PH	Public Health	57
PRAMS	Pregnancy Risk Assessment Monitoring System	13
RBC	red blood cell	24
SAT	Scholastic Aptitude Test	12
U.S.	United States	6
USDA	United States Department of Agriculture	35
USPHS	United States Public Health Service	11
WIC	Women Infant Children	56

Summary

The chapters of this thesis are presented in the following manner. In chapter one, the need to appropriately partition and analyze data was introduced for its inherent value in accurately identifying and reporting disparities among publics at risk. Chapter two provides the scientific background necessary to identify publics at risk for having an NTD-affected pregnancy, or for developing colorectal adenomas. Additionally, chapter two highlights how data are partitioned and reported to the CDC. Thus, chapter two lays the foundation to investigate scientific effects related to folic acid consumption and disease among North Dakota publics.

Chapter three provides the conceptual framework necessary to understand theoretical underpinnings that are useful for measuring the impact of an education intervention. In chapter three, the diffusion approach is explored in depth in order to understand how a risk communication intervention has the potential to aggregately and differentially impact multiple publics. Chapter three expands upon the shortcomings of past diffusion research, and presents the opportunity to address previous research limitations in the design of a new study. Chapter four presents the methods necessary to overcome research shortcomings in study design and implementation. Chapter five reports the results of the risk-based communication study.

To test hypotheses, chapter six will discuss the findings of the folic acid study, as they apply to an extended model of diffusion. Throughout chapter six, a new diffusion model is revealed in six stages. Each stage addresses its relevance to shortcomings of previous diffusion research. Additionally, limitations of the statewide folic acid study design will be recognized, as will limitations of the new diffusion model.

Recommendations for continued research and model development will be presented, prior to drawing final conclusions.

SCIENTIFIC BACKGROUND

To reveal scientific background associated with folic acid and NTDs, this chapter provides the following sections: state and national NTD-prevalence rates, findings from past folic acid research, food fortification policy, national initiatives and objectives, and CDC monitoring agencies. Additionally, this chapter discusses the potential for direct and indirect consequences associated with folic acid intake levels for populations at risk.

These sections are related in the following way. The CDC has assigned multiple agencies the responsibility of tracking vital statistics and information related to folic acid awareness, knowledge, intake behavior, and the prevalence of NTDs. Research institutions have been funded through grants to investigate the association between folic acid and NTDs. Based on research findings, the FDA has issued regulations to fortify the food supply in an attempt to increase folic consumption and folate levels among females, and the USPHS issued a recommendation for females of childbearing age to consume 400 mcg of folic acid daily to reduce the risk of having an NTD-affected pregnancy. The USPHS has been monitoring the nation's progress toward meeting health objectives aimed at reducing NTDs.

The scientific background is needed in order to understand how agencies gather and analyze data for the CDC, how research findings are used to develop government policies related to public health, and how 10-year national health objectives related to folic acid and NTDs are continuously monitored.

NTD Surveillance

According to the CDC, about 3000 babies are born with NTDs such as anencephaly or spina bifida in the U.S. each year (CDC, 1992). NTDs are structural defects of the spinal

cord and brain that occur in the developing fetus during the first 17 to 30 days after conception (CDC, 1999b). The formation of the neural tube occurs early in pregnancy–in many cases, before a woman realizes she is pregnant and long before her first prenatal visit (CDC, 2001). It is estimated that 50-75% of these birth defects are preventable through adequate intakes of folic acid (pteroylmonoglutamic acid) before and during the first trimester of pregnancy (CDC, 1999a).

The number of anencephaly and spina bifida cases and prevalence rates for the years 2001 through 2005 are presented in Table 2.1.

Table 2.1. North Dakota Birth Defects 2001 through 2005

Defects	North Dakota Cases	North Dakota[a] birth prevalence	U.S. Annual cases	U.S.[b] birth prevalence
Anencephalus	10	2.5	1965	1.05
Spina bifida without Anencephalus	23	5.76	3619	1.93

[a]per 10,000 live births. ND pooled data from birth years 2001-2005. Adapted from *Birth Defects Research, Part A journal* (National Birth Defects Prevention Network [NBDPN], 2008, p. 880). [b]per 10,000 live births. U.S. pooled data from birth years 2001-2005. Adapted from *Trends in spina bifida and anencephalus in the United States, 1991-2006* (National Center for Health Statistics [NCHS], 2009).

The number of live births for the years 2001 through 2005 are presented in Table 2.2.

Table 2.2. Number of Live Births in North Dakota and the U.S. for 2001 through 2005

Year	Number of live births in North Dakota[a]	Number of live births in U.S.[b]
2001	7664	3640555
2002	7755	3645770
2003	7976	3715577
2004	8179	3860720
2005	8381	3887109
Total Pooled Live Births (2001-2005)	39955	18749731

[a]Adapted from *1937-2005 Births and Birth Rates by County* (North Dakota Department of Health [NDDH, 2009). [b]Adapted from *Trends in spina bifida and anencephalus in the United States, 1991-2006* (NCHS, 2009).

Folic Acid

If taken before conception and during early pregnancy, folic acid can help prevent birth defects of a baby's brain and spinal cord during early fetal development. Folic acid, a B vitamin, is a synthetic compound used in fortified food and dietary supplements (Committee on Genetics, 1999, p. 325). Folic acid has been available since the 1950s and has been used to treat folate-deficiency diseases (Oakley, 2007, p. 367). Folic acid has been added to foods such as enriched breads, pastas, rice, fortified cereals and vitamin supplements. For more than 20 years, most multivitamin preparations in the United States have contained 400 mcg of folic acid per serving (Oakley, 2007, p. 368) and this water-soluble vitamin has no known toxicity (Committee on Genetics, 1999, p. 326).

Many times, folic acid is referred to as folate, a generic term for food compounds that have the biologic activity of folic acid. In general, folates obtained from foods are not as well absorbed as is folic acid (CDC, 1992). Folate is naturally found in foods such as leafy green vegetables, cooked dry edible beans, broccoli, peanuts, citrus fruits and others.

According to the CDC, 10%-15% of the women know that they need folic acid before and in the first weeks of pregnancy. Because adequate folic acid levels are required during the first 28 to 30 days of gestation, prior to closure of the neural tube, it is often too late to begin vitamin supplementation once pregnancy is confirmed (Bentley, Ferrini, & Hill, 1999, p. 264). Whether a pregnancy is planned or unplanned, research shows that timely folic acid intervention reduces the risk of having an NTD-affected pregnancy.

Past Folic Acid Research

For more than 40 years, researchers have studied the relationship between folic acid and NTDs. Published data are available from randomized controlled trials, nonrandomized

intervention trials and observational studies. For example, three of four observational studies targeted women who have not had a prior NTD-affected pregnancy. A rigorous randomized prevention trial conducted by the British Medical Research Council (MRC) Vitamin Study Group targeted women who have had a prior NTD-affected pregnancy. Moore, Bradlee, Singer, Rothman, and Milunsky (2003) examined the dose-response relationship between maternal folic acid supplements or total folate intake and NTDs (p. 201). Based on a synthesis of information from several studies, including those which used multivitamins containing folic acid at a daily dose level greater than or equal to 400 mcg, it was inferred that folic acid alone at levels of 400 mcg per day will reduce the risk of NTDs (CDC, 1992). The reason why folate influences NTD rates remains unknown (Heseker, Mason, Selhub, Rosenberg, & Jacques, 2008, p. 1). More specifically, the molecular mechanism is not understood.

Because not all women receive adequate levels of folic acid from the food supply, increasing the use of vitamins containing folic acid remains a significant component of NTD prevention (CDC, 1992). Most supplement pills contain 400 mcg per pill (Mason, 2009, p. 209). Moore et al. (2003) examined the dose-response relationship of NTD-risk and folic acid/folate intake from supplements alone, food alone, and supplements and food combined (pp. 202-203) among women during the first five weeks of pregnancy.

When analyzing folic acid intake from supplements alone, Moore et al. (2003) found no evidence of a dose-response relationship (p. 202). When analyzing the effect of folate intake from foods, Moore et al. (2003) found that women with the lowest intakes of dietary folate from foods had the highest risk of having an NTD-affected pregnancy

(p. 203). When examining NTD-risk in relationship to total folate dose during the first five weeks of pregnancy, Moore et al. (2003) found that NTD-risk generally declined as total folate dose increased (p. 203) and the effect was even stronger for those consuming more than 600 DFEs per day of total folate at the time of conception (p. 204).

It is estimated that 35 percent of the U.S. adult population regularly consumes a multivitamin supplement containing folic acid, of which 40 percent of those consuming a daily supplement containing folic acid are 60 years and older (Radimer et al., 2004, p. 341). Conclusive scientific evidence linking the effectiveness of folic acid supplements on the reduction of NTDs prompted the formation of public health policy. The public health recommendation to take folic acid supplements periconceptionally was coupled with mandatory fortification (Bailey, Rampersaud, & Kauwell, 2003, p.1961S).

In 1992, in an attempt to reduce the frequency of NTDs and their associated economic burden, the USPHS began to urge women of childbearing age in the United States to meet the daily recommendation for folic acid intake. Because the effects of high daily intakes are unknown, the USPHS further advised that folate consumption remain less than 1 mg per day, except under the supervision of a physician (CDC, 1992). According to the CDC, the average cost of caring for a child born with spina bifida for life is between $636,000 and $1,000,000 per child each year (Grosse, Waitzman, Romano, & Mulinare, 2005, p. 1920). Thus, a reduction in NTDs through folic acid fortification in the United States has an estimated economic benefit of $312-$425 million annually (CDC, 2008).

Fortification

After reviewing much data and proposing regulations for public review, the FDA issued regulations (Oakley, 2007, p. 367). Given the 400 mcg dosage recommendation, the FDA reviewed three potential approaches for the delivery of folic acid to the general population. The delivery options included: a) fortification of the U.S. food supply, b) use of dietary supplements, and c) improvement in dietary habits (CDC, 1992). Food fortification was deemed necessary because of the perceived inability of public health efforts to influence voluntary and timely folate consumption among childbearing aged women (Shane, 2003, p. 8).

Folic acid fortification is broken into three periods: 1) pre-fortification; 2) voluntary fortification; and 3) mandatory fortification. The optional period for folic-acid cereal-grain enrichment started in March 1996, and mandatory fortification followed in January 1998 (CDC, 2002b). While large food companies began voluntary fortification, all manufacturers were required to comply with folic-acid fortification policies in January 1998.

Food fortification of commonly consumed foods by the public provided a way to increase the folic acid intake of the general population without having to rely on self-supplementation practices. Synthetic folic acid was ideal for fortification because it is a) more bio-available than natural folate; b) more stable in food than folate; and c) more readily absorbed into a woman's bloodstream before passing to her fetus (Wald & Oakley, 2007, p. 1252). A 140 mcg fortification level was estimated to increase an individual's daily folic acid intake by an average of 100 mcg per day, resulting in a total intake of approximately 300 mcg (Bentley et al., 1999, p. 265). The FDA selected the

140 mcg fortification level primarily because of safety concerns (Federal Register, 1996). Raising the fortification level above 140 mcg might possibly put an unknown number of individuals at risk to consume more than 1 mg of folic acid per day (Bentley et al., p. 265).

The fortification of wheat flour remains an effective, simple and inexpensive strategy for supplying folic acid to large segments of the population. For example, the cost of wheat-flour fortification with folic acid is estimated at pennies per person per year. The large proportion of the North American populations consuming flour products enriched with vitamins and minerals provided the opportunity for population-wide implementation of inexpensive and highly effective spina bifida and anencephaly prevention programs (Oakley & Brent, 2008, p. 746). Research makes a convincing case for folic acid fortification to prevent neural tube defects.

National Initiatives

The process of eliminating neural tube birth defects remains challenging and complex. According to the CDC, principal challenges to eliminating folic-acid preventable birth defects include:

- Lack of awareness of this prevention opportunity by health care providers, policy-makers, and the public;
- The financial burden and logistical barriers to providing supplements to women;
- Lack of centrally processed and distributed foods to serve as fortification vehicles in some countries;
- Regulations in some countries limiting the amount of folic acid in supplement pills;

- Misinterpretation of data, resulting in recommendation to promote only an increased consumption of folate-rich foods rather than an adequate fortification or supplement programme with crystalline folic acid (pteroylmonoglutamic acid);
- An unwillingness of government to set fortification concentration levels high enough. (CDC, 1999a, p. 3)

National initiatives were implemented in response to the folic acid and NTD research findings. In 2000, the Department of Health and Human Services (DHHS) launched the national health promotion and disease prevention agenda, called Healthy People 2010 (HP2010). HP2010 provides science-based, 10-year national objectives for promoting health and preventing disease (retrieved "About Healthy People" January 7, 2010 from Web site http://www.cdc.gov/nchs/healthy_people/hp2010.htm). Three HP2010 objectives pertain to folic acid intake, NTD reduction, and measurement of red blood cell (RBC) folate levels of women. Two objectives of HP2010 were to increase the number of women consuming 400 mcg of folic acid daily to 80% (CDC, 2004b), and a 50 percent reduction in NTD cases by the year 2010. An additional objective of the HP2010 agenda was to increase in the baseline red blood cell (RBC) folate levels of females consuming folic acid to 220 ng/ml.

Objectives tracked by HP2010 are reflected in the following four tables. Data were retrieved from the CDC Web site http://wonder.cdc.gov/DATA2010/OBJSEARC.HTM using search words folic, spina bifida and folate. Table 2.3 presents the HP2010 objective measures of the general female population. While general female population results appear to be moving closer to the objective targets, results that are categorized by the variable race reflect gaps in improvement levels among multiple publics. Table 2.4 presents the HP2010

folic acid intake objective measure by race. Table 2.5 presents the HP2010 NTD-cases objective measure by race.

Table 2.3. Healthy People 2010 Objective Measures of General Female Population

HP2010 objectives[a]	Baseline year of measure[a]	Baseline measure*	Year of measure*	Recent results[a]	HP2010 target[a]
16-16a: Folic intake	1991-1994	21%	2002-2003	27%	80%
16-15: NTD cases	1996	6	2003	5	3
16-16b: RBC folate	1998-1994	158	2003-2004	235	220

*Data Source: CDC, NBDPN, National Center on Birth Defects and Developmental Disabilities (NCBDDD), NHANES, NCHS

Table 2.4. Healthy People 2010 Objective Measure Folic Intake by Race

16-16a: Folic intake among females[a]	Baseline year of measure[a]	Baseline measure[a]	Year of measure[a]	Recent results[a]	HP2010 target[a]
White	1991-1994	23%	2002-2003	34%	80%
Black	1991-1994	18%	2002-2003	11%	80%
Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander	-	-	-	-	80%

[a]Data Source: CDC, NHANES, NCHS

Table 2.5. Healthy People 2010 Objective Measure NTD Cases by Race

16-15: NTD cases among females[a]	Baseline year of measure[a]	Baseline measure[a]	Year of measure[a]	Recent results[a]	HP2010 target[a]
White	1996	-	2003	5	3
Black	1996	-	2003	4	3
Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander		-		-	3

[a]Data Source: CDC, NBDPN, NCBDDD

Table 2.6 presents the HP2010 RBC folate objective measure by race. Among all three HP2010 objectives, data tracked and reported are insufficient for Asians, American

Indians or Alaska Natives, Native Hawaiians or Other Pacific Islanders. Pooled year results indicate that the HP2010 objectives are improving, but have not been met.

Table 2.6. Healthy People 2010 Objective Measure RBC Folate by Race

16-16b: RBC folate among females[a]	Baseline year of measure[a]	Baseline measure[a]	Year of measure[a]	Recent results[a]	HP2010 target[a]
Black	1988-1994	122	2003-2004	195	220
White	1988-1994	164	2003-2004	247	220
Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander		-		-	220

[a]Data Source: CDC, NCHS, NHANES

Monitoring Agencies

Currently, no single agency is assigned the responsibility of monitoring the fortification program for long-term health impact or overall safety (Rader & Schneeman, 2006, p. 1398). The CDC collects data from multiple agencies in order to evaluate changes in periconceptional folic acid intake, the prevalence of NTDs and the effectiveness of folic acid intervention programs. For example, the CDC's National Center for Health Statistics collects birth defects data from U.S. birth certificates to determine the effect of folic acid fortification and other sources of folic acid supplementation (CDC, 2002b). The National Health and Nutrition Examination Survey tracks the medium serum folate concentrations among non-pregnant women of childbearing age (CDC, 2007). The Pregnancy Risk Assessment Monitoring System conducts state-specific surveys each month to assess maternal attitudes among women who have recently given birth (CDC, 2001). Additionally, since 1995, the MOD has monitored awareness, knowledge and behavior regarding folic acid, among women of childbearing age (CDC, 2008).

The National Center for Health Statistics

The NCHS houses two major types of data systems: systems based on populations and systems based on records. As the nation's principal health statistics agency, the CDC's NCHS conducts a data collection program and tracks key health indicators and trends while monitoring the health of the U.S. (CDC, 2006). The agency houses data such as: vital statistics records, medical records, personal interviews, telephone and mail surveys, physical examinations, and laboratory testing. The agency also serves as a resource for NTD-related data.

Since the time that mandatory fortification of cereal grain products went into effect, the prevalence of anencephaly and spina bifida was reported to have declined (CDC, 2004a). Using population-based surveillance systems, the CDC evaluates NTD prevalence rate comparisons between a 24-month pre-fortification and a 24-month post-fortification period. The number of live births is used as a denominator to calculate the prevalence estimates from 1995 through 2000.

Based on surveillance data for systems with prenatal ascertainment, an estimated 2,490 spina-bifida pregnancies and 1,640 anencephaly-affected pregnancies occurred annually during the pre-fortification period from 1995 through 1996 (CDC, 2004a). Approximately 1,640 spina-bifida affected pregnancies and 1,380 anencephaly-affected pregnancies occurred during the post-fortification period from 1999-2000 (CDC, 2004a). The surveillance data for systems with prenatal ascertainment reflect a 27% decline in the total annual average of NTD-affected pregnancies between the two periods.

Based on surveillance data for systems without prenatal ascertainment, an estimated 1,980 spina-bifida affected pregnancies and 970 anencephaly pregnancies occurred

annually during the pre-fortification period from 1995 through 1996 (CDC, 2004a). Approximately 1,340 spina-bifida affected pregnancies and 840 anencephaly-affected pregnancies occurred during the post-fortification period from 1999-2000 (CDC, 2004a). The surveillance data for systems without prenatal ascertainment reflect a 26% decline in the total annual average of NTD-affected pregnancies between the two periods. According to the NCHS data (1995-2000), the estimated decrease in the number of NTD-affected pregnancies during the fortification period suggests the success of folic acid fortification in the food supply.

National Health and Nutrition Examination Survey

NHANES studies are conducted among non-institutionalized U.S. residents to measure the nutritional status of the U.S. population and monitor changes over time. The first cycle of NHANES studies was conducted between 1971 and 1975. To assess temporal trends in serum and red blood cell (RBC) folate concentrations among women of childbearing age, the CDC has compared NHANES data for periods: NHANES 1988-1994, NHANES 1999-2000, NHANES 2001-2002, and NHANES 2003-2004 (CDC, 2002a; CDC, 2007). Studies completed from 1988 through 1994 fall within the folic acid pre-fortification period. The three continuous studies from 1999 through 2000 took place during the post-fortification period.

In addition to a household interview, a physical examination was conducted for each participant and blood samples were collected by venipuncture. From 1988 through 2000, serum and RBC folate were measured in CDC's NHANES central labs. NHANES findings indicate that serum and RBC folate concentrations for women of childbearing age increased from 1988 to 2000 (CDC, 2002a). Between these two periods, median serum

folate concentrations increased from 4.8 to 13.0 ng/mL and median RBC folate concentrations increased from 159.9 to 263.6 ng/mL RBC (CDC, 2002a). When analyzing by race/ethnicity, serum and blood folate levels have increased among non-Hispanic white, non-Hispanic black and Mexican-American females from 1988-1994 through 1999-2000 (CDC, 2002a).

Additional NHANES studies during the post-fortification period were conducted from 2001 through 2004 among women of childbearing age (CDC, 2007). Median serum folate concentrations have declined from 12.6 ng/mL (NHANES 1999-2000) to 11.4 ng/mL (NHANES 2001-2002) and 10.6 ng/mL (NHANES 2003-2004). A significant 16% decline was observed from 1999-2000 (12.6 through 2003-2004 based on comparison of geometric means [p=<0.001]. Similarly, a statistically significant 8% decline was observed from 255 ng/mL during 1999-2000 to 235 ng/mL during 2003-2004 [p=0.028] (CDC, 2007). When analyzing median serum folate levels by race/ethnicity, the largest decrease (16%) was noted among non-Hispanic whites [p=0.008], while the serum folate concentration was lowest among non-Hispanic blacks for all three survey periods (CDC, 2007).

Non-Hispanic white and Mexican-American women exceeded the HP2010 objective for median RBC folate concentration (220ng/mL) during all three post-fortification survey periods (CDC, 2007). Non-Hispanic black females have not yet met this objective. "Trend differences from 1999-2000 through 2003-2004 in RBC folate concentrations were not statistically significant among each of the three racial/ethnic populations (non-Hispanic whites [p=0.106], non-Hispanic blacks [p=0.076], and Mexican Americans [p=0.064]" (CDC, 2007). While overall, the findings from the NHANES data

(1999-2000) indicate that food fortification and efforts to increase folate consumption have been effective, if folate-intake levels continue to decline, RBC folate concentrations might decrease to <220 ng/mL, thus falling short of the HP2010 objective.

Pregnancy Risk Assessment Monitoring System

PRAMS is a collaborative surveillance project of the CDC and state health departments that gathers state-specific, population-based data on maternal attitudes and experiences of women, before, during and shortly after pregnancy. To examine folic acid awareness among women of childbearing age, the CDC analyzed multiple years of PRAMS data (1995-1998) using certain demographic and prenatal characteristics such as race, ethnicity, marital status, age, and education status (CDC, 2001). The PRAMS survey gauges general folic acid awareness among females. For example, the survey does not measure whether women know how much folic acid to take or whether they know when to take it. Variations of increased levels of awareness become noticeable when survey results are correlated with demographic and prenatal characteristics.

The prevalence of folic acid awareness estimates remained lower among women who were younger, unmarried, uninsured, did not intend to become pregnant, had a high school education or less, participated in WIC, began prenatal care after the first trimester, and received prenatal care from the health department (CDC, 2001). Women who were black, Hispanic, or from other racial ethnic groups, were significantly less likely to know of the relationship between folic acid and the reduction of birth defects. Individuals entering prenatal care later than the first trimester or had no care at all also were significantly less likely to be aware of the benefits of folic acid. In comparison, women who reported that their place of prenatal care was a federally funded program or the Indian

Health Service were more likely to know about folic acid in general (CDC, 2001). The data also indicate that collaborative efforts among national, state and local authorities are contributing to the increase in folic-acid awareness (CDC, 2001).

The findings of the PRAMS data (1995-1998) indicate a general overall increase in folic acid awareness among all groups of women, albeit slowly in some populations. The PRAMS data analysis also suggests that gaps in folic acid awareness and consumption exist among demographically categorized groups of females. According to the Gallop Organization Poll results, folic-acid messages directed at the general publics are perceived differently among age groups. Rather than generalizing one message to all women of childbearing age to ultimately reduce the incidence of NTDs, multiple messages tailored to each age group may prove more effective. For example, in order to change behaviors, increase knowledge and raise awareness among women aged 18-24 years, innovative and effective messages are needed.

March of Dimes Foundation

Since 1995, the Gallup Organization has conducted annual surveys for the MOD (CDC, 2004b). These annual surveys have included data on vitamin use and dietary behaviors among women of childbearing age. The CDC analyzed results of the Gallop Organization polls from 1995 through 2007.

An increase in vitamin consumption among women of childbearing age indicates a change in behavior and suggests the potential for consumption of vitamins containing folic acid to impact the number of NTD-affected pregnancies. Although the survey data from 1995 through 2003 did not indicate a substantial increase in the proportion of female vitamin users, a substantial increase was observed in 2004 among women between the ages

of 18 and 45 years. In 2004, 40% of the women reported taking vitamins containing folic acid, compared to 32% in 2003. In contrast, these findings suggest that 60% of surveyed females are not consuming a vitamin containing folic acid. Of the women surveyed, 24% in 2004 knew that folic acid prevents birth defects compared to 21% in 2003; and 12% in 2004 knew that folic acid should be taken before pregnancy compared to 10% in 2003 (CDC, 2004b).

To assess folic acid awareness, knowledge and behavior, the CDC examined the Gallup Organization survey results from 2003 through 2007. In 2007, 40% of surveyed women reported daily consumption of a folic-acid containing supplement, compared to 33% in 2005, 40% in 2004, and 32% in 2003 (CDC, 2008). The level of folic acid awareness varied among age groups surveyed in 2007. For example, 61% of women aged 18-24 reported awareness, compared with 87% of women aged 25-34 years and 89% of women aged 35-45 years (CDC, 2008). When compared to women aged 25-45 years, women aged 18-24 years were less knowledgeable about the need for periconceptional folic-acid supplementation. The 2007 findings also indicate that consumption of vitamins containing folic acid also was lower among women aged 18-24 years, when compared to women aged 25-45 years. While both women's knowledge about and consumption of folic acid have increased since the Public Health Service issued the recommendation in 1992, most childbearing aged women still do not consume the recommended amount of folic acid on a daily basis (Hammond et al., 2000, p. 1).

Direct and Indirect Consequences

Potential Beneficial Effects

A reduced incidence in NTD-affected pregnancy is considered to be a direct effect or consequence of the folic acid fortification program. Data analysis demonstrated that NTDs declined during the post-mandatory fortification period, when compared to the incidence of NTDs during the pre-fortification period. Although mandatory folic acid fortification of the U.S. food supply was initially implemented in 1998 in order to reduce the number of NTDs among women of childbearing age, health experts thought there might be added benefits to others, beyond pregnant women (Harvard Women's Health Watch, 2008, p. 1). Because men, women and children share the same U.S. fortified food supply, mandatory folic acid fortification impacts the entire U.S. population. Assessment of the secondary effects resulting from adding folic acid to the U.S. food supply yields mixed results.

While the direct relationship between folic acid intake and reduced NTD prevalence among the female subset appear reasonably supported through research, few data exist on the indirect benefits and adverse effects of folic acid fortification on populations beyond women of childbearing age. Most studies related to folic acid focus on NTD-reduction. In comparison, very few studies have looked at the secondary effects of elevated folate intakes (Shane, 2003, p. 9) or the potentially harmful health outcomes (Troen et al., 2006, p.189).

For the past several decades, collective evidence, from pre-clinical and clinical studies, has indicated that high dietary intake of folic acid among the general population provides protection from the development of certain common cancers such as colorectal,

breast, lung, pancreas and others (Mason, 2009, p. 206). Such potential added health-related benefits are examples of indirect consequences resulting from the folic acid intervention program. Experts hoped that the consumption of supplements containing folic acid, vitamins B6 and B12 would lower homocysteine levels and reduce the number of heart attacks and cardiovascular events (Harvard Women's Health Watch, 2008, p. 3). In observational studies, folic acid supplementation has been shown to be associated with reduced risk of vascular disease (Bailey et al., 2003, p. 1961S). Authors of a study published in the journal *Circulation* (March 14, 2006) believed that the sharp drop between 1998 and 2002 in the rate of stroke deaths is probably due to fortification (Harvard Women's Health Watch, 2008, p. 2).

The results of several trials have been disappointing to experts. Past studies have only included participants who already had heart disease. Conclusions of the effect of supplements containing folic acid, B6 and B12 on the *development* of heart disease could not be drawn and as a result, the American Heart Association was not able to recommend folic acid and B vitamins to reduce the risk of heart attacks or stroke (Harvard Women's Health Watch, 2008, p. 3).

Potential Adverse Effects

In select circumstances, strong laboratory and clinical evidence have indicated that over-abundant folic acid intake can stimulate the growth of cancer cells in some individuals (Harvard Women's Health Watch, 2008, p. 2; Mason, 2009, p. 209). While scientific evidence suggests that continuous high intakes of dietary folate protects against colorectal cancer, synthetic folic acid may inadvertently create a negative-health effect. Findings from

controlled studies in a variety of animal models indicate that supplemental folic acid is protective only before neoplastic foci appear in the intestine (Mason, 2009, p. 209).

Data from prior studies in both animals and humans indicate that administration of large quantities of folic acid can facilitate the development of benign growths into cancers, or small cancers into larger ones (Health & Nutrition Letter, 2007, p. 2). Researchers at the Jean Mayer United States Department of Agriculture (USDA) Human Nutrition Research Center on Aging (HNRCA) at Tufts point out that during the early years of folic acid fortification in the U.S. food supply, when average blood levels of folate doubled, there have been four to six additional cases of colorectal cancer for every 100,000 individuals each year compared to a 15-year decline prior to fortification (Harvard Women's Health Watch, 2008, p. 2). In the U. S., this remarkable departure from decline began in 1996 and continued through 1998.

Mason et al. (2007) suggest a very close chronological relationship between the rise in colorectal cancer incidences and the elevated systemic folate status of adults resulting from folic acid fortification (p. 1327). It has been known for years that oral doses of synthetic folic acid, found in supplements and fortified food, may lead to unmetabolized folic acid in the bloodstream and produce detrimental effects because the oxidized, non-substituted form of folate is not a naturally occurring coenzymatic form of the vitamin (Mason, 2009, p. 209). When folic acid is added to that which appears in fortified foods such as breakfast cereals plus the additional quantity that is now consumed in the form of mandatory cereal grain fortification, it should come as no surprise that a substantial percentage of the population has detectable quantities of folic acid chronically circulating in the bloodstream (Mason et al., 2007, p. 1328).

Without taking into consideration any folic acid consumed from fortified foods, individuals complying with the daily 400 mcg folic acid supplementation recommendation are at risk for accumulating sufficient folic acid levels that will lead to unmetabolized folic acid in serum (Sweeney, McPartlin, & Scott, 2007, p. 6). Mason (2009) points out, higher intakes of folate are cancer-protective in nearly all circumstances, except among individuals consuming high quantities of folic acid and who have pre-existing neoplastic lesions, in which case the folate increases the risk of tumorigenesis (p. 209). Colorectal adenoma and dysplastic nodules of the prostrate are slow-growing cancers that take years to evolve through an "indolent dysplastic phase." These cancers are exceedingly common among the general population of healthy, elderly adults (Mason, 2009, p. 209).

In a study of older Americans during the age of folic acid fortification, blood serum folate levels were examined for a potential association with anemia and cognitive impairment. Morris, Jacques, Rosenberg and Selhub (2007) found direct associations between high serum folate and both anemia and cognitive impairment in subjects with low vitamin B12 status (p. 196). Over-abundant accumulations of folic acid intake may have the potential to mask a vitamin B12 deficiency in some adults which can cause pernicious anemia and result in irreversible neurological damage if left untreated (Harvard Women's Health Watch, 2008, p. 3; CDC, 1992). In contrast, Morris et al. (2007) found an association between high serum folate and cognitive impairment protection among subjects with normal vitamin B12 status (p. 196).

Populations At Risk

Inadequate dietary intake of folic acid is a risk factor of having an NTD-affected pregnancy for women of childbearing age. According to the CDC, additional risk factors

include: Having a previous NTD-affected pregnancy; having diabetes with-out-of-control blood sugar; taking certain medicines such as those for treating epilepsy; being obese; experiencing high temperatures in early pregnancy from fevers, hot tubs and saunas; or being Hispanic. No one can predict which women will have an NTD-affected pregnancy. Whether a pregnancy is planned or unplanned, all women of childbearing age are at risk for having a baby born with an NTD.

Established in 2003, the North Dakota Birth Defects Monitoring System (NDBDMS) has been tracking the occurrence of anencephaly and spina bifida in North Dakota. In the most recently published NDBDMS surveillance report, North Dakota rates of anencephaly and spina bifida were compared to data collected by birth defect surveillance systems in Utah and Colorado. Based on state surveillance for the period 1995 through 1999, North Dakota had a higher rate of spina bifida than the other states, averaging 7.1 cases per 10,000 births compared to 3.8 in Utah, and 3.6 in Colorado (retrieved October 9, 2009 from Web site http://www.ndhealth.gov/CSHS/docs/birth-defects-report.pdf).

While women of childbearing age are clearly at risk for having an NTD-affected pregnancy, the potential for colorectal cancer development, pernicious anemia and cognitive impairment raises concerns about the cumulative effects of folic acid intake from supplements and food fortification on individuals aged 50 years and older. This aging population subset is more likely to already have polyps (Harvard Women's Health Watch, 2008, p. 3). Although pernicious anemia rarely occurs before the age of 50 years, and rarely occurs among women consuming folic acid during childbearing age

(Desposito et al., 1999, p. 326), individuals over the age of 50 are susceptible to anemia and cognitive impairment.

Summary

Temporal trends of NTDs were inversely related to the folic acid fortification of the United States food supply. Data analysis demonstrated that NTDs declined during the post-mandatory fortification period, when compared to the incidence of NTDs during the pre-fortification period. The CDC gathered data from many agencies and sources in order to assess the effectiveness of folic acid delivery to the general population. Through an examination of integrated data, the CDC was able to evaluate the levels of folic acid intake and folate serum among women of childbearing age. According to the NCHS data (1995-2000), the estimated decrease in the number of NTD-affected pregnancies during the fortification period suggests the success of folic acid fortification in the food supply. While overall, the findings from the NHANES data (1999-2000) indicate that food fortification and efforts to increase folate consumption have been effective, if folate-intake levels continue decline, RBC folate concentrations might decrease to <220 ng/mL, thus falling short of the HP2010 objective.

An increase in vitamin consumption among women of childbearing age indicated a change in behavior and suggested the potential for consumption of vitamins containing folic acid to impact the number of NTD-affected pregnancies. Supplement use and fortified food consumption remain as valid strategies aimed at reducing NTDs. At this point in time, the general recommended daily folic acid intake level of 400 mcg remains for most women of childbearing age.

Research indicates that potential benefits and risks are associated with the cumulative effects of folic acid intake among multiple population subsets. Folic acid fortification of the food supply may benefit some individuals at the expense of others. In other words, folic acid intake from a fortified food supply may put some individuals at greater risk for disease, while others continue to benefit. According to Mason (2009), the biological plausibility of the cancer-promoting effect is possible and if it exists, the large-scale ramifications of such an effect cannot be overlooked in this era of folic acid fortification (p. 210).

Although monitoring systems exist to measure NTD-affected births, folate serum levels of females, and folic acid awareness, knowledge and behavior among women, systems fall short of monitoring the long-term effects of folic acid fortification on population subsets beyond women of childbearing age. For example, current tracking systems do not monitor the folate status and folic acid intake levels of populations at risk. Careful monitoring of additional affected population subsets may reveal data that more accurately reflects the short and long term effects of folic acid fortification.

North Dakota publics may have folate-related risk factors that are unique to the state's population of multiple publics. Simpson's Paradox indicates that research findings may vary when analyzed at individual, state and national levels. For example, findings related to gaps in folic acid awareness among populations of females may differ when data are partitioned at the individual, state and national levels. The rates of NTD prevalence before and after folic acid fortification may differ when analyzed at the state and national levels. The findings related to the risk of having an NTD-affected pregnancy may also differ when compared at the individual, state and national levels.

Additionally, findings related to potential adverse affects of folic acid intake, such as increased colorectal adenoma development, may differ when compared at the individual, state and national level. For example, the prevalence of individuals at risk for developing colorectal adenomas or colorectal cancer due to the daily consumption of supplements containing folic acid may be higher at the state level, when compared to the national level. Research findings are utilized to assess progress toward reaching HP2010 objectives. Appropriately partitioned data likely plays a significant role in the ability to draw accurate conclusions that in turn will be used to influence policy development. In view of the potential risks resulting from inadequate or over-abundant folic acid consumption, this study will investigate multiple North Dakota populations potentially at risk for adverse affects related to daily folic intake behavior.

LITERATURE REVIEW

The focus of the previous chapter was on the scientific relationship between folic acid and NTDs. This chapter will provide the background pertaining to risk communication, such as a folic acid education and intervention efforts aimed at reducing NTDs. To reveal the potential communication effects that are grounded in diffusion of innovation theory, this chapter provides the following sections: risk communication, national efforts, diffusion of innovation, consequences, communication effects gap, and causality.

These sections are related in the following way. Risk communication is a form of communication that seeks to educate and motivate individuals to respond in a specific manner for the purpose of risk aversion. The CDC has aligned itself with a national coalition for the purpose of educating individuals throughout U.S. about the USPHS daily folic acid recommendation. As Noar (2006) points out, campaigns are increasingly incorporating the use of theory to drive success (p. 25). Thus, diffusion is considered a conceptual framework for information management and dissemination.

A variety of consequences associated with diffusion are discussed. Shortcomings that are typical to diffusion research are highlighted. Several methodologies that have been used to measure communication effects gaps related to diffusion are presented. Statistical and epidemiologic methodologies are investigated for their potential to quantify an individual's levels of understanding, information richness and risk. Finally, the opportunity to extend the diffusion model for the purpose of improving conclusions drawn from research results is considered. Thus, the communication background is necessary in order to investigate shortcomings of diffusion research, so that limitations may be addressed and

overcome in future study designs. Through improvements made to the diffusion paradigm, an extended model becomes possible.

Risk Communication

Considered a fundamental part of life, risk perception lies in the eyes of the beholder. In the basic form, risk is the absence of certainty, and how an individual perceives and manages risk has a profound impact on quality of life (Sellnow et al., 2009, p. 3). Advanced technology, science, and government agencies play a role in risk management at the national level, where measurements of risk are scientifically investigated and research findings serve as the basis for development and implementation of policies, such as the mandatory food fortification of the U. S. food supply. In 1983, the National Research Council (NRC) completed a study of the risk assessment of government agencies, and established risk communication as a democratic dialogue that includes an interactive process with persons whose lives could be impacted by a given risk (Sellnow et al., 2009, p. 5).

Research findings also serve as the basis for risk messages that become crafted and adapted by technical experts for audience members to consider on a personal level (Sellnow et al., 2009, p. 4). Thus, through the incorporation of a forward-looking approach, risk messages can be designed to warn individuals about the potentiality of an undesirable event. Ultimately, the goal of risk communication is to prevent a crisis, such as the negative consequence of having an NTD-affected pregnancy. Preventative campaigns, supported by scientific evidence, often promote risk-centered messages that forewarn of the negative consequences that may result from an unhealthy behavior, such as lung cancer from cigarette smoking, or the formulation of neural tube birth defects from lack of folic acid

during fetus development. Although risk communication campaigns are carefully controlled and orchestrated, they may fail miserably when risk messages do not account perceptions of publics (Sellnow et al., 2009, p. 6).

Public health literature and risk communication literature have emphasized the importance of messages that provide specific information telling people what they can do to reduce their harm (Seeger, 2006, p. 242). *Self-efficacy* refers to an individual's sense of empowerment to manage risk. Self efficacy is a vital component in an individual's perception of risk, where an individual becomes more likely to respond to messages that present a reasonable strategy of reducing the probability of risk (Sellnow et al., 2009, p. 9), such as the USPHS folic acid recommendation. For example, an individual may perceive a sense of empowerment in the ability to consume of a folic acid supplement every day for the purpose of averting an NTD-affected pregnancy. In contrast, an individual who does not perceive the ability to meet the folic acid recommendation may perceive a lack of self-efficacy. Clear, concise and consistent messages reduce public confusion and increase the probability that recommendations will be taken.

However, the simple exposure to information, such as a campaign message, does not automatically translate into individual's level of understanding of a potential health risk (Sellnow et al., 2009, p. 9). For example, as a result of a folic acid campaign, an individual may become aware of folic acid's existence but may not know who needs it or why. Campaign objectives aimed at measuring an increase in awareness stop short of comprehending how individuals interpret, understand and will respond to a message. For example, without a level of understanding, a female of childbearing age may not feel empowered or self-motivated to respond to the need to take folic acid every day, and thus

her level of NTD-risk remains unchanged. In order to reduce risk, a level of understanding of the message and potential risk needs to be ascertained and acted upon. Therefore, an individual's level of understanding is relevant to an individual's level of risk, and both need to be assessed individually, as well as in combination.

National Efforts

Since 1992, the USPHS has recommend a daily folic acid intake level of 400 mcg for women of childbearing age in order to reduce the national prevalence of neural tube birth defects, increase red blood cell folate levels of women to 220 ng/mL, and increase the number of women consuming 400 mcg of folic acid daily. Research findings demonstrate a relationship between timely and adequate folic acid intake and the reduction of risk for having an NTD-affected pregnancy. Research findings also indicate that most women of childbearing age do not consume the recommended amount of folic acid on a daily basis (Hammond et al., 2000, p. 1).

The CDC determined that an educational campaign was needed to educate the public about the relationship between folic acid and neural tube birth defects. In 1998, the NCFA and the *Ready or Not* campaign were created in response to this need. A *campaign* usually entails an organized set of activities and messages, such as posters, radio spots and so forth, aimed at generating specific outcomes or effects by a relatively large number of individuals, and usually involves an organized set of communication activities (Rogers & Storey, 1988). The *Ready or Not* campaign was conducted in partnership with the NCFA.

Through the *Ready or Not* campaign, the NCFA coalition, comprised of national organizations, health professional associations, nonprofit organizations, community health coalitions, state folic acid councils, and government agencies, aimed to improve health

through the promotion of folic acid consumption benefits (Hammond et al., 2000, p. 2). Launched in May 1999, the *Ready or Not* campaign utilized radio, television, print public service announcements (PSAs), news coverage, and a range of mass media and support materials dissemination by coalition partners to reach women of childbearing age (Hammond et al., 2000, p. 2). The goal of the *Ready or Not* campaign was to achieve the following CDC objectives by December 2002:

1. Increase by 20 percent the number women aged 18 to 35 years who are aware of folic acid.
2. Increase by 50 percent the proportion of women aged 18 to 35 years who know that consuming a folic acid consuming supplement can reduce the chances of having an NTD-affected pregnancy.
3. Increase by 50 percent the number of women aged 18 to 35 years who know that a folic acid-containing supplement needs to be taken before pregnancy to prevent certain birth defects.
4. Increase by 12 percent the number of women aged 18 to 35 years who report taking daily a folic acid containing supplement.

(Hammond et al., 2000, p. 4)

These objectives were selected to target a specific knowledge, attitude, or behavior relative to folic acid, among women of childbearing age (Hammond et al., 2000, p. 4). Thus, the campaign aimed to educate women of reproductive age about the need to consume the USPHS recommended amounts of folic acid every day. Effective communication is an essential element of public health education campaigns, and can make or break the success

of prevention efforts. *Effectiveness* is the degree to which an intervention program fulfills its objectives (Rogers, 2003, p. 367).

Today, the NCFA coalition continues to build folic acid awareness among health care providers, policymakers and consumers, and reaches over 100 million people a year with the folic acid message (http://www.folicacidinfo.org/forms/press_releases/Mar09Release.pdf). Folic acid and birth defect information can be accessed on the NCBDD Web site at www.cdc.gov/Features/FolicAcid/. The Spina Bifida Association provides information related to folic acid and birth defects on its Web site www.spinabifidaassociation.org/site/c.liKWL7PLLrF/b.2642327/k.5899/FAQ_About_Spina_Bifida.htm. Folic acid and birth defect information is available on the MOD Web site (www.marchofdimes.com/professionals/19695_1151.aspincludes). "The significant role that the diffusion of innovation can perform in health promotion efforts cannot be underestimated, especially with the use of mass media channels of communication to influence health awareness, education, decisions, practices, and care" (Haider & Kreps, 2004, p. 6).

Mass Media Channels. Mass media channels are a means of transmitting messages that involve a mass medium, such as radio, television, newspapers, and so on, which enables a source of one or a few individuals to reach an audience of many (Rogers, 2003, p. 205). Mass media channels play a crucial role in the diffusion of a public health campaign. As Noar (2006) points out, "mass media campaigns have long been a tool for promoting public health" (p. 21). The *Ready or Not* campaign utilized mass media channels to publicly disseminate messages pertaining to NTD-prevention. The NCFA coalition

members have publicly distributed folic acid messages through multifaceted interventions such as: partnerships that provide free folic acid supplements, telephone hotlines, educational programs for providers, brochures, fact sheets, national health fair conferences, Web sites, bulletins, and e-mail news (National Council on Folic Acid [NCFA], 2009).

Folic acid guidelines posted on Web sites or presented through email notifications are readily obtainable by individuals with Internet access. However, folic acid guidelines distributed through electronic means are more difficult to obtain by individuals who are harder to reach, such as those without Internet access. Likewise, individuals without access to television, print, and radio may be more challenging to reach with a campaign message distributed through venues such as television, newspapers, and radio. While billboard advertising may be an option for message distribution, this communication channel will overlook individuals without access to the billboard, for example individuals who have limited access to transportation. Message dissemination using specific distribution channels may benefit certain individuals, while overlooking others.

Interpersonal Channels. Interpersonal channels involve a face-to-face exchange between two or more individuals. Interpersonal communication channels can help one individual secure clarification or additional information about an innovation from another individual. The role of interpersonal channels is especially useful in persuading an individual to adopt a new idea (Rogers, 2003, p. 205). *Change agents* are individuals who influence the direction of their client's willingness to adopt or reject an innovation (Rogers, 2003, p. 366). A change agent often utilizes face-to-face-exchange to communicate with clients. The agricultural extension service is reported to be one of the world's most successful change agencies (Rogers, 2003. p. 391). The agricultural extension model

consists of three main components: a research subsystem, county extension agents, and state extension specialists. In the capacity of change agents, county extension agents work with individuals at the local level (Rogers, 2003, p. 165).

Diffusion of Innovation

Diffusion of innovation is a conceptual framework that can be used and improved in order to better understand how publics interpret, understand, and respond to risk messages. Conceptual paradigms and theory can also serve as useful foundations for campaign design and implementation: "Use of theory as a guide to campaigns may be vital to campaign success," and campaigns are increasingly using theory (Noar, 2006, p. 25). Everett Rogers is credited with the development of the conceptual paradigm *diffusion of innovation* (Berger, 2005). Early application of the diffusion model to U.S. agriculture began in the 1950s and has since been generalized to multiple fields, including public health (Rogers, 2004, p. 13).

Preventative Innovation

Diffusion is a social change model with strong orientations toward development of improved public health. According to Rogers (2003), a *preventative innovation* is a new idea that an individual adopts now in order to lower the probability of some unwanted future event (p. 234). The *Ready or Not* campaign is an example of a preventative innovation. Sponsored by the CDC and implemented by its partners, the *Ready or Not* campaign addressed the scientific relationship between folic acid levels and the risk of NTD development in fetuses (Hammond et al., 2000, p. 4) in an effort to decrease NTDs across the nation. Birth defects are the leading cause of infant mortality and contribute substantially to morbidity and disability in the United States (Committee on Genetics,

1999, p. 325; Bohn, 2004, p. 2). Designed to launch a process to improve public health through folic acid consumption, the *Ready or Not* campaign emphasized folic acid's potential to prevent birth defects. Females of childbearing age were encouraged to consume 400 mcg of folic acid every day, in order to reduce the risk of having an NTD-affected pregnancy that they may or may never experience.

The unwanted event that is avoided by adopting a preventative innovation is difficult to perceive because it is a nonevent, the absence of something that otherwise might have happened (Rogers, 2003, p. 234). The delayed reward of being prepared for future conception, through timely and adequate folic acid accumulation, is difficult for many individuals to perceive and comprehend. Research findings demonstrate that if women have an adequate accumulation of folic acid in their bodies, starting at least a month before conception, sufficient levels of folic acid can prevent up to 70 percent of the potential brain and spinal birth defects during fetal development (Hammond et al., 2000, p. 1; CDC, 1992; CDC, 1999a).

Diffusion Process

Diffusion is a process that is situated within a time-order sequence. Rogers (2003) defines diffusion as the process through which an innovation, defined as an idea perceived as new, spreads via certain communication channels over time among the members of a social system (p. 35). Even if others are already aware of an idea or product, diffusion happens when an individual becomes aware of it:

> In specific terms, innovation communication refers to all oral and written messages concerning an innovation that are sent and received anytime from the point of

inception to the point at which the innovation is eventually adopted, rejected or simply forgotten. (Cheney, Block, & Gordon, 1986, p. 214)

Thus the main elements in the diffusion of new ideas are defined as: (1) an *innovation* (2) that is *communicated* (3) *over time* (4) among the members of a *social system* (Rogers, 2003, p. 36). Figure 3.1 presents the diffusion process.

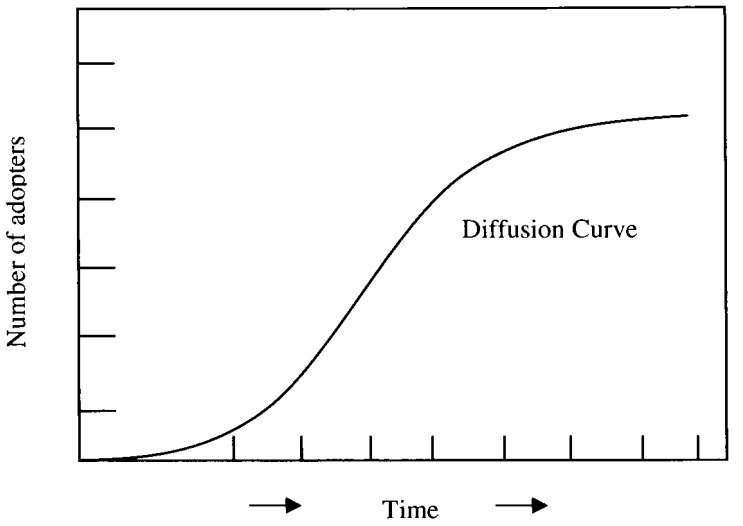

Figure 3.1. Diffusion process. Adapted from *Methods of Gathering Data* (Rogers, 2003, p. 112).

Innovation-Decision Process. Diffusion scholars have long recognized that an individual's decision to adopt or reject an innovation occurs over time and consists of a series of different actions (Rogers, 2003, p. 169). There are five stages in the innovation-decision process through which an individual (or decision-making unit) passes while deciding to adopt or reject an innovation. The five stages of the innovation-decision process defined by Rogers (2003) are presented in sequential order in Table 3.1.

Table 3.1. Innovation-Decision Process

Stages	Process defined
#1: Knowledge	Occurs when an individual (or decision-making unit) is exposed to the existence of an innovation, and gains understanding of its functions.
#2: Persuasion	Occurs when an individual (or decision-making unit) forms an attitude toward the innovation.
#3: Decision	Takes place when an individual (or decision-making unit) engages in activities leading to the decision to adopt or reject the innovation.
#4: Implementation	Occurs when an individual (or decision-making unit) puts the innovation to use.
#5: Confirmation	Occurs when an individual seeks reinforcement of decision to adopt or reject an innovation already made; and may possibly reverse the decision.

Note. Adapted from *A Model of the Innovation-Decision Process* (Rogers, 2003, p. 169).

Knowledge Stage. The knowledge stage begins when an individual (or decision making unit) is exposed to the existence of an innovation. At this point, the individual first becomes aware of the innovation and gains an understanding of how it functions. For example, an individual could first learn of the relationship between folic acid and NTD-reduction when initially seeing a poster that promotes the public health recommendation to consumer folic acid every day. At first glance, the individual might wonder: *what is folic acid?*, *what does folic acid do?*, and *why does folic acid work?* Rogers (2003) defined three types of knowledge emerge over time, as an individual is exposed to an innovation's existence. Table 3.2 presents the three types of knowledge in sequential order.

Table 3.2. Sequential Order of Knowledge Types

Knowledge types sequence	Process defined
1: Awareness-knowledge	Provides proof of the innovation's existence
2: How-to knowledge	Consists of information necessary to understand how to use the innovation.
3: Principles-knowledge	Consists of information related to the functioning principles underlying how the innovation works.

Note. Adapted from *Three Types of Knowledge* (Rogers, 2003, p. 173).

Communication Effects Gap

Communication effects among populations have been of great interest to diffusion scholars. Over time, the measurements of analysis used to assess communication effects evolved. To date, two dimensions of communication effects are recognized in diffusion research.

Gap Dimensions. Most of the past diffusion studies have investigated a dimension of communication effects by measuring aggregate changes in knowledge, attitudes or adoption behavior among individuals, regarding an innovation (Rogers, 2003, pp. 457-458). Within this dimension, investigators sought to ascertain the aggregate or average effects of communication among individuals regarding an innovation-decision process. In this dimension, diffusion researchers investigating an average change among an audience asked "What are the effects of a communication activity to diffuse an innovation?" (Rogers, 2003, p. 457).

Diffusion scholars became interested in a second dimension of communication effects that differed from the first. In this dimension, researchers sought to ascertain the equality of communication effects and asked, "Has the communication activity to diffuse an innovation had a greater, or different, effect on certain individuals rather than others?" (Rogers, 2003, pp. 459-460).

Gap Paradigm. In order to study communication effects gaps, Tichenor and colleagues (1970) proposed a useful research paradigm based on data collection at two or more points in time, both before and after a diffusion intervention (Rogers, 2003, p. 460). Data collection at multiple points provides a richer analysis of the gap creation and changes that occur among specific audiences during the innovation process. A main implication of

the communication effects paradigm was to investigate through differential analysis the diffusion of innovation affects among multiple publics. In other words, through differential analysis investigators could ascertain an indication of who in the audience were affected most and who least.

More specifically, an audience can be categorized into two or more segments on the basis of socioeconomic status, adoption category or the level of information that individuals possess (information-rich versus information-poor). Information-rich individuals can be categorized as the "ups." In contrast, information-poor individuals can be categorized as the "downs." Regardless of how the "ups" and "downs" are classified, regularities related to equality-inequality in the consequences of diffusion are found (Rogers, 2003, p. 460).

Consequences

Rogers (2003) defined consequences as "the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation. Innovation consequences are classified as (1) desirable versus undesirable, (2) direct versus indirect, and (3) anticipated versus unanticipated" (p. 470). Functionality of consequences depends on how the innovation affects the adopters. Consequence impact can differ among groups of individuals. Change agents have the ability to shape consequence impact.

Desirable Versus Undesirable Consequences

Desirable consequences are the functional effects of an innovation for an individual or social system (Rogers, 2003, p. 442). For example, being self-prepared for future conception through daily folic acid consumption may be a desirable consequence for individuals. Undesirable consequences are the dysfunctional effects of an innovation to an

individual or to a social system (Rogers, 2003, p. 442). For example, the financial expense related to regular purchases of folate rich foods and folic acid containing supplements may create financial challenges to individuals with limited income.

Direct Versus Indirect Consequences

Direct consequences are the changes to an individual or a social system that occur in immediate response to adoption of innovation (Rogers, 2003, p. 445). For example, an individual's willingness to learn more about NTD-prevention may result in consequences of being better informed about the benefits of folic acid consumption. Increased knowledge may be a consequence of an individual's willingness to learn about the importance of daily folic acid consumption. An individual's willingness to consume 400 mcg of folic acid every day may result in the consequences of being better prepared to prevent and NTD-affected pregnancy. Therefore, being prepared or unprepared may be a consequence of one's willingness to adopt or reject the responsibility of meeting the daily folic acid consumption recommendation.

Indirect consequences are the changes that occur as a result of the direct consequences of innovation (Rogers, 2003, pp. 445-446). As a result of being better informed about folic acid consumption and NTD-prevention, individuals may in turn communicate with others about USPHS folic acid recommendation. On the other hand, using funds to purchase folic acid supplements may eliminate purchasing options that an individual might otherwise make. A feeling of being financially challenged is an example of an indirect consequence that results from adopting the decision to consume folic acid every day.

Anticipated Versus Unanticipated Consequences

Anticipated consequences are changes due to an innovation that are recognized and intended by members of a social system (Rogers, 2003, p. 448). For example, being nutritionally prepared for a NTD-free pregnancy through folic acid consumption may result in a sense of decreased dependency on the government or others for assistance that would be needed to care for a child born with spina bifida. Unanticipated consequences are changes due to an innovation that are neither intended nor recognized (Rogers, 2003, p. 448). An example of an unanticipated consequence might be the increased risk for individuals over the age of 50 years to develop colorectal adenomas due to too over-abundant folic acid accumulations in their systems.

Equality of Innovation Consequence

Consequences of an innovation can be classified by the degree to which they increase or decrease equality among the members of a social system. For example, consequences resulting from a communication effects gap may be categorized as to how they aggregately and differentially impact multiple publics. Innovations may benefit some individuals; while at the same time widen the socioeconomic gap between adopters and rejecters. For example, while some individuals may be willing and financially able to adopt the idea of consuming 400 mcg of folic acid every day, some may not be financially able to do so and will choose to reject the idea due to lack of funds. In this example, a socioeconomic gap is created between the "haves" and the "have-nots."

An individual's level of knowledge or information richness also may be a factor that differentiates the "haves" from the "have-nots." For example, access to folic acid related materials may contribute to one's level of folic acid knowledge and information

richness. Those with greater access to folic acid information may develop a greater understanding about the relationship between folic acid and NTD-reduction, than do those without access to folic acid materials. In turn, the socioeconomic gap will widen between the "information rich" and the "information poor."

Reaching Out to Vulnerable Publics

Change agents are able to shape the consequences of an innovation through client interaction. Because change agents tend to contact the socioeconomic elites rather than the poorer and less educated individuals, the benefits of the innovation are unequally distributed within a social system. Usually, change agents prefer contact with better educated, higher status individuals in a system, which in turn tends to widen socioeconomic gaps through the innovation diffusion process while decreasing the degree of equality in a social system (Rogers, 2003, p. 456). Individuals who apply to utilize public services such as food and nutrition programs, public health clinics, and the Women Infant and Children (WIC) programs must first meet low-income eligibility requirements. Upon meeting the requirements, individuals become enrolled in the programs and have access to the service providers.

Extension Family and Nutrition Program. The Family Nutrition Program (FNP) is a federally funded program that seeks to help families with limited incomes use available resources to improve food and nutrition practices in order to prevent nutrition-related health problems (Hoover, Martin, & Litchfield, 2009, p. 1). "The FNP is a free and voluntary educational program that teaches basic nutrition, food safety, preparation, food resource management, and food purchasing to individuals who are receive and who are eligible to receive food stamps" (Steinhaus, Brunt, Pankow, Garden-Robinson, & Terbizan,

2009, p. 2). For example, FNP service providers could teach clients the relationship between folate rich foods and NTD-prevention.

Women Infant Children Program. The WIC program is a nutrition program administered at the federal level by the USDA's Food and Nutrition Service (FNS). In order to qualify for the WIC program, applicants must be considered at a nutritional risk and have a low family income. Applicants are asked to fill out a diet and medical history and provide documentation that their family income does not exceed 185 percent of the federal poverty guidelines (Women Infant Children [WIC], 2009).

The mission of WIC is to safeguard the health of low-income families, including pregnant and breastfeeding women, infants and young children who are at nutritional risk. The program provides foods, nutrition information, health screenings, counseling and support to eligible clients (WIC, 2009). For example, the WIC service providers could screen clients for habits of daily folic acid consumption and provide information to those who are unaware of the relationship between folic acid intake and NTD-risk.

Public Health. Public Health (PH) offers family planning services to low-income clients. Public health clients are often enrolled in Medicaid and Medicare plans. Public health clinicians often provide education about reproduction to clients, including women of childbearing age who are trying to prevent pregnancy or seek a pregnancy (North Dakota Public Health [NDPH], 2009). For example, during physical exams, public health service providers could educate their clients about the USPHS recommendation to prevent NTDs and encourage clients to consume a folic acid-containing supplement every day.

Vulnerability. Low-income audiences are frequently at high risk for many health problems, and often are considered difficult to reach during campaign implementation

(Freimuth, 1995). For example, low-income females of childbearing age who have not adopted the recommendation to consume 400 mcg of folic acid every day may be considered hard-to-reach. Lower educated and lower status individuals often are labeled "hard-to-reach" because they have not adopted behavior change strategies at the rate of their elite counterparts (Freimuth, 1995). For example, a service provider could consider female clients who never graduated from high school and who do not consume 400 mcg of folic acid every day as "hard to reach" and at risk for having an NTD-affected pregnancy. In comparison, a service provider would not label female clients who have graduated from high school and who do take a daily supplement containing folic acid as "hard-to-reach" because they are meeting the USPHS recommendation.

"Low income individuals often are depicted as both financially and psychologically impoverished, focused on short-term rewards, and therefore uninterested in pursuing preventative health benefits" (Freimuth, 1995). Due to lack of funds and lack of nutrition, the health status of low income individuals, including women of childbearing age, may be compromised. When campaigns are evaluated for effectiveness, these groups of individuals typically emerge as less exposed, less knowledgeable, and less likely to change their behaviors (Freimuth, 1995).

Diversity of Diffusion Research

Most past research has concentrated on predicting the rate of adoption by measuring five perceived attributes of relative advantage, compatibility, complexity, trialability, and observability. The first research on attributes of innovations and their rate of adoption was conducted with farmers, but studies of teachers and school administrators suggested that similar attributes predict the rate of adoption for educational innovations (Rogers, 2003, p.

223). Among the various types of diffusion analysis, the most popular diffusion research topic focuses on variables related to individual innovativeness. "Innovativeness was originally assumed to be constant for each individual; that is that each consumer is *born with* a certain allotment of innovativeness and this personality trait remains constant over a person's lifetime" (Hynes & Lo, 2006, p. 32). Several studies present innovativeness as a general concept and mediating variable.

While much research has focused on such individual characteristics related to innovativeness, diffusion scholars are beginning to investigate the social system network influences on an individual's innovativeness. Many of the experimental designs conducted in the diffusion field surround family planning innovations in developing nations or experiments carried out by marketing researchers in the United States (Rogers, 1976). "Many researchers have focused on diffusion at the interorganizational level, examining interaction between and among organizations" (Cheney, Block, & Gordon, 1986, p. 214). Rogers examined the diversity of diffusion research and identified eight types (Rogers, 2003, pp. 96-97). The quantity of research related to the investigation of consequences of innovations is deficient. Table 3.3 summarizes the diversity of diffusion research and the variables of interest.

Shortcomings of Diffusion Research

Diffusion research has significantly contributed to the understanding and promotion of behavioral change (Haider & Kreps, 2004, p. 6). Diffusion provides a common conceptual ground that can support collaborative research and a variety of methodologies (Rogers, 2003, p. 104). However, research related to diffusion is not without limitations.

Rogers (2003) suggested several shortcomings of diffusion research such as lack of consequence research, change agent tendencies, pro-innovation bias, and research methods.

Table 3.3. Diversity of Types of Diffusion Research

Type	Independent variable	Dependent variable	Proportion of type in diffusion publications
1	Characteristics of members	Earliness of knowing about innovation	5%
2	Attributes of innovation	Rate of adoption	1%
3	Characteristics of members	Innovativeness of members of a social system	58%
4	Characteristics of members	Opinion leadership	3%
5	Patterns in the network links between two or more members of a system	Diffusion networks	< 1%
6	System norms; characteristics of social system	Rate of adoption	2%
7	Innovativeness and other characteristics of members of a social system	Communication channel use	7%
8	Characteristics of members; nature of social system; nature and use of innovation	Consequences of an innovation	0.2%
Others	-	-	22%

Note. Adapted from *Eight Types of Diffusion Research* (Rogers, 2009, pp. 96-97).

Consequence Research

Consequence research is the study of consequences related to the diffusion of an innovation. In diffusion research, consequences have not been studied adequately because (1) change agencies have over-emphasized adoption per se, assuming that an innovation's consequence will be positive, (2) the usual survey research methods may be inappropriate for investigating consequences, and (3) consequences are difficult to measure (Rogers, 2003, p. 470).

Consequences of an innovation usually occur over extended periods of time, following diffusion. Thus, the study of consequences requires a long-range approach to analyze consequences of an innovation, which may take years to discover (Rogers, 2003,

p. 440). For example, although scientific evidence reveals that folic acid alone at levels of 400 mcg per day will reduce the risk of NTDs (CDC, 1992), strong laboratory and clinical evidence are beginning to raise concerns of cancer-cell development related to overly-abundant folic acid intake (Harvard Women's Health Watch, 2008, p. 2; Mason, 2009, p. 209). The scientific evidence, reflecting negative consequences, are beginning to emerge many years following the 1992 USPHS daily folic acid recommendation and the communicated efforts of the 1999 *Ready or Not* campaign.

Innovativeness has been the main dependent variable in much past diffusion research. Much past diffusion research has asked: What variables are related to innovativeness? Future investigations need to ask: What are the effects of adopting innovations? (Rogers, 2003, p. 440). More specifically, future investigations need to investigate innovativeness as the predictor of a more ultimate dependent variable, the consequences of innovation.

Change Agent Tendencies

Change agents typically do not concentrate their efforts on their most disadvantaged clients and many change agents do not try to contact their needier, lower-status clients because they think that their lower-status clients will be irresponsive to the innovation diffusion efforts (Rogers, 2003, p. 383). Socioeconomic elites are considered more responsive to suggested health behavior changes because they are said to have greater health knowledge to build on, and care more about themselves than individuals of lower socioeconomic status (Freimuth, 1995). This type of client stereotyping discourages contact initiation from change agents to the less disadvantaged clients (Rogers, 2003, p. 383).

For example, change agents may avoid contact with lower-status clients based on the assumption that these clients lack the financial resources to adopt the USPHS recommendation. Under this assumption, change agents may feel that any effort to educate financially-strapped individuals about the need to purchase folic acid-containing supplements would be a waste of time. In turn, change agents may divert their education efforts to higher status clients under the assumption that they have financial resources available to meet the USPHS daily recommendation, thus appearing more responsive.

Pro-Innovation Bias

Pro-innovation bias is the implication of diffusion research that an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented or rejected (Rogers, 2003, p. 106). While pro-innovation bias is assumed rather than clarified in most diffusion publications, a lack of recognition of pro-innovation bias is potentially dangerous because it leads researchers to ignore important aspects of diffusion. More specifically, the bias can lead diffusion researchers to disregard the ignorance of innovations, to underemphasize innovation rejection or discontinuance, and overlook innovation re-invention, and fail to investigate anti-diffusion programs designed to prevent adoption of innovations (Rogers, 2003, p. 107).

Much diffusion research, funded by change agencies, includes a pro-innovation bias. In this situation, the agency bias is supported by their very purpose to promote innovations, and their viewpoint is shared by the diffusion researchers they fund, and whose students they hire to assist with the research (Rogers, 2003, p. 110). In *centralized* diffusion systems, such as the United States agricultural extension services, overall control

of diffusion decisions (such as which innovations to diffuse, which diffusion channels to use, and to whom to diffuse innovations) is held by government officials and technical subject matter experts" (Rogers, 2003, p. 401). For example, an agency such as the NCFA may provide funding to a university-based diffusion researcher to promote a project on an innovation that the agency believes the public should adopt. In a centralized system, diffusion flows from the top-down among experts and users. Because of pro-innovation bias, we know much about innovation successes, research reports of innovation failures are few. Pro-innovation bias is one of the most serious shortcomings of diffusion research (Rogers, 2003, p. 106).

Research Methods

Data Collection. Predominantly, diffusion studies have gathered data from adopter after an innovation has diffused by asking survey respondents to look backward in time. Most diffusion investigations are limited to one-shot surveys of the adopters of an innovation with data gathering taking place only after a new idea has been diffused (Rogers, 2003, p. 72). For example, numerous campaigns incorporate a one time, post-only survey or a one-group pretest-posttest design as the sole evaluation tool for campaign effectiveness (Noar, 2006, p. 31). This is an example of a weak design that will likely not control for a number of threats to internal validity. Nearly all campaigns using a one time, post-only survey design were funded efforts and one can only speculate if these study designs were limited by available funding, or whether investigators were unaware of the design weakness, or whether they were aware of and found the weakness acceptable (Noar, 2006, p. 31). Unfortunately, cross-sectional studies cannot reveal much about causality, or answer "why" questions related to the decision making process related to an

intervention. Thus, investigations that include "why" questions about adoption are seldom probed effectively by diffusion researchers. Figure 3.2 presents the predominant data gathering method that is used in diffusion studies.

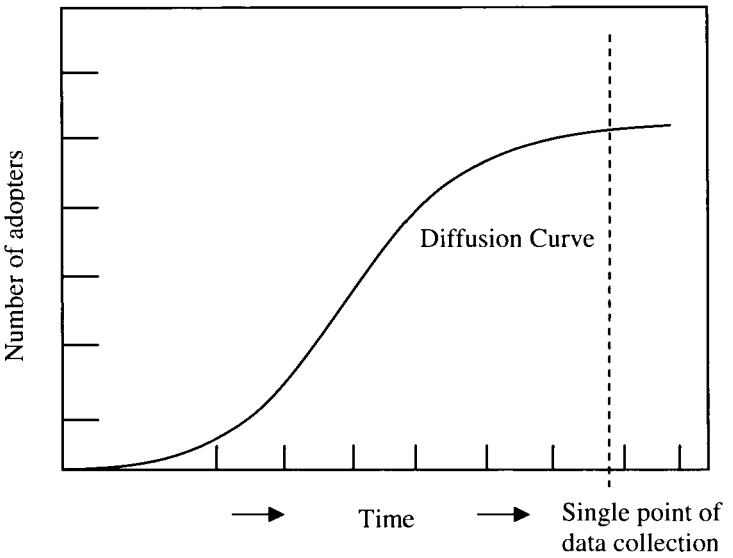

Figure 3.2. Example of study with single point of data collection. Adapted from *Methods of Gathering Data* (Rogers, 2003, p. 112).

To date, few diffusion investigations have incorporated field experiments. Rogers (2003) defined a *field experiment* as "an experiment conducted under realistic conditions in which pre-intervention and post-intervention measurements are usually obtained by surveys" (p. 128). Generally, subjects are randomized into treatment and control groups for the purpose of comparing outcomes between groups. A field experimental design applies a method that examines an intervention taking place outside of a laboratory. Typically the intervention is a type of communication strategy that aims to speed the diffusion process. Few experiments have included benchmark and follow-up surveys where variables of knowledge, attitudes and rate of adoption are assessed for differences (Rogers, 2003, p. 72).

Analysis. Roughly 60 percent of all diffusion research studies positions innovativeness as the main dependent variable, and most studies do not clearly state the linear relationship between the independent and dependent variables (Rogers, 2003, p. 128). Rather, findings imply that the stated independent variable causes innovativeness. Roger (2003) points out that time-order field experiments are ideally suited for assessing the effect of various independent variables on a dependent variable (p.128). If diffusion research is ideally suited due to its time-order sequence, why are there not more diffusion studies conducted that include tests of causality? The pro-innovation bias in diffusion research, and the overwhelming reliance on correlational analysis of survey data, often led to avoiding or ignoring the issue of causality among variables of interest (Rogers, 2003, p. 128).

Conceptual Summary of Study Design

Rogers (2003) suggested that future diffusion studies should include measures to shed the pro-innovation bias (p. 113). One way to shed the bias is to utilize alternative approaches to data gathering during the innovation process (Rogers, 2003, p. 112). Diffusion research tends to include a rearward orientation that leads most innovation investigations to concentrate on successful diffusion projects. However, Rogers (2003) suggested that the incorporation of a field experiment in which data are gathered before and after an intervention, will shed the bias as the investigation is conducted while the diffusion process is still underway (p. 112). Investigations that ask "why" questions about adoption, are seldom probed effectively by diffusion researchers. Rogers (2003) encouraged researchers to investigate the context in which an innovation diffuses, such as policy-

related decisions that influence the decision to diffuse an innovation to members of society (p. 115).

Consequence Research and Data Collection

Rogers (2003) pointed out that consequences related to an innovation usually occur over extended periods of time and a long-range approach must be taken in which the development of consequence are analyzed (p. 440). One way to address the lack of consequence research in diffusion studies is to investigate the impact of positive and negative consequences that are related to the 1992 USPHS folic acid recommendation. For example, data gathered at two different points, during a 2008-2009 statewide folic acid campaign may be useful in measuring consequences of communication and scientific effects among publics that related to daily folic acid intake behaviors that have been encouraged through the years by the USPHS recommendation. Such data are necessary in order to quantify the risks related to the adoption of vitamin intake behaviors and communication effects of the USPHS recommendation.

Change Agent Tendencies and Pro-Innovation Bias

Rogers (2003) pointed out that change agencies which sponsor diffusion research tend to assume that the consequences of innovation-decisions will be positive (p. 440). One way to address change agent tendencies in diffusion research is to conduct a study that is not limited to one sponsoring change agency. For example, the inclusion of multiple change agencies that differ in missions and objectives, within a study may be useful in overcoming the possibility of pro-innovation bias. Another way to address the potentiality of pro-innovation bias is to conduct a field experiment that includes control and treatment variables, such as extension and non-extension service providers. Because agricultural

extension agents often conduct diffusion research for sponsoring agencies, non-extension agents can be included in the present study to overcome the pro-innovation often associated with change agency sponsorship.

Conceptual Summary of Data Analysis

One way to address the limitation of research method analysis is to explore alternative ways in which data are methodologically analyzed. In the present study, a combination of methods, such as gap analysis, causal approach, and epidemiologic procedures may be useful to statistically test for aggregate and differential changes, linear relationships, effects modification, and confounding between variables.

Gap Analysis

Diffusion of innovations generally cause wider socioeconomic gaps within a social system, thus decreasing the degree of equality among members of society (Rogers, 2003, p. 457). However, the tendency toward gap widening is not inevitable, and need not occur. Rogers (2003) pointed out that when special efforts are taken in a diffusion study, it is possible to narrow, rather than widen, socioeconomic gaps (Rogers, 2003, p. 471). One way to narrow the gap impact of diffusing a message is to utilize communication channels that can reach individuals of lower socioeconomic status, who might otherwise remain untouched by an education intervention. For example, in order to reach vulnerable publics, a diffusion study can utilize change agents from FNP, WIC, and public health to contact publics who are often considered difficult to reach during campaign implementation (Freimuth, 1995).

In the present diffusion study, gap analysis can be conducted by investigating two dimensions of communication effects. An aggregate form of analysis can be used to

explore the average change in knowledge, attitudes and adoption behavior of the UPHS recommendation by a set of individuals (Rogers, 2003, p. 458). Additionally, a differential form of analysis can be used to ascertain the equality of communication effects pertaining to the UPHS among a set of individuals. The gap paradigm proposed by Tichenor and colleagues (1970) can be used to investigate the folic acid knowledge-based differentials between socioeconomic groups (Gaziano & O'Leary, 1998, p. 29), including vulnerable publics who frequently receive information from FNP, WIC, and public health service providers.

Causal Approach

In the present study, variables that reflect an individual's level of understanding and level of information richness about the USPHS recommendation can be tested for simple and multiple mediating effects on the relationship between an individual's folic acid awareness and the daily vitamin consumption behavior. In turn, level of understanding and level of information richness can be used aggregately and differentially measure the knowledge-based changes among publics. Baron and Kenny (1986) suggest that tests of mediation provide opportunities to probe more deeply into the nature of causal mechanism and integrate seemingly irreconcilable theoretical positions (p. 1173). Mediating variables account for why and how effects occur between the predictor and criterion.

Epidemiologic Procedures

In the present study, epidemiologic tests can be used to explain causation of vitamin intake behavior and NTD-risk. Rogers (2003) pointed out that the consequence of an innovation is difficult to measure due to the complicated nature of the cause-and-effect relationship (Rogers, 2003, p. 442). The potential for confounding effects on the causal

relationship further complicates the ability to make a determination in a precise manner. Epidemiologic models of causation and statistical tests have been developed through the years in an attempt to explain causation of an outcome and the interrelationships of factors or exposures causing the outcome.

Causal Inference. Epidemiology is an observational science that is often used to describe or assess the health of a community, to identify causes of outcomes or disease, and to study risks to individuals. Through epidemiologic research, multiple factors of exposure are considered when determining causal agents of an outcome or disease (p. 73) Individuals are studied and categorized with respect to presence or absence of an exposure. In epidemiologic research it is customary to refer to an exposure that is associated with an outcome or disease as a risk factor (Friis & Sellers, 2009, p. 74). The three requisite criteria for risk factors are presented in Table 3.4.

Table 3.4. Criteria for Risk Factors

Items	Requisite criteria for risk factors
1.	Frequency of the outcome or disease varies by category or factorial influence;
2.	Risk factor must precede the onset of the outcome or disease;
3.	Observed association between exposure and outcome must not be due to any source of error.

Note. Adapted from *Risk Factors* (Friis & Sellers, 2009, p. 74).

Modern causal research recognizes six issues as relevant to causality of effect and epidemiologic research. Although it is not critical that all six of the lines of evidence be present to uphold the concept of causality, the more that are supported, the more the case of causality is strengthened (Friis & Sellers, 2009, p.79). Table 3.5 presents the criteria recognized as relevant to causality, by level of importance.

Table 3.5. Causal Inference Criterion used by Epidemiologists

Sequence*	Causal inference criterion
1	*Strength of association* quantities the importance of the relationship between a specific factor and an outcome
2	*Consistency of effect* validates strength of association through results of multiple studies
3	*Biologic plausibility* provides a logical explanation to support the statistically significant relationship between exposure and outcome
4	*Dose-response* refers to the relationship that results when the change in exposure causes a change in outcome
5	*Temporal sequence* clarifies that an exposure must precede an outcome
6	*Specificity of effect* states that a cause leads to one effect rather than to multiple effects and cannot be independent of strength of association

Note. The sequence is listed in the order of level of importance (1 being most important, 6 being least important) (Torrence, 1997, pp. 134-135).

Confounding. In the present study, epidemiologic procedures can be conducted to statistically investigate confounders of the relationship between an individual's level of information richness and NTD-risk. Confounding, one of the most difficult biases to detect and control (Torrence, 1997, p.118) in research studies, is the masked or distorted effect of a third extraneous factor on an association between exposure and outcome variables (Torrence, 1997, p. 129). Confounding variables are not a consequence of exposure. Rather, a confounding variable is associated with exposure, and affects the outcome of exposure (Torrence, 1997, p. 129). Thus, a confounding variable is not an intermediate link in the linear relationship between exposure and outcome. Because confounding can increase, decrease, or change direction of an estimated relationship between exposure and outcome, it is vital to account for the bias of confounding in a research study (Torrence, 1997, p. 129). Figure 3.3 presents the linear relationships between exposure, outcome, and a confounding variable.

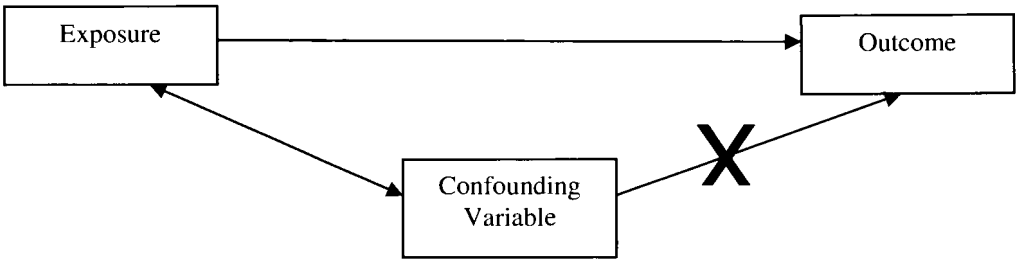

Figure 3.3. Variable relationships.

In order to advance diffusion research, the following hypotheses are proposed:

H1: The percentage of information-poor females will not decrease following an educational intervention that promotes the USPHS folic acid recommendation.

H1a: The percentage of information-poor females will decrease following an educational intervention that promotes the USPHS folic acid recommendation.

H2: Extension service providers will not have a smaller percentage of information-poor female clients than will non extension service providers, following an education intervention.

H2a: Extension service providers will have a smaller percentage of information-poor female clients than will non extension service providers, following an education intervention.

H3: Information richness will not mediate the relationship between awareness and behavior.

H3a: Information richness will mediate the relationship between awareness and behavior.

H4: Of the information-poor females, the odds of being unaware of folic acid among females who do not take a folic acid containing supplement every day will not be greater than the odds of being unaware of folic acid among females

who do take a folic acid containing supplement every day.

H4a: Of the information-poor females, the odds of being unaware of folic acid among females who do not take a folic acid containing supplement every day will be greater than the odds of being unaware of folic acid among females who do take a folic acid containing supplement every day.

H5: Among stratified groups of females, the odds of being information-poor among females at risk for having an NTD-affected pregnancy will not be greater than the odds of being information-poor among females not at risk for having an NTD-affected pregnancy.

H5a: Among stratified groups of females, the odds of being information-poor among females at risk for having an NTD-affected pregnancy will be greater than the odds of being information-poor among females not at risk for having an NTD-affected pregnancy.

H6: Variables of ethnicity, race, proximity, information service provider affiliation, and age will confound the relationship between information richness and being at risk for having an NTD-affected pregnancy.

H6a: Variables of ethnicity, race, proximity, information service provider affiliation, and age will not confound the relationship between information richness and being at risk for having an NTD-affected pregnancy.

H7: A portion of the NTDs occurring in North Dakota cannot be attributed to information poorness.

H7a: A portion of the NTDs occurring in North Dakota can be attributed to information poorness.

Summary

In summary, the diffusion model is a conceptual paradigm that demonstrates relevance in many disciplines (Rogers, 2003, p. 103.) This conceptual paradigm serves as an invaluable tool to facilitate the spread of messages among publics. Because diffusion is concerned with the dissemination of messages among publics, the diffusion framework is of great value to many disciplines, especially the field of public health where the priority is to promote and maintain the well-being of a community or population (Haider & Kreps, 2009, p. 6). However, the contributions and growth of diffusion research have been stunted by diffusion approach limitations (Rogers, 2003, p. 105).

The current chapter has outlined potential areas of improvement to Rogers' (2003) diffusion model. Through alternative approaches to study design and data analysis, the present study proposes a new diffusion model that can contribute to the growth of diffusion research. In the following chapter, the design and application of a folic acid study will be presented in greater detail.

METHODS

This chapter presents the method used to conduct this study. In section one, the participants are described. Section two defines the survey instruments. Procedures of data collection and details of the folic acid campaign development and implementation are outlined in section three. Section four describes the variable measures to be used in data analysis. Finally, the data analysis plan for this study is presented in section five.

Participants

Demographics

Demographic data collected from survey participants included age, gender, ethnicity, race, and residential proximity. A total of 1004 surveys were completed for this study. Using SPSS software, frequencies and percentiles were computed for the demographic data gathered from survey participants.

Age. Within pre-and post-surveys, participants were asked to report their age using a fill–in-the-blank method. Age was valued as a continuous variable, and additionally recoded categorically. Additionally, five age ranges were established based on childbearing age criteria. Age groupings were compared to those found in published materials from the CDC and the March of Dimes studies. For this study, women within the age range of 18 and 49 years were considered of childbearing age.

Of the age-reporting participants, 66 were male and 933 were female. Five participants did not report their age, and their surveys were removed from age-related data analysis. Table 4.1 presents the age groups of surveyed participants. Age-reporting participants ranged from 18 to 89 years, and the 25th and 50th percentiles consisted of individuals between the ages of 18 and 26 years. Of the 933 females surveyed, 86.5% were considered of

childbearing age. The largest age group of women (46.2%) ranged from 18 to 25 years, and the smallest age group of women (7%) ranged from 42 and 49 years.

Table 4.1. Age Ranges and Childbearing Age

Gender	Age	Childbearing age	Survey One		Survey Two		Total
Males	18-25 years		11	44.0%	35	85.4%	69.7%
	26-33 years		4	16.0%	2	4.9%	9.1%
	34-41 years		1	4.0%.	2	4.9%	4.5%
	42-49 years		2	8.0%	1	2.4%	12.1%
	50+ years		7	28.0%	1	2.4%	4.6%
Females	18-25 years	Yes	234	43.4%	197	50.0%	46.2%
	26-33 years	Yes	108	20.0%	95	24.1%	21.8%
	34-41 years	Yes	59	10.9%	48	12.2%	11.5%
	42-49 years	Yes	47	8.7%	18	4.6%	7.0%
	50+ years	No	91	17.0%	36	9.1%	13.5%

Gender and Ethnicity. Participants were asked to report their gender and ethnicity. In order to track data by *gender*, males were assigned to category one and females were assigned to category two. For the variable *ethnicity*, respondents of Latino or Hispanic origin were assigned to category one, while individuals not of Latino or Hispanic origin were assigned to category two.

Of the ethnicity-reporting females, 21 (2.3%) were of Latino or Hispanic origin. One male and seven females did not report their ethnicity and were excluded from the data analysis. Table 4.2 presents the ethnicity of surveyed participants.

Table 4.2. Ethnicity

Gender	Ethnicity	Survey One		Survey Two		Total
Males	Latino or Hispanic	2	8.3%	0	0.0%	3.1%
	Not Latino or Hispanic	22	91.7%	41	100.0%	96.9%
Females	Latino or Hispanic	8	1.5%	13	3.3%	2.3%
	Not Latino or Hispanic	534	98.5%	376	96.7%	97.7%

Race. Survey respondents were asked to select their race from a list of options. Race was categorized as white, black, Asian, American Indian or Alaska Native, or Native Hawaiian or Other Pacific Islander. For statistical analysis, the variable race also was dichotomized by each race versus all others. For example, white was categorically compared to non-white. Of the race-reporting female survey respondents, 86 percent were white. Seven survey participants did not report their race and were excluded from the data analysis. Table 4.3 presents the race of male and female survey participants.

Table 4.3. Race

Gender	Race	Survey One		Survey Two		Total
Males	White	24	96.0%	36	87.9%	91.0%
	Black	0	0.0%	1	2.4%	1.5%
	Asian	0	0.0%	1	2.4%	1.5%
	Native American	1	4.0%	2	4.9%	4.5%
	Native Hawaiian or Other Pacific Islander	0	0.0%	1	2.4%	1.5%
Females	White	461	85.6%	336	85.5%	85.5%
	Black	4	0.7%	3	0.8%	0.8%
	Asian	10	1.9%	3	0.8%	1.3%
	Native American	60	11.2%	45	11.4%	11.3%
	Native Hawaiian or Other Pacific Islander	3	0.6%	6	1.5%	1.0%

Generalized Survey Population. The demographics of the surveyed publics were compared to population estimates of the North Dakota Department of Health (NDDH) and the U. S. Census Bureau. The variable *race* was utilized to draw comparisons between state, national and the survey populations. Table 4.4 presents the population comparisons. Compared to the Department of Health statistics, Survey One and Survey Two included fewer whites and twice as many Native Americans. Surveys One and Two did not allow for reporting of two or more races for a survey respondent. Based on the North Dakota

Department of Health and the U. S. Census Bureau statistics, the current data sets (Survey One and Two) were found comparable and generalizable to the North Dakota population.

Table 4.4. Population Estimates

	White	Black	Asian	Native American or Alaska Native	Native Hawaiian or Other Pacific Islander	Reported two or more races	Total
Survey One participants	86.14%	0.70%	1.80%	10.83%	0.53%	-	100.0%
Survey Two participants	85.72%	0.92%	0.92%	10.83%	1.61%	-	100.0%
Survey One Plus Survey Two participants	86.00%	0.80%	1.40%	10.80%	1.00%	-	100.0%
ND Department of Health 2006[a]	92.00%	0.80%	0.70%	5.40%	0.00%	1.10%	100.0%
ND stats from U.S. Census Bureau 2008[b]	91.30%	1.10%	0.70%	5.60%	0.10%	1.20%	100.0%

Note. ND = North Dakota. aAdapted from State and County Quickfacts: North Dakota. (Census Bureau, 2008a). [b]Adapted from *State and County Quickfacts:USA*. (Census Bureau, 2008b).

Regional Proximity. North Dakota has 53 (100%) counties and one Reservation with Extension presence. Research collaborators comprised primarily of Extension agents promoted folic acid messages within the following 34 (63%) counties: Adams, Barnes, Benson, Bottineau, Bowman, Burleigh, Cass, Dunn, Fort Berthold, Foster, Grand Forks, Grant, Hettinger, Kidder, McHenry, McIntosh, McKenzie, McLean, Mercer, Morton, Mountrail, Ramsey, Ransom, Renville, Richland, Rolette, Sargent, Sheridon, Sioux, Stark, Stutsman, Towner, Walsh, Ward, and Williams. These counties included the most populous cities.

Survey participants were asked to report their county and/or city of residence. Reported cities were converted to counties and each county was assigned a unique number. Counties were further collapsed within eight regional categories. Regions were selected on the basis of the eight regional human service centers designated by the North Dakota Department of Human Services (NDDHS) that serve designated multi-county areas as shown in the following map. Figure 4.1 presents eight regional proximities of North Dakota counties.

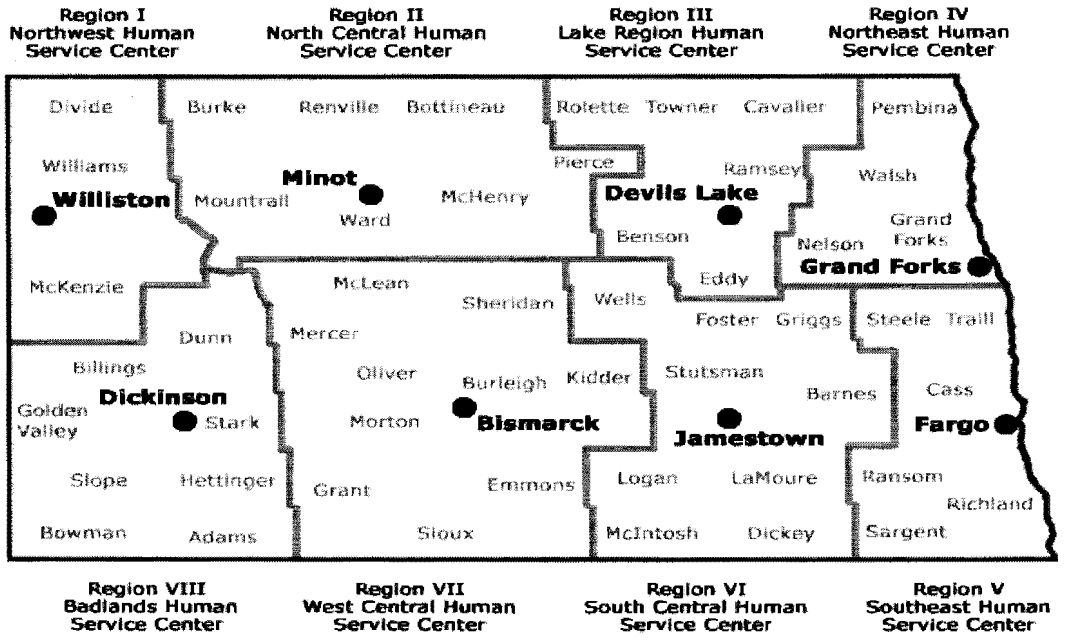

Figure 4.1. Map of regional proximity. Map retrieved October 9, 2009 from Web site www.nd.gov/dhs/locations/regionalhsc/

Survey participants were categorized by self-reported county of residence, which corresponded with their survey completion site. Of the female participants, the majority of the surveys (28.7%) were completed in region two, and the fewest number of surveys (1.3%) were completed in region eight. Table 4.5 presents the results of regional proximity of survey participants.

Table 4.5. Regional Proximity

Gender	Regions	Survey One		Survey Two		Total
Males	Region 1	3	12.0%	0	0.0%	4.5%
	Region 2	6	24.0%	2	4.9%	12.1%
	Region 3	2	8.0%	1	2.4%	4.5%
	Region 5	1	4.0%	24	58.5%	37.9%
	Region 6	11	44.0%	2	4.9%	19.7%
	Region 7	2	8.0%	12	29.3%	21.2%
Females	Region 1	41	7.5%	2	0.5%	4.6%
	Region 2	129	23.8%	140	35.5%	28.7%
	Region 3	41	7.5%	29	7.3%	7.5%
	Region 4	25	4.6%	23	5.8%	5.1%
	Region 5	146	26.9%	89	22.6%	25.0%
	Region 6	55	10.1%	31	7.8%	9.2%
	Region 7	103	19.0%	72	18.2%	18.6%
	Region 8	3	0.6%	9	2.3%	1.3%

For statistical analysis, the variable *county* was also dichotomized on the basis of urban or rural proximity. Urban proximity was identical to the advertising placement locations selected for the folic acid campaign. For example, Grand Forks, Ward, Burleigh and Cass County were categorized as urban, and all other counties fell into the category *rural*. Thus, four North Dakota Regions (1, 3, 6, and 8) were considered to be rural, and four North Dakota Regions (2, 4, 5, and 7) were considered to be urban. Of the total number of females surveyed, 211 (22.5%) of the women reported living in rural locations, and 727 (77.5%) of the women reported living in urban locations. Table 4.6 presents the results of urban and regional proximity of survey participants.

Table 4.6. Urban and Rural Proximity

Gender	Proximity	Survey One		Survey Two		Total
Males	Rural	16	64.0%	3	7.3%	28.8
	Urban	9	36.0%	38	92.7%	71.2%
Females	Rural	140	25.8%	71	18.0%	22.5%
	Urban	403	74.2%	324	82.0%	77.5%

Survey Instruments

Paper Surveys

Two paper survey instruments were used to gather data at multiple points in time. The survey samples are provided in Appendixes A and B. The USPHS folic acid recommendation was used to frame the survey questions. Survey questions in the present study were comparable to questions noted in MOD publications for the CDC.

Identical (or similarly worded) questions were included on Survey One and Two so that comparative assessments could be drawn from participant responses. General demographic data were collected from the respondents (e.g. age, gender, race, ethnicity, and proximity). Professional service affiliation was tracked by the location of survey completion. Data from Survey One were compared with data from Survey Two in order to investigate changes in populations following an educational intervention. Additionally, data from Survey One and Survey Two were merged to form a third data set (*Survey One plus Survey Two)* for the purpose of calculating ratios using epidemiologic methods to asses risk.

Survey One. Survey One included 16 multiple choice and fill-in-the-blank questions. Overall, survey questions were designed to gather general demographic data and provide insight into a baseline assessment of folic acid awareness, understanding, behavior,

and associated risks among North Dakotans, prior to an educational intervention. The survey included five questions pertaining to demographic data including age, gender, ethnicity, race and county of residence. Participants answered eight questions related to knowledge and awareness. Respondents were asked three questions related to attitude and behavior.

Survey Two. Survey Two included sixteen multiple choice and fill-in-the-blank questions. Overall, the questions were designed to gather general demographic data and provide insight into the changes in awareness, understanding, behavior, and associated risks among North Dakotans, following the educational intervention. Respondents answered five questions pertaining to demographic data including age, gender, ethnicity, race and county of residence. Participants answered six questions related to knowledge and awareness. Additionally, the survey included four questions related to attitude and behavior.

Procedures

Participants were self-selected to participate in the surveys in an identical fashion. Survey participants for this study were recruited by survey coordinators positioned at statewide service provider locations. Survey respondents included low-income clients of: Extension FNP, WIC, and PH. Additional participants were drawn from North Dakota universities and community colleges. Surveys also were administered to the general public at North Dakota Health Fairs, and North Dakota Wellness Centers.

Survey Administration

Survey packets were distributed to 39 survey administrators. Each packet included instructions, survey questionnaires and incentive "goodie" bags for each participant. Two

thousand completed surveys were anticipated. Before each survey could be administered, voluntary participant consent was needed. Task force members administered the statewide surveys to participants and distributed goodie bags upon questionnaire completion. Each goodie bag included coupons and promotional materials containing folic acid messages. For example, goodie bags were packed with survey participant incentives such as recipe cards, coupons, bookmarks, key chains, and pencils.

Control Groups

For this study, treatment and control groups were established on the basis of survey administration location and information service provider involvement. Participants were categorized as being affiliated with extension agencies or non-extension service providers. Extension (treatment) and non extension (control) professionals administered surveys to clients.

Clients of survey administrators were segmented into treatment and control groups on the basis of information and service provider involvement. Extension agent clients were assigned to the treatment group. Non-extension agent clients were assigned to the control group. Table 4.7 presents the service provider affiliation of survey participants. Of the females surveyed, there were 403 (43%) women assigned to the treatment group and 535 (57%) women assigned to the control group.

Data Collection

Before any data collection involving participants began, permission to conduct research with human research was granted by the Institutional Review Board (IRB) at North Dakota State University (NDSU). The data collection process began in October 2008 and was completed in April 2009. Survey administration took place over two distinct

periods. The first survey period covered the time frame October 1, 2008 through December 31, 2008. Survey period two covered the time frame January 16, 2009 through April 1, 2009.

Table 4.7. Information Service Provider Affiliation

Gender	Information service provider	Survey One		Survey Two		Total
Males	Extension	14	56.0%	16	39.0%	45.5%
	Public Health	11	44.0%	2	4.9%	19.7%
	General public and students	0	0.0%	22	53.7%	33.3%
	WIC	0	0.0%	1	2.4%	1.5%
Females	Extension	221	40.7%	182	46.1%	43.0%
	Public Health	135	24.9%	92	23.3%	24.2%
	General public and students	103	18.9%	57	14.4%	17.0%
	WIC	84	15.5%	64	16.2%	15.8%

Survey coordinators administered Survey One in order to assess baseline levels of folic acid awareness, attitudes, and behavior among North Dakotans. During and after an educational intervention, the survey coordinators administered Survey Two in order to assess the campaign's impact on changes in folic acid awareness, attitudes, and behavior among North Dakotans. Overall, 1004 paper surveys were collected between the two periods, of which 93.4 percent were completed by female participants. Surveys with missing responses were excluded from data analysis. Table 4.8 presents the survey periods.

Table 4.8. Survey Periods

Gender	Survey One		Survey Two		Total
Males	25	4.4%	41	9.4%	6.6%
Females	543	95.6%	395	90.6%	93.4%

Project Collaborators

In 2008, the NDSU Extension Service and the North Dakota Folic Acid/Health Pregnancy Task Force formed a coalition to educate North Dakota women of childbearing age about the relationship between folic acid consumption and the risk of NTDs. This author served as the project coordinator for the North Dakota Folic Acid Task Force coalition. An NDSU Extension food and nutrition specialist provided the leadership for the study. Project collaborators were recruited through email Listservs provided by the NDSU Extension food and nutrition specialist.

Educational Intervention

In a concerted effort, the task force coalition conducted a communication-based intervention campaign to educate North Dakotans about the relationship between folic acid intake and neural tube birth defects. The education intervention took place between December 1, 2008 and February 15, 2009. The statewide campaign, modeled after the *Ready or Not* campaign, utilized mass media channels and interpersonal channels to disseminate the USPHS recommendation.

Information service providers from WIC and public health were asked to order and acquire the available *Ready or Not* education intervention materials directly from the CDC, while CDC materials for statewide extension agents were ordered and provided by the funded university extension agent. A Web site (www.ndsu.edu/health) was updated to market the campaign message and included links to folic acid-related information. Mass media distribution in four major cities across the state included radio PSAs and bathroom poster ads placed in retail establishments. Face-to-face methods of contact were utilized for community distribution of education materials and surveys. University students of a major

university placed brochures and posters throughout dining centers, and conducted health fairs in order to promote the USPHS recommendation to students and the general public. Thus, the coalition utilized Internet, telephone, community-distribution, radio, newspapers, and face-to-face methods to market the folic acid awareness program.

Sponsorship

Funding for the statewide campaign was initiated by the NCFA, a change agency that partners with the CDC. The statewide folic acid campaign was funded in part by the NCFA (36%), a state-based medical foundation (36%), the MOD (1.8%), a university extension service (9.1%), a bean growers cooperative (11.7%), and a nonprofit pulse growers association (5.4%). Total funding was directed to one United States Extension specialist for the purpose of paying the costs associated with mass media advertising, acquisition of promotional materials such as posters, emery boards and marriage certificate cards for community dissemination, auxiliary labels for pharmacy dissemination, and incentive materials for survey participants. The campaign's overall goals were to: (1) increase folic acid awareness and knowledge and folic acid intake behavior among women of childbearing age. In order to evaluate goals achievement, the campaign objectives were established as:

- Following the intervention, folic acid awareness among female participants will increase to at least 50 percent.
- Following the intervention, folic acid knowledge among female participants will increase to at least 50 percent.

- Following the intervention, self-reported folic acid intake through supplementation among female participants will be greater than the 25 percent.

Measures

Independent, dependent, and mediating variables were established in the present study. *Awareness* was considered the main independent variable. *Behavior* was considered the dependent variable. *Level of understanding* and *level of information richness* were considered mediating variables of the relationship between awareness and behavior.

Awareness

The main independent variable in the study, *awareness,* was measured by an individual's response of having heard, read or seen anything about folic acid. Questions pertaining to folic acid awareness varied slightly between Surveys One and Two. To evaluate an individual's level of folic acid awareness, Survey One participants were asked to respond to the following multiple-choice question: "Have you ever heard, read or seen anything about folic acid or folate?" Yes and no responses were dichotomized categorically.

To evaluate an individual's level of folic acid awareness, Survey Two participants were asked to respond to the following multiple-choice questions: "In the past two months, where have you seen or heard information about folic acid or folate?" Respondents were provided a listing of 27 options, of which they were asked to circle all that applied. Level of awareness was considered a continuous variable and each response was valued in the following manner: Responses of "I haven't" or "I'm not sure" were valued at zero, while

any of the other sources selected were each provided a point value of one. A total point value was summed and used as the basis to assess an individual's level of awareness.

The individual's *level of awareness* point value was further dichotomized into categories based on whether they reported having heard, seen or read anything about folic acid, or not. Individuals with a point value of zero were considered unaware, while individuals with a point value greater than zero were categorized as aware on the basis of having heard, read, or seen anything about folic acid. Table 4.9 presents the coding process for the variable *awareness.*

Table 4.9. Variable Awareness

Variable code	Survey One responses	Survey Two responses	Surveys One and Two
Aware:	• Have heard • -	• - • Sources cited	• Have heard • Sources cited •
Unaware:	• Have not heard • Unsure • -	• - • - • No sources cited	• Have not heard • Unsure • No sources cited

Level of Understanding

In order to ascertain an individual's level of understanding of the USPHS folic acid recommendation, all survey participants were asked to respond to the following five multiple-choice questions:

1. What is folic acid or folate?
2. What are some sources of folic acid or folate?
3. Some health experts recommend that women get the recommended amount of folic acid/folate to _____.
4. How much folic acid/folate is recommended daily for women during childbearing age?

5. During childbearing age, when should women take folic acid?

Level of Information Richness

In order to define an information-richness score, participants' responses to questions pertaining to level of understanding were valued for correctness and incorrectness through the method of formula scoring, an approach that was developed more than 80 years ago to evaluate multiple-choice test responses (Thurston, 1919, p. 235, Holzinger, 1924, p. 445). Using the formula-scoring approach, answers to each survey question pertaining to the USPHS folic acid recommendation were valued within a range of a negative 100 percent to a positive 100 percent. This range was proportioned for single or multiple answer options. Questions one, three and four required a single answer response and were scored in the following manner. An incorrect answer to question one was valued as a negative 100 percent. A correct answer to question one was valued as a positive 100 percent. An "I don't know" response received zero percentage points.

Questions two and five allowed for multiple responses. Percentage points were summarized for each response selected. Question two was scored in the following manner. Each incorrect answer selected in question two produced a value of a negative 20 percent. There were five incorrect answers available for a total negative score of 100 percent. Each correct answer selected produced a positive value of 20 percent. There were five correct answers available for a total positive score of percent. An "I don't know" response received zero percentage points.

Question five was scored in the following manner. A totally incorrect answer received a negative value of 100 percent. A totally correct answer received a positive score of 100 percent. In order to be totally correct, the participant needed to select all three

correct multiple-choice options "before, during and after a pregnancy." A partially correct answer received either a positive score of 33 percent (for one of the three correct choices) or a positive score of 67 percent (for two of the three correct choices). An "I don't know" response received zero percentage points.

An individual's percentage point totals for each of the five questions were summed. This cumulative percentage total was further divided by five, yielding an overall percentage representing an individual's information-richness score. For example, a score of 17.4% would be calculated for an individual scoring 87 points out of 500 possible points. Table 4.10 presents the coding process for the variable *information-richness score.*

Table 4.10. Information Richness Score Example

Question number	Points earned	Points possible
1	-100	100
2	20	100
3	100	100
4	0	100
5	67	100
Total points	87	500
Information richness score	17.4%	

Note. Information Richness Score 17.4% = 87 points/5 questions

Information Poor Versus Information Rich. Using SPSS statistical software, frequencies and percentiles were computed for the aggregate sum of information-richness scores for Surveys One, Two, and Survey One plus Two. Pretest and posttest scores falling within the 25th and 50th percentiles were categorized as information poor, while scores in the 75th and 100th percentile were categorized as information rich. Scores falling within the information-poor category were dummy-coded as zero, while scores in the information-rich category were coded as one. Table 4.11 presents the coding process for the variable information richness.

Table 4.11. Variable Information Richness

Percentile	Survey One	Survey Two	Survey One and Two
25th	Information Poor	Information Poor	Information Poor
50th	Information Poor	Information Poor	Information Poor
75th	Information Rich	Information Rich	Information Rich
100th	Information Rich	Information Rich	Information Rich

Behavior

The main dependent variable in the study, *behavior,* was measured by an individual's self report of current vitamin consumption patterns. Questions pertaining to vitamin consumption varied slightly between Surveys One and Two.

Responses to the Survey One question "Do you take a pill containing folic acid on a "daily basis?" were dichotomized into categories of "yes" or "no." Responses of "no" and I don't know" were collapsed into the category "no." Survey Two respondents were asked to report how long they have been taking a daily vitamin or supplement containing folic acid. Individual responses were placed within a range of three categories: 1) never, 2) less than a month, or 3) more than a month. Additionally, the variable *behavior* from Survey Two was dichotomized into categories of *more than a month* and *not more than a month.* Table 4.12 presents the coding process for the variable *behavior.*

Table 4.12. Variable Behavior

Variable Code	Survey One Responses	Survey Two Responses	Survey One and Two
Yes	• Yes • - • -	• - • Less than a month • More than a month	• Yes • Less than a month • More than a month
No	• No • I don't know • -	• - • - • Never	• No • I don't know • Never

Barriers

In order to ascertain an individual's perceived barriers to daily vitamin consumption, similar but slightly different questions were posed on Surveys One and Two. For example, Survey One participants were asked to respond to the multiple-choice question: "If you don't, why don't you take a vitamin or mineral supplement on a daily basis?" Survey Two participants were asked to respond to the multiple-choice question: "If you don't, why don't you take a vitamin/mineral supplement each day?"

In both surveys, individuals were asked to select all applicable barriers from a list of multiple choice options. Individuals, who reported taking a pill containing folic acid on a *daily basis*, were assigned a value of zero (for zero barriers reported). The total number of reported barriers was summed and coded as a continuous variable for each survey respondent. Additionally, the total number of barriers reported by a respondent was dichotomized into two categories: 1) *zero barriers reported,* or 2) *one or more barriers reported.*

NTD-Risk

In order to estimate females at-risk for having an NTD-affected pregnancy, variables of *age* and *vitamin consumption behavior* were correlated. Females within childbearing age who did not take a daily folic acid containing supplement were considered at the highest risk (100%) for having an NTD-affected pregnancy. Females of childbearing age who took a daily folic acid containing supplement reduced their risk for having an NTD-affected pregnancy by 70% (CDC, 1992; CDC, 1998a). Females beyond childbearing age were not considered at risk for having an NTD-affected pregnancy.

Adenoma-Risk

In order to estimate populations at-risk for the development of colorectal adenomas, variables of *age* and *vitamin consumption behavior* were correlated. Individuals over 50 years of age who took a daily vitamin containing folic acid were categorized at the highest risk level for developing a colorectal adenoma. Individuals over 50 years of age who did not take a folic acid containing supplement were categorized at a medium risk level for adenoma development. Individuals 50 years and younger were categorized at the lowest risk level for adenoma development, regardless of vitamin intake behavior.

Data Analysis

Descriptive statistics and frequencies were computed for each variable. The researcher computed cronbach's alpha, regression analysis and ANOVAs to test the data. Keeping in mind the number of items, the researcher chose an ANOVA-test to reduce error in variance and adjust effects. An ANOVA test was computed to ascertain the significance of the mean difference between variables at the .05 level of significance. The researcher manually input the paper survey data into the SPSS statistical software program (SPSS Statistics version 17.0). The data were entered into SPSS in order to obtain the correlation matrix (or covariances) between each of the variables. In order to fit the model to the data, maximum likelihood estimation was used. Data were aggregately analyzed (Survey One plus Survey Two data) and comparatively analyzed (Survey One versus Survey Two data).

Tests of Indirect Effects

Mediation. Tests of simple mediation were conducted using Baron and Kenny's (1986) causal approach. Responses to five questions related to folic acid knowledge were tested as potential mediators in a linear relationship between awareness and behavior.

Measures of folic acid knowledge were scored and collapsed to form the single mediating measure of information richness. In order to determine whether an individual's level of information richness might have mediated the relationship between folic acid awareness and daily vitamin consumption, Baron and Kenny's (1986) causal approach was followed. Simple mediation was tested for data sets: Survey One, Survey Two, and Survey One plus Survey Two.

In order to test for mediation, the level of information-richness was regressed on folic acid awareness (along with control variables); vitamin consumption was regressed on folic acid awareness (with controls), and vitamin consumption was regressed on both level of information-richness *and* folic acid awareness (with controls). If the effect of folic acid awareness in the first and second equations was statistically significant, and if the effect of folic acid awareness on the dependent variable was significantly smaller in the third regression than in the second regression, then support for mediation would be obtained.

Bootstrapping. The bootstrapping method was used to analyze the specific and total indirect effects of the sampling distribution. Bootstrapping, a computationally-intensive nonparametric-resampling procedure (Preacher and Hayes, 2008, p. 880), was used to generate an empirical representation of the sampling distribution of the indirect effect by treating the obtained sample sizes as a representation of the population in miniature (Hayes, 2009, p. 412). Tests of simple and multiple mediation were conducted using the bootstrapping method.

Through bootstrapping, Survey One, Survey Two, and Survey One plus Survey Two, data samples were resampled with replacement 5000 times using a 95% confidence interval. The percentile based bootstrap confidence interval was adjusted to yield a bias-

corrected confidence interval. The interval was checked for an inclusion or exclusion of zero. If zero was not within the confidence interval, a claim could be made that the indirect effect is not zero with 95% confidence. This claim is conceptually similar to a claim of causal approach where the null hypothesis (that the true indirect effect is zero) would be rejected at a .05 level of significance (Hayes, 2009, p. 412).

In order to test the multiplicity of intervening variables, a more modern approach was warranted to investigate multiple mediation of the relationship between folic acid awareness and daily vitamin consumption. In order to determine whether variables might have mediated the relationship, an approach that would quantify indirect effects of five variables was followed. These variables were drawn from the same questions used to determine an individual's level of understanding of the USPHS recommendation. Due to the complexity of multiple mediation analysis, a statistical software macro developed by Preacher and Hayes (2008) was used to test the five variables for intervening effects. Table 4.13 presents the *simple* and *multiple mediation* variables used in the bootstrapping analysis.

Table 4.13. Bootstrapping Simple and Multiple Mediation Variables

Simple mediation variable	Multiple mediation variables
1. Information Richness	1. What is folic acid or folate
	2. Food sources of folic acid/ folate
	3. Why is folic acid needed
	4. How much folic acid is needed
	5. When should folic acid be taken

Tests of Communication Effects

Communication-Effects Gaps. Survey One responses were assessed and compared to Survey Two responses in order to determine changes at two different points in time, among North Dakota population subsets. This analytic approach looked for differential

effects in data variables, and assessed whether different segments were more affected by the folic acid communication intervention than were other segments. For example, Survey One information-richness scores among specific groups of North Dakotans were compared to Survey Two information-richness scores specific groups of North Dakotans.

NTD-Risk Assessment

The Breslow-Day test was run to assess the appropriateness of collapsing individual data sets into an aggregate form for continued statistical analysis. Additionally, the Breslow-Day test was used to assess variable relationships for effects modification at the .05 level of significance.

Odds Ratios. In order to estimate populations at-risk for having an NTD-affected pregnancy, variables of *gender, age, vitamin consumption behavior* were correlated. Odds ratios (OR) were computed to assess the population at risk for having an NTD-affected pregnancy. Using the data set for Survey One plus Survey Two, odds ratios for the outcome *At risk for an NTD-affected pregnancy* were computed. Table 4.14 presents the variable comparisons used to compute odds ratios and NTD-risk assessment.

Confounding. In order to test for confounding, cross product odds ratios, crude odds ratios, and adjusted odds ratios were computed for variables of interest and compared. Crude odds ratio for each variable were stratified. For example, an overall odds ratio for ethnicity could be additionally stratified by age groups, or an overall odds ratio for vitamin consumption could be further stratified by race. An adjusted odds ratio was computed through stratified odds ratios, and compared to the crude odds ratio. Confounding was based on a 10% differential between the crude odds ratio and the adjusted odds ratio.

Table 4.14. Variables for Odds Ratios and NTD-Risk Assessment

Variable A	Variable B
Survey period (e.g. Survey One)	Survey period (e.g. Survey Two)
Gender (e.g. females)	Gender (e.g. males)
Folic acid awareness	No folic acid awareness
Information richness (e.g. information poor)	Information richness (e.g. information rich)
Vitamin behavior (e.g. take daily)	Vitamin behavior (e.g. do not take daily)
Barriers to daily folic acid intake	No barriers to daily folic acid intake
Service provider (e.g. Extension)	Service Provider (e.g. Non Extension)
Proximity (e.g. Urban)	Proximity (e.g. Rural)
Age (e.g. age groups)	Age (e.g. age groups)
Ethnicity (e.g. Latino or Hispanic)	Ethnicity (Not Latino or Hispanic)
Race (e.g. white)	Race (e.g. non-white)
At-risk for having an NTD-affected pregnancy	Not at risk for having an NTD-affected pregnancy
At –risk for adenoma development	Not at risk for adenoma development

NTD Attributable Fractions. Attributable fractions (AF) were computed for the survey population at-risk for having an NTD-affected pregnancy. North Dakota prevalence rates for NTD-affected pregnancies were provided by the North Dakota Department of Health. Prevalence of risk factors among the survey populations were calculated and compared to the prevalence rates reported by the North Dakota Department of Health. In turn, attributable fractions were used to calculate population attributable fractions (AFp).

Adenoma Risk Assessment

In order to estimate populations at-risk for the development of colorectal adenomas, variables of *age* and *vitamin consumption behavior* were correlated. Individuals complying with the daily folic acid recommendation through vitamin intake were considered at greater risk for accumulating sufficient folic acid levels that can lead to unmetabolized folic acid in serum (Sweeney, McPartline, & Scott, 2007, p. 6). In turn, unmetabolized folic acid in an individual's serum was considered a risk factor for developing a colorectal adenoma (Mason, 2009, p. 209). In the present study, individuals over 50 years of age were categorized as being at risk for developing a colorectal adenoma, on the basis of age.

Individuals over 50 years of age who took a daily vitamin containing folic acid were categorized at a higher risk for developing a colorectal adenoma, on the basis of age plus daily folic acid intake behavior.

Summary

This chapter has outlined the methods used to gather and analyze data for this study. Initially, the survey participants were described in great detail. Following a description of data collection and the folic acid campaign design, variable measures were detailed. The procedures and measures illustrated in this chapter are necessary for the development of a new diffusion model. This chapter concluded with a presentation of this study's analysis strategy. In chapter five, the results of this analysis plan are described.

RESULTS

This chapter presents the analyses of data set one (Survey One), data set two (Survey Two) and data set three (Surveys One and Two combined). Survey responses from males and females will be included in data analysis related to colorectal adenoma risk assessment. However, survey responses from male participants will be excluded from data analysis related to folic acid awareness, knowledge and behavior, as well as NTD-risk assessment. Published materials from the CDC and MOD suggest that females between the age of 18 and 45 are considered of childbearing age. For this study, a more conservative approach considered childbearing aged females to be within the range of 18 and 49 years.

Descriptive and Frequency Analyses

Data Variables

Independent Variable. Beyond participant demographics, (e.g. service provider affiliation, proximity, age, gender, ethnicity, and race) previously discussed, the primary independent variable in the current study is *awareness*. The questions used to measure *awareness* varied slightly between Survey One and Two. Table 5.1 presents the general folic acid awareness among female participants.

Table 5.1. General Folic Acid Awareness

Gender	Awareness	Survey One		Survey Two	
Male	Not aware	13	52.0 %	20	48.8 %
	Aware	12	48.0 %	21	51.2 %
Female	Not aware	130	24.1 %	94	23.9 %
	Aware	409	75.9 %	299	76.1 %

Within both survey periods, more females than males claim to have heard, seen, or read anything about folic acid. A review of the Survey One data reveals that about 409 (75.9%) of surveyed females indicated that they were already aware of folic acid. Folic

acid awareness increased among Survey Two female respondents to 76.1 percent (up 0.2%).

Of the 436 participants responding to Survey Two, individuals were asked to report where they have seen or heard information about folic acid or folate in the last two months. Table 5.2 presents how often folic acid-message sources were recalled by the participants.

Table 5.2. Frequency of Recalled Message Sources Among Survey Two Respondents

Gender	Recalled message source	Frequencies	
Male and Female	Brochure	101	23.2 %
	Poster display	87	20.0 %
	Clinic	85	19.5 %
	WIC	83	19.0 %
	Television	82	18.8 %
	Food label	79	18.1 %
	Magazine	67	15.4 %
	Display	53	12.2 %
	Supplement bottle label	52	11.9 %
	Other	46	10.6 %
	Healthcare provider	45	10.3 %
	At college	44	10.1 %
	Classroom	40	9.2 %
	Internet	36	8.3 %
	Survey	36	8.3 %
	Billboard	35	8.0 %
	Pharmacy	25	5.7 %
	Newspaper	22	5.0 %
	Email	19	4.4 %
	From a friend	18	4.1 %
	Radio	17	3.9 %
	Coupon	8	1.8 %
	Recipe card	7	1.6 %
	Restaurant	1	0.2 %

Of the folic acid-message sources recalled, the five-most reported sources included: brochures (23.2%), poster displays (20%), at a clinic (19.5%), through WIC (19%), and

television (18.8%). The five least-reported sources included: restaurants (0.2%), recipe cards (1.6%), coupons (1.8%), radio (3.9%), and from a friend (4.1%).

Additionally, Survey Two participants were assessed for their *level of folic acid awareness*. The *level of folic acid awareness* among Survey Two participants were categorized by ranges of folic acid message sources recalled. When asked to respond to a multiple-choice question "In the past two months, where have you seen or heard information about folic acid or folate," the majority of the female respondents (45.8%) were able to recall between one and three message sources. Table 5.3 presents folic acid awareness based on message source recall for Survey Two male and female participants.

Table 5.3. Grouping of Messages Recalled by Survey Participants

Gender	Range of sources recalled	Survey Two	
Male	0	20	48.8%
	1-3	13	31.7%
	4-6	7	17.1%
	7-9	1	2.4%
	10+	0	0.0%
Female	0	104	26.3%
	1-3	181	45.8%
	4-6	78	19.8%
	7-9	23	5.8%
	10+	9	2.3%

Dependent Variable. Behavior is the main dependent variable in the current study. The questions used to measure *behavior* varied slightly between Surveys One and Two. For both surveys, respondents clarified whether they took a daily vitamin containing folic acid, or not. The total number of females reporting to take folic acid every day increased from survey period one (43.4%) to survey period two (58.6%). Twelve females did not report

their daily supplement behavior, and thus were excluded from the analysis. Table 5.4 presents the results of daily folic intake behavior among survey participants.

Table 5.4. Daily Folic Intake Behavior

Gender	Behavior	Survey One		Survey Two	
Male	Do not take folic daily	20	80.0 %	33	80.5 %
	Do take folic daily	5	20.0 %	8	19.5 %
Female	Do not take folic daily	307	56.6 %	159	41.4 %
	Do take folic daily	235	43.4 %	225	58.6 %

Additionally, Survey Two respondents were additionally asked to report how long they have been consuming a daily vitamin. Of the female respondents taking folic on a daily basis, 206 (53.6%) have been taking folic acid for more than a month. Eleven females did not indicate a duration of folic acid intake and were excluded from this analysis. Table 5.5 presents the results of folic intake duration among female participants.

Table 5.5. Folic Intake Duration Survey Two

Gender	Intake duration	Survey Two	
Male	Do not take	33	80.5 %
	Less than a month	0	0.0 %
	More than a month	8	19.5 %
Female	Do not take	159	41.5 %
	Less than a month	19	4.9 %
	More than a month	206	53.6 %

Gender, age, and vitamin intake behavior were correlated in order to determine the category of survey respondents at risk for having an NTD-affected pregnancy. Of the female respondents between the ages of 18 and 49 years in Survey One, 252 (46.75%) did not take a daily supplement containing folic acid and therefore were considered at risk for having an NTD-affected pregnancy. Of the female respondents between the ages of 18 and

49 years in Survey Two, 143 (36.29%) were not consuming a daily folic acid containing supplement and therefore were considered at risk for having an NTD-affected pregnancy. Table 5.6 presents the results of females at risk for having an NTD-affected pregnancy.

Table 5.6. Women at Risk for Having an NTD-Affected Pregnancy

Gender	NTD-risk level groups	Age groups	Survey Two		Survey Two	
Female	At risk	18-25	163	64.7 %	87	60.8 %
		26-33	54	21.4 %	33	23.1 %
		34-41	22	8.7 %	17	11.9 %
		42-49	13	5.2 %	6	4.2 %
	Not at risk	18-25	71	24.7 %	106	44.0 %
		26-33	54	18.8 %	57	23.7 %
		34-41	37	12.9 %	30	12.4 %
		42-49	34	11.9 %	12	5.0 %
		50+	91	31.7 %	36	14.9 %

Age was used to determine the category of survey respondents at risk for developing colorectal adenomas. Of the respondents who were 50 years and older in Survey One, 7 males (7.2%) and 91 females (92.8%) were considered at risk for developing colorectal adenomas due to their age. Of the respondents who were 50 years and older in Survey Two, 1 male (2.8%) and 36 females (97.2%) were considered at risk for developing colorectal adenomas due to their age. Table 5.7 presents the age-based risk for developing colorectal adenomas among survey participants who were 50 years and older.

Table 5.7. Age-Based Risk for Developing Colorectal Adenoma

Risk level group	Gender	Survey One		Survey Two	
At risk	Males	7	7.2 %	1	2.8 %
	Females	91	92.8 %	36	97.2 %

Note. At risk for adenoma development = 50+ years of age.

Age, and vitamin intake behavior were correlated in order to determine the category of survey respondents at risk for developing colorectal adenomas. Of the male and female respondents 50 years and older in Survey One, 50 (51%) took a daily supplement containing folic acid and therefore were considered at greater risk for accumulating sufficient developing colorectal adenomas, as compared to those who were 50 years and older, but did not take a daily supplement containing folic acid (49%). Of the Survey Two male and female respondents 50 years and older, 22 (59.5%) were consuming a daily folic acid- containing supplement and therefore were considered at greater risk for developing colorectal adenomas, as compared to those who were 50 years and older, but did not take a daily supplement containing folic acid (40.5%). Table 5.8 presents the vitamin intake and age-based risk for developing colorectal adenomas among survey participants who were 50 years and older.

Table 5.8. Vitamin Intake and Age-Based Risk for Developing Colorectal Adenoma

Risk level group	Gender	Survey One		Survey Two	
At risk	Males	1	1.0 %	1	2.7 %
	Females	49	50.0 %	21	56.8 %
Not at risk	Males	6	6.1 %	0	0.0 %
	Females	42	42.9 %	15	40.5 %

Note. At risk for adenoma development = 50+ years of age + consumption of daily supplement containing folic acid.

Barriers to Vitamin Intake. For both surveys, female respondents reported barriers to taking a daily vitamin containing folic acid. In review of Survey One results, 356 (65.6%) female respondents reported at least one barrier to taking a daily supplement containing folic acid. In comparison, 201 (50.9%) of the female respondents from survey two reported at least one barrier as their reason for not consuming supplements containing

folic acid every day (down 14.7%). Table 5.9 presents the perceived barriers to daily folic intake for female participants.

Table 5.9. Perceived Barriers to Daily Folic Intake

Gender	Barrier	Survey One		Survey Two	
Female	Barriers noted	356	65.6 %	201	50.9 %
	No barriers noted	187	34.4 %	194	49.1 %

Mediating Variables. Level of knowledge was a mediating variable between the awareness-behavior relationship. Five questions were used to assess folic acid knowledge among surveyed females. Female participants were assessed for their ability to correctly answer the five questions related to the USPHS folic acid recommendation, following the education intervention. Tables 5.10, 5.11, 5.12, 5.13, and 5.14 present the level of folic acid knowledge among surveyed females.

Table 5.10. What is Folic Acid?

Gender	Knowledge	Survey One		Survey Two	
Male	Cannot identify folic acid	15	60.0 %	25	61.0 %
	Can identify folic acid	10	40.0 %	16	39.0 %
Female	Cannot identify folic acid	262	48.7 %	127	32.7 %
	Can identify folic acid	276	51.3 %	261	67.3 %

Note. Twelve female participants did not respond to this question, and their responses were removed from this analysis.

Table 5.11. What are Folic Acid Sources?

Gender	Knowledge	Survey One		Survey Two	
Male	Cannot identify five sources	25	100.0 %	41	100.0 %
	Can identify five sources	0	0.0 %	0	0.0 %
Female	Cannot identify five sources	533	98.3 %	346	88.0 %
	Can identify five sources	9	1.7 %	47	12.0 %

Note. Three female participants did not respond to this question, and their responses were removed from this analysis.

Table 5.12. Why is Folic Acid Needed?

Gender	Knowledge	Survey One		Survey Two	
Male	Cannot identify why folic is needed	13	52.0 %	19	46.3 %
	Can identify why folic is needed	12	48.0 %	22	53.7 %
Female	Cannot identify why folic is needed	164	30.3 %	82	20.8 %
	Can identify why folic is needed	378	69.7 %	313	79.2 %

Note. One female participant did not respond to this question, and her response was removed from this analysis.

Table 5.13. How Much Folic Acid is Needed?

Gender	Knowledge	Survey One		Survey Two	
Male	Cannot identify how much folic is needed	18	72.0 %	32	80.0 %
	Can identify how much folic is needed	7	28.0 %	8	20.0 %
Female	Cannot identify how much folic is needed	380	71.2 %	211	54.8 %
	Can identify how much folic is needed	154	28.8 %	174	45.2 %

Note. One male and nineteen female participants did not respond to this question, and their responses were removed from this analysis.

Table 5.14. When Should Folic Acid be Taken?

Gender	Knowledge	Survey One		Survey Two	
Male	Cannot identify when to take folic	25	100.0 %	35	85.4 %
	Can identify when to take folic	0	0.0 %	6	14.6 %
Female	Cannot identify when to take folic	379	69.9 %	220	56.0 %
	Can identify when to take folic	163	30.1 %	173	44.0 %

Note. Three female participants did not respond to this question, and their responses were removed from this analysis.

Statistical and Regression Analyses

Information Richness

Level of information richness was calculated by summing the level of knowledge scores per individual. Using SPSS statistical software, the 50th percentile cutoff of individual scores was 42.60 percent. The percentage of information-poor females decreased from Survey One to Survey Two (down 19.8%). Table 5.15 presents the results for information richness among survey participants.

Table 5.15. Level of Information Richness

Gender	Information richness group	Survey One		Survey Two	
Male	Poor	16	64.0 %	31	75.6 %
	Rich	9	36.0 %	10	24.4 %
Female	Poor	311	57.3 %	148	37.5 %
	Rich	252	42.7 %	247	62.5 %

Stratified Data

Stratified data revealed that level of information richness was statistically significant among females (p-value 0.05) and statistically insignificant among males (p-value =.312). Males are removed from the stratified data analysis.

Ethnicity. Information richness was stratified by ethnicity. Of the non Latino or non Hispanic female participants, the percentage of information poor decreased by 20.5 percent from Survey One to Survey Two. Table 5.16 presents the results of the information-richness analysis among surveyed females, grouped by ethnicity. Eight individuals did not report their ethnicity, and therefore were omitted from the analysis.

Table 5.16. Level of Information Richness Stratified by Ethnicity

Gender	Information richness group	Ethnicity	Survey One		Survey Two	
Female	Poor	Latino or Hispanic	5	0.9 %	8	2.1 %
		Not Latino or Hispanic	306	56.5 %	140	36.0 %
	Rich	Latino or Hispanic	3	0.6 %	5	1.3 %
		Not Latino or Hispanic	228	42.0 %	236	60.6 %

White and non-white. Information-richness analysis was further stratified by white and non-white females. The percentage of information-poor white females and information-poor non-white females decreased following the education intervention. Seven females did not indicate their race and were omitted from the analysis. Table 5.17 presents

the result of information richness among female participants, stratified by white and non-white females.

Table 5.17. Information Richness Stratified by Race Dichotomy

Gender	Information richness group	Race	Survey One		Survey Two	
Female	Poor	White	255	47.4 %	125	31.8 %
		Non-white	54	10.0 %	23	5.9 %
	Rich	White	206	38.3 %	211	53.7 %
		Non-white	23	4.3 %	34	8.6 %

Five Races. Information richness was assessed among individuals, stratified by five races. The percentage of information-poor individuals was compared within each race. Of the surveyed females, the "white" females reflected the largest decrease in information-poor females (down 15.6%) Table 5.18 presents the results of the information-richness analysis among five races.

Table 5.18. Information Richness of Females Stratified by Five Races

Gender	Information richness group	Race	Survey One		Survey Two	
Female	Poor	White	255	47.4 %	125	31.8 %
		Black	3	0.6 %	1	0.3 %
		Asian	6	1.1 %	1	0.3 %
		Native American or American Indian	42	7.8 %	18	4.5 %
		Native Hawaiian or Other Pacific Islander	3	0.6 %	3	0.8 %
	Rich	White	206	38.3 %	211	53.6 %
		Black	1	0.2 %	2	0.5 %
		Asian	4	0.7 %	2	0.5 %
		Native American or American Indian	18	3.3 %	27	6.9 %
		Native Hawaiian or Other Pacific Islander	0	0.0 %	3	0.8 %

Rural-Urban Proximity. Information richness was stratified by rural-urban proximity. Of the female participants residing in urban areas, the percentage of

information-poor women decreased from Survey One (42%) to Survey Two (31.6%). In comparison, the percentage of information-poor women decreased by 9.5 percent among female participants residing in rural areas. Table 5.19 presents the results of the information-richness analysis among surveyed females, grouped by rural-urban proximity.

Table 5.19. Level of Information Richness Stratified by Rural-Urban Proximity

Gender	Information richness group	Proximity	Survey One		Survey Two	
Female	Poor	Rural	83	15.3 %	23	5.8 %
		Urban	228	42.0 %	125	31.6 %
	Rich	Rural	57	10.5 %	48	12.2 %
		Urban	175	32.2 %	199	50.4 %

Regional Proximity. Additionally, information richness was stratified by regional proximity. Table 5.20 presents the analysis of information richness among surveyed females, grouped by regional proximity.

Table 5.20. Level of Information Richness Stratified by Regional Proximity

Gender	Information richness group	Proximity	Survey One		Survey Two	
Female	Poor	Region 1	22	4.1 %	0	0.0 %
		Region 2	57	10.5 %	42	10.6 %
		Region 3	24	4.4 %	10	2.5 %
		Region 4	10	1.8 %	16	4.1 %
		Region 5	99	18.2 %	35	8.9 %
		Region 6	36	6.6 %	10	2.5 %
		Region 7	62	11.4 %	32	8.1 %
		Region 8	1	0.2 %	3	0.8 %
	Rich	Region 1	19	3.5 %	2	0.5 %
		Region 2	72	13.3 %	98	24.8 %
		Region 3	17	3.1 %	19	4.8 %
		Region 4	15	2.8 %	7	1.8 %
		Region 5	47	8.7 %	54	13.7 %
		Region 6	19	3.5 %	21	5.3 %
		Region 7	41	7.5 %	40	10.1 %
		Region 8	2	0.4 %	6	1.5 %

Of the female participants, Region 5 reflected the largest decrease in the percentage of information-poor women (down 9.3%) from Survey One to Survey Two. In contrast, Regions 4 and 8 reflected increases in the percentage of information-poor female participants. The percentage of information-poor females remained constant for Region 2.

Service Provider. Information richness was stratified by service provider affiliation. Of the female clients of extension service providers, the percentage of information-poor women decreased from Survey One (21.5%) to Survey Two (13.2%). In comparison, the percentage of information-poor females decreased from Survey One (35.7%) to Survey Two (24.3%) among clients of non-extension service providers. Table 5.21 presents the results of the information-richness analysis among surveyed females, grouped by service provider affiliation.

Table 5.21. Level of Information Richness Stratified by Service Provider

Gender	Information richness group	Service provider	Survey One		Survey Two	
Female	Poor	Extension	117	21.5 %	52	13.2 %
		Non extension	194	35.7 %	96	24.3 %
	Rich	Extension	104	19.2 %	130	32.9 %
		Non extension	128	23.6 %	117	29.6 %

Age. Information-richness analysis was further stratified by age. Of the female participants, the age group 18 to 25 years reflected the largest decrease in the percentage of information-poor females, following the education intervention (down 6.3%). The age group 26 to 33 years reflected an increase in the percentage of information-poor females from Survey One to Survey Two (up 1.7%). Table 5.22 presents the level of information richness among female participants, stratified by age groups. Five individuals did not provide their age, and therefore were omitted from the analysis.

Table 5.22. Information Richness Stratified by Age Groups

Females	Information richness group	Age groups	Survey One		Survey Two	
	Poor	18-25	160	29.7 %	87	22.0 %
		26-33	39	7.2 %	35	8.9 %
		34-41	29	5.4 %	9	2.3 %
		42-49	31	5.8 %	3	0.8 %
		50+	52	9.6 %	13	3.3 %
	Rich	18-25	74	13.7 %	110	28.0 %
		26-33	69	12.8 %	60	15.2 %
		34-41	30	5.6 %	39	9.9 %
		42-49	16	3.0 %	15	3.8 %
		50+	39	7.2 %	23	5.8 %

Causal Approach Mediation

Due to the large sample size, tests of simple mediation were conducted using Baron and Kenny's (1986) causal approach. The results of the four Baron and Kenny (1986) steps are presented. Significance was verified at the 95% confidence interval.

Survey One. Simple mediation was tested for data set Survey One. The effect of awareness on behavior (or path c) was equal to .257 ($p<.05$), at the 95% confidence interval. Step one was passed. Table 5.23 presents the test for step one.

Table 5.23. Survey One Mediation Step One for Coefficients[a,b]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.208	.042		4.936	.000
	Folic Acid Awareness	.297	.048	.257	6.151	.000

[a]Dependent Variable: Daily Folic Intake Behavior. [b]Selecting only cases for which Gender = Female.

The effect of awareness on level of information richness (or path a) was equal to .331 ($p<.05$), at the 95% confidence interval. Step two was passed. Table 5.24 presents the test results for step two.

Table 5.24. Survey One Mediation Step Two for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.138	.041		3.374	.001
	Folic Acid Awareness	.382	.047	.331	8.115	.000

[a]Dependent Variable: Information Richness. [b]Selecting only cases for which Gender = Female.

The effect of level of information richness on behavior, controlling for awareness (or path b) was equal to .192 ($p<.05$), at the 95% confidence interval. Step three was passed. Table 5.25 presents the test results for step three.

Table 5.25. Survey One Mediation Step Three for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.180	.042		4.317	.000
	Folic Acid Awareness	.222	.050	.192	4.412	.000
	Information Richness	.198	.043	.198	4.549	.000

[a]Dependent Variable: Daily Folic Intake Behavior. [b]Selecting only cases for which Gender = Female.

The effect of path c prime (.192) is closer to zero than the effect of path c (.257). Therefore, step four was passed, and mediation was confirmed. The indirect effect of mediation (.08) was significant at the .05 level.

Survey Two. Simple mediation was tested for the Survey Two data set. The effect of awareness on behavior (or path c) was equal to .283 ($p<.05$), at the 95% confidence interval. Step one was passed. Table 5.26 presents the test results for step one. The effect of awareness on level of information richness (or path a) was equal to .319 ($p<.05$), at the 95% confidence interval. Step two was passed. Table 5.27 presents the test results for step two.

Table 5.26. Survey Two Mediation Step One for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.337	.049		6.821	.000
	Folic Acid Awareness	.326	.057	.283	5.757	.000

[a]Dependent Variable: Daily Folic Intake Behavior. [b]Selecting only cases for which Gender = Female.

Table 5.27 Survey Two Mediation Step Two for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.351	.047		7.402	.000
	Folic Acid Awareness	.361	.054	.319	6.645	.000

[a]Dependent Variable: Information Richness. [b]Selecting only cases for which Gender = Female.

The effect of level of information richness on behavior, controlling for awareness (or path b) was equal to .239 ($p<.05$, at the 95% confidence interval. Step three was passed. Table 5.28 presents the test results for step three.

Table 5.28. Survey Two Mediation Step Three for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.292	.052		5.602	.000
	Information Richness	.133	.053	.130	2.521	.012
	Folic Acid Awareness	.276	.060	.239	4.626	.000

[a]Dependent Variable: Daily Folic Intake Behavior. [b]Selecting only cases for which Gender = Female.

The effect of path c prime (.239) was closer to zero than the effect of path c (.283). Therefore, step four was passed, and mediation was confirmed. The indirect effect of mediation (.07) was significant at the .05 level.

Surveys One and Two. Simple mediation was tested for data set Survey One plus Survey Two. The effect of awareness on behavior (or path c) was equal to .265 ($p<.05$), at

the 95% confidence interval. Step one was passed. Table 5.29 presents the test results for step one.

Table 5.29. Surveys One Plus Two Mediation Step One for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.477	.065		-7.370	.000
	Folic Acid Awareness	.619	.074	.265	8.325	.000

[a]Dependent Variable: Daily Folic Intake Behavior. [b]Selecting only cases for which Gender = Female.

The effect of awareness on level of information richness (or path a) was equal to .320 ($p<.05$), at the 5% confidence interval. Step two was passed. Table 5.30 presents the test results for step two.

Table 5.30. Surveys One Plus Two Mediation Step Two for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.228	.032		7.187	.000
	Folic Acid Awareness	.374	.036	.320	10.290	.000

[a]Dependent Variable: Information Richness. [b]Selecting only cases for which Gender = Female.

The effect of level of information richness on behavior, controlling for awareness (or path b) was equal to .201 ($p<.05$), at the 95% confidence interval. Step three was passed. Table 5.31 presents the test results for step three.

Table 5.31. Surveys One Plus Two Mediation Step Three for Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.564	.065		-8.646	.000
	Folic Acid Awareness	.470	.077	.201	6.083	.000
	Information Richness	.393	.066	.197	5.951	.000

[a]Dependent Variable: Daily Folic Intake Behavior. [b]Selecting only cases for which Gender = Female.

The effect of path c prime (.201) was closer to zero than the effect of path c (.265). Therefore, step four was passed, and mediation was confirmed. The indirect effect of mediation (.0506) was significant at the .05 level.

Bootstrapping Simple Mediation

Simple mediation was confirmed using the bootstrapping method of statistical analysis. Survey data samples (Survey One, Survey Two, and Surveys One plus Two) were resampled with replacement 5000 times using a 95% confidence interval. The percentile based confidence intervals were adjusted to yield bias-corrected confidence intervals. The intervals were checked for the inclusion of zero. The simple mediation results using the bootstrapping method are presented.

Simple Mediation Survey One. Bias-corrected confidence intervals for survey data set one were checked for the inclusion of zero. The mediating variable, Information Richness, did not include zero in the bias-corrected confidence intervals (CI= .1732, .4836; 95%). Thus, mediation of *information richness* on the awareness-behavior relationship was confirmed for survey data set one using the bootstrapping method. Table 5.32 presents the mediation test results for Survey One.

Table 5.32. Survey One Simple Mediation Bootstrapping Results

	Indirect Effects of Independent Variable on Dependent Variable through Proposed Mediator					
					Bias Corrected And Accelerated Confidence Interval	
Proposed Mediator	Data	Boot	Bias	SE	Lower	Upper
Information Richness	.3238	.3256	.0019	.0787	.1732	.4836

Note. Bootstrap resample is 5000. Survey One (n=563). Dependent variable is *vitamin behavior*. Independent variable is *folic acid awareness*. Level of confidence interval is .95

Simple Mediation Survey Two. Bias-corrected confidence intervals for survey data set one were checked for the inclusion of zero. The mediating variable, Information

Richness, did not include zero in the bias-corrected confidence intervals (CI=.1052, .4831; 95%). Therefore, mediation of *information richness* on the awareness-behavior relationship was confirmed for survey data set two using the bootstrapping method. Table 5.33 presents the mediation test results for Survey Two.

Table 5.33. Survey Two Simple Mediation Bootstrapping Results

	Indirect Effects of Independent Variable on Dependent Variable through Proposed Mediator					
					Bias Corrected And Accelerated Confidence Interval	
Proposed Mediator	Data	Boot	Bias	SE	Lower	Upper
Information Richness	.2842	.2866	.0023	.0962	.1052	.4831

Note. Bootstrap resample is 5000. Survey Two (n=424). Dependent variable is *vitamin behavior*. Independent variable is *folic acid awareness*. Level of confidence interval is .95.

Simple Mediation Surveys One and Two. Bias-corrected confidence intervals for survey data set one plus two were checked for the inclusion of zero. The mediating variable, information richness, did not include zero in the bias-corrected confidence intervals (CI=.2207, .4544; 95%). Therefore, mediation of *information richness* on the awareness-behavior relationship is confirmed for survey data set one plus two using the bootstrapping method. Table 5.34 presents the mediation test results for Surveys One plus Two.

Table 5.34. Surveys One and Two Simple Mediation Bootstrapping Results

	Indirect Effects of Independent Variable on Dependent Variable through Proposed Mediator					
					Bias Corrected And Accelerated Confidence Interval	
Proposed Mediator	Data	Boot	Bias	SE	Lower	Upper
Information Richness	.3337	.3341	.0004	.0601	.2207	.4544

Note. Bootstrap resample is 5000. Surveys One and Two (n=987). Dependent variable is *vitamin behavior*. Independent variable is *folic acid awareness*. Level of confidence interval is .95.

Bootstrapping Multiple Mediation

Multiple mediation was tested using the bootstrapping method of statistical analysis. Survey data samples (Survey One, Survey Two, and Survey One plus Two) were resampled with replacement 5000 times using a 95% confidence interval. The percentile based confidence intervals were adjusted to yield bias-corrected confidence intervals. The intervals were checked for the inclusion of zero. The multiple mediation results using the bootstrapping method are presented.

Multiple Mediation Survey One. Bias-corrected confidence intervals for survey data set one were checked for the inclusion of zero. Two variables, *what is folic acid* and *why take folic acid* included zero in the confidence interval. Three variables did not include zero in the bias-corrected confidence intervals. Thus, when reviewed individually, mediation was confirmed for three of five variables on the awareness-behavior relationship using the bootstrapping method. Table 5.35 presents the multiple mediation test results for Survey One.

Table 5.35. Survey One Multiple Mediation Bootstrapping Results

percentage	Indirect Effects of Independent Variable on Dependent Variable through Proposed Mediator					
					Bias Corrected And Accelerated Confidence Interval	
Proposed Mediators	Data	Boot	Bias	SE	Lower	Upper
What is folic	-.0324	-.0344	-.0019	.0333	-.1107	.0221
Folic food sources	.1893	.1914	.0022	.0826	.0326	.3582
Why take folic	.1724	.1793	.0069	.1092	-.0326	.3973
How much folic	.1046	.1063	.0017	.0447	.0317	.2103
When to take folic	.3962	.4022	.0059	.1245	.1574	.6464
Total Mediation	.8301	.8449	.0148	.1435	.5555	1.1146

Note. Bootstrap Resample is 5000. Survey Period One (n=549). Dependent variable is *vitamin behavior*. Independent variable is *folic acid awareness*. Level of confidence interval is .95.

The following three variables tested positive for mediation: 1) food sources of folic (CI= .0326, .0582; 95%), 2) how much folic (CI= .0317, .2103; 95%), and 3) when to take folic (CI= .1574, .6464; 95%). When reviewed in combination, total mediation was confirmed (CI = .5555, 1.1146; 95%).

Multiple Mediation Survey Two. Bias-corrected confidence intervals for survey data set one were checked for the inclusion of zero. Two variables, *folic food sources* and *when to take folic,* included zero in the confidence interval. Three variables did not include zero in the bias-corrected confidence intervals. Thus, when reviewed individually, mediation was confirmed for three of five variables on the awareness-behavior relationship using the bootstrapping method. Mediation was confirmed in the following three variables: 1) what is folic (CI= -.2204, -.0037; 95%), 2) why take folic (CI= .0441, .5372; 95%), and 3) how much folic (CI= .0301, .3446; 95%). When reviewed in combination, total mediation was confirmed (CI = .3772, 1.0334; 95%). Table 5.36 presents multiple mediation tests for Survey Two using the bootstrapping method.

Table 5.36. Survey Two Multiple Mediation Bootstrapping Results

	Indirect Effects of Independent Variable on Dependent Variable through Proposed Mediator					
					Bias Corrected And Accelerated Confidence Interval	
Proposed Mediators	Data	Boot	Bias	SE	Lower	Upper
What is folic	-.0849	-.0881	-.0032	.0541	-.2204	-.0037
Folic food sources	.2550	.2587	.0037	.1371	-.0152	.5270
Why take folic	..2648	.2716	.0068	.1254	.0441	.5372
How much folic	.1722	.1772	.0050	.0803	.0301	.3446
When to take folic	.0773	.0722	-.0052	.1270	-.1894	.3118
Total Mediation	.6808	.6952	.0145	.1689	.3772	1.0334

Note. Bootstrap Resample is 5000 with n=405 . Dependent variable is *vitamin behavior*. Independent variable is *folic acid awareness*. Level of confidence interval is .95.

Multiple Mediation Surveys One and Two. Biased corrected confidence intervals for survey data set one were checked for the inclusion of zero. One variable, *what is folic*, included zero in the bias-corrected confidence interval. Four variables did not include zero in the confidence intervals. Thus, when reviewed individually, mediation was confirmed for four of five variables on the awareness-behavior relationship using the bootstrapping method. Mediation was confirmed in the following four variables: 1) food sources of folic (CI= .0956, .3894; 95%), 2) why take folic (CI= .0622, .3764; 95%), 3) how much folic (CI= .0637, .2192; 95%), and 4) when to take folic (CI= .0942, .4243; 95%). When reviewed in combination, total mediation was confirmed (CI = .6059, 1.0240; 95%). Table 5.37 presents multiple mediation tests for Surveys One plus Two using the bootstrapping method.

Table 5.37. Surveys One and Two Multiple Mediation Bootstrapping Results

	Indirect Effects of Independent Variable on Dependent Variable through Proposed Mediator					
					Bias Corrected And Accelerated Confidence Interval	
Proposed Mediators	Data	Boot	Bias	SE	Lower	Upper
What is folic	-.0412	-.0425	.0013	.0272	-.1041	.0038
Folic food sources	.2385	.2400	.0015	.0743	.0956	.3894
Why take folic	.2137	.2172	.0035	.0802	.0622	.3764
How much folic	.1296	.1292	-.0004	.0390	.0637	.2192
When to take folic	.2594	.2621	.0026	.0840	.0942	.4243
Total Mediation	.8000	.8059	.0059	.1072	.6059	1.0240

Note. Bootstrap Resample is 5000 times with n=954. Ten responses were omitted from the analysis, due to missing data. Dependent variable is *vitamin behavior*. Independent variable is *folic acid awareness*. Level of confidence interval is .95.

Correlations

Correlations among two groups of variables were tested using SPSS statistical software for Survey One plus Survey Two. Table 5.38 presents correlation test results for Group One. In Group One, correlations were computed for the variables gender, awareness,

information richness, behavior, barriers, NTD-risk, and adenoma risk. With the exception of the variable adenoma risk, variables of gender, awareness, information richness, behavior, barriers, and NTD-risk were all significantly correlated at the 0.01 level. More specifically, adenoma risk was significantly correlated with variables of awareness, behavior, barriers to behavior, and NTD-risk at the 0.01 level. However, adenoma risk was not significantly correlated with gender or information richness at the 0.01 level.

Table 5.38. Correlations Group One Survey One Plus Survey Two

			1.	2.	3.	4.	5.	6.	7.
1.	Gender	Pearson Correlation	1	.148**	.110**	.150**	.091**	-.217**	.043
		Sig. (2-tailed)		.000	.000	.000	.004	.000	.176
		N	1004	998	1004	992	1004	993	1001
2.	Awareness	Pearson Correlation	.148**	1	.333**	.275**	.239**	.180**	.092**
		Sig. (2-tailed)	.000		.000	.000	.000	.000	.004
		N	998	998	998	987	998	988	995
3.	Info-Richness	Pearson Correlation	.110**	.333**	1	.270**	.275**	.172**	.041
		Sig. (2-tailed)	.000	.000		.000	.000	.000	.193
		N	1004	998	1004	992	1004	993	1001
4.	Behavior	Pearson Correlation	.150**	.275**	.270**	1	.668**	.761**	.292**
		Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
		N	992	987	992	992	992	991	989
5.	Barriers	Pearson Correlation	.091**	.239**	.275**	.668**	1	.540**	.258**
		Sig. (2-tailed)	.004	.000	.000	.000		.000	.000
		N	1004	998	1004	992	1004	993	1001
6.	NTD Risk	Pearson Correlation	-.217**	.180**	.172**	.761**	.540**	1	.228**
		Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
		N	993	988	993	991	993	993	991
7.	Adenoma Risk	Pearson Correlation	.043	.092**	.041	.292**	.258**	.228**	1
		Sig. (2-tailed)	.176	.004	.193	.000	.000	.000	
		N	1001	995	1001	989	1001	991	1001

**Correlation is significant at the 0.01 level (2-tailed).

Correlations were computed for the variables extension affiliation, urban or rural proximity, ethnicity, race, age groups, information richness, NTD-risk, and adenoma.

Table 5.39 presents the correlation test results for group two.

Table 5.39. Correlations Group Two Survey One Plus Survey Two

Variable			1.	2.	3.	4.	5.	6.	7.	8.
1.	Service provider	Pearson Correlation	1	-.272**	.052	.147**	.310**	.118**	.108**	.171**
		Sig. (2-tailed)		.000	.100	.000	.000	.000	.001	.000
		N	1004	1004	996	997	999	1004	993	1001
2.	Proximity	Pearson Correlation	-.272**	1	-.005	.027	.044	.015	.033	.005
		Sig. (2-tailed)	.000		.876	.396	.162	.644	.305	.875
		N	1004	1004	996	997	999	1004	993	1001
3.	Ethnicity	Pearson Correlation	.052	-.005	1	-.032	.079*	.044	.052	.017
		Sig. (2-tailed)	.100	.876		.316	.012	.162	.103	.598
		N	996	996	996	989	991	996	986	993
4.	Race	Pearson Correlation	.147**	.027	-.032	1	.009	-.070*	-.035	-.026
		Sig. (2-tailed)	.000	.396	.316		.775	.026	.267	.417
		N	997	997	989	997	992	997	986	994
5.	Age	Pearson Correlation	.310**	.044	.079*	.009	1	.073*	.351**	.551**
		Sig. (2-tailed)	.000	.162	.012	.775		.022	.000	.000
		N	999	999	991	992	999	999	989	997
6.	Info-richness	Pearson Correlation	.118**	.015	.044	-.070*	.073*	1	.172**	.041
		Sig. (2-tailed)	.000	.644	.162	.026	.022		.000	.193
		N	1004	1004	996	997	999	1004	993	1001
7.	NTD-risk	Pearson Correlation	.108**	.033	.052	-.035	.351**	.172**	1	.228**
		Sig. (2-tailed)	.001	.305	.103	.267	.000	.000		.000
		N	993	993	986	986	989	993	993	991
8.	Adenoma-risk	Pearson Correlation	.171**	.005	.017	-.026	.551**	.041	.228**	1
		Sig. (2-tailed)	.000	.875	.598	.417	.000	.193	.000	
		N	1001	1001	993	994	997	1001	991	1001

** Pearson Correlation is significant at the 0.01 level (2-tailed). * Pearson Correlation is significant at the 0.05 level (2-tailed).

The variable *information richness* was significantly correlated with variables of service provider, race, age groups, NTD-risk at the 0.05 level. The variable *service provider* was significantly correlated with variables of urban/rural proximity, race, age groups, information richness, NTD-risk, and Adenoma risk at the 0.01 level. The variable *NTD-risk* was significantly associated with variables of service provider, age groups, information richness, and adenoma risk at the 0.01 level. The variable *adenoma risk* was significantly correlated with variables of service provider, age groups, and NTD-risk at the 0.01 level.

Epidemiologic Analyses

Awareness and Behavior Stratified by Information Richness

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between awareness and daily folic intake behavior, stratified by information richness and survey period. Table 5.40 presents the results of the Breslow-Day test.

Table 5.40. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	8.920	7	.258

When stratified by survey periods, information richness was not an effect modifier (p-value=.258) of the relationship between awareness and daily folic intake behavior. No significance among hemogeneity was observed, meaning there was no evidence that the odds ratios differed across the survey period stratum. Because the p-value (.258) was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the awareness–behavior relationship, stratified by information richness. Within the aggregated data set, information richness was not an effect modifier ($p = .184$) between the relationship awareness and daily folic intake behavior. Table 5.41 presents the results of the Breslow-Day test for the aggregate data set. No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the information-richness stratum. Because the p-value (.184) was not significant, it was acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Table 5.41. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	4.834	3	.184

Awareness was significantly correlated with behavior for *information-poor females* ($p < 0.05$), while awareness was not significantly correlated with behavior for information-rich females ($p > 0.08$). Tables 5.42 and 5.43 present the test results of statistical significance for awareness and behavior among information rich or poor females.

Table 5.42. Chi-Square Tests of Awareness and Behavior Survey One Plus Two

Gender	Information richness		Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	Information Poor	Pearson Chi-Square	35.899[a]	1	.000		
		Fisher's Exact Test				.000	.000
		N of Valid Cases	452				
	Information Rich	Pearson Chi-Square	3.061[b]	1	.080		
		Fisher's Exact Test				.088	.057
		N of Valid Cases	469				

[a]0 cells (.0%) have expected count less than 5. [b]The minimum expected count is 62.77.

Table 5.43. Symmetric Measures of Awareness and Behavior Survey One Plus Two

Gender	Information richness			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Male	Information Poor	Interval by Interval	Pearson's R	.092	.150	.620	.538[c]
		N of Valid Cases		47			
	Information Rich	Interval by Interval	Pearson's R	.127	.212	.527	.605[c]
		N of Valid Cases		19			
Female	Information Poor	Interval by Interval	Pearson's R	.282	.042	6.231	.000[c]
		N of Valid Cases		452			
	Information Rich	Interval by Interval	Pearson's R	.081	.048	1.752	.080[c]
		N of Valid Cases		469			

[a]Not assuming the null hypothesis. [b]Using the asymptotic standard error assuming the null hypothesis. [c]Based on normal approximation.

Table 5.44 presents the crosstabulation results of awareness and behavior among information-poor female participants. Of the information-poor female respondents, 140 (48.6%) participants had not heard of folic acid and did not take a folic acid supplement every day.

Table 5.44. Crosstabulation Awareness * Behavior * Information Richness * Gender

Gender	Information richness	Awareness		Folic intake behavior: Do not take folic daily	Folic intake behavior: Do take folic daily
Female	Information Poor	Have not heard about folic	Count	140	33
			% within	48.6%	20.1%
		Have heard about folic	Count	148	131
			% within	51.4%	79.9%

Table 5.45 presents the risk estimate for information-poor females. The odds ratios for folic acid awareness and folic acid intake behavior were calculated and verified for *information-poor females* using SPSS statistical software and EPI Info statistical software. Among the information-poor female respondents, the odds of being unaware of folic acid among participants who were at risk for not taking folic acid every day were 3.755 greater than the odds of being unaware of folic among participants who took folic acid every day.

This relationship was statistically significant as the odds ratio was greater than 1, the 95% confidence interval did not include 1, and the p-value is much less than 0.05.

Table 5.45. Risk Estimate for Information Poor Females

			95% Confidence Interval	
Gender		Value	Lower	Upper
Female	Odds Ratio[a]	3.755	2.403	5.867
	Crude Odds Ratio[b]	3.920	2.843	5.404
	N of Valid Cases	927		

[a]Odds ratio calculated in SPSS and EPI Info software programs. [b]Crude odds ratio calculated in EPI Info software program.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.46 presents Mantel-Haenszel OR estimate (2.797) for information-poor females at risk of being unaware about folic acid and at risk for having an NTD-affected pregnancy.

Table 5.46. Mantel-Haenszel Common Odds Ratio Estimate for Information Poor Females

Estimate			2.797
ln(Estimate)			1.029
Std. Error of ln(Estimate)			.173
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.992
		Upper Bound	3.929
	ln(Common Odds Ratio)	Lower Bound	.689
		Upper Bound	1.368

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Confounding is based on a 10% differential between the crude odds ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for awareness and behavior among information-poor females was computed at 3.92, and the adjusted odds ratio was 2.797. The differential of 1.123 (28.65%) was greater than

10 percent and confirmed that information richness was a confounding factor between awareness and behavior among the survey population.

Information Richness and NTD-Risk Stratified by Survey Period

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk, stratified by survey period. Survey period was not an effect modifier (p-value=.956). Table 5.47 presents the results of the Breslow-Day test.

Table 5.47. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	.003	1	.956

No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differ across the survey period stratum. Because the p-value (.956) was larger than .05, it was appropriate to aggregate data sets for Survey One and Survey Two for further analysis. Due to the insignificant p-value (.956), it was also acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding. Tables 5.48 and 5.49 present the test results of statistical significance for information richness and NTD-risk among females. Information richness was significantly correlated with females at risk for having an NTD-affected pregnancy (p-value < 0.05).

Table 5.48. Chi-Square Tests of Information Richness and NTD-Risk

Gender		Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	Pearson Chi-Square	40.020[a]	1	.000		
	Fisher's Exact Test				.000	.000
	N of Valid Cases	927				

[a]0 cells (.0%) have expected count less than 5. The minimum expected count is 194.37.

Table 5.49. Symmetric Measures of Information Richness and NTD-Risk

Gender			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Female	Interval by Interval	Pearson's R	.208	.032	6.460	.000[c]
	N of Valid Cases		927			

[a]Not assuming the null hypothesis. [b]Using the asymptotic standard error assuming the null hypothesis. [c]Based on normal approximation.

Table 5.50 presents the crosstabulation results of information richness and NTD-risk among females surveyed. Of the female respondents, 242 (61.1%) were information poor and were at risk for having an NTD-affected pregnancy.

Table 5.50. Crosstabulation Information Richness * NTD-Risk * Gender

			NTD-risk	
Gender	Information richness		At risk for an NTD-affected pregnancy	Not at risk for an NTD-affected pregnancy
Female	Information Poor	Count	242	213
		% within	61.1%	40.1%
	Information Rich	Count	154	318
		% within	38.9%	59.9%

Table 5.51 presents the risk estimate for information-poor females. Among the female respondents, the odds of being information poor among participants at risk for having an NTD-affected pregnancy were 2.35 greater than the odds of being information poor among females that were not at risk for having an NTD-affected pregnancy (OR=2.35, 95% CI=1.80, 3.06; p=.00). This relationship was statistically significant as the odds ratio was greater than 1, the 95% confidence interval did not include 1, and the p-value was much less than 0.05. The crosstabulation percentages also correspond. Of the female participants, 61.1% were information poor among those at risk for having an NTD-affected pregnancy, compared to 40.1% that were information poor among those not at risk for having an NTD-affected pregnancy.

Table 5.51. Risk Estimate for Information Poor Females at Risk for NTD

Gender		Value	95% Confidence Interval	
			Lower	Upper
Female	Odds Ratio[a]			
	Crude Odds Ratio[b]	2.346	1.798	3.062
	N of Valid Cases	927		

[a]Odds Ratio not computed due to no stratification. [b]Crude Odds Ratio calculated in EPI Info software programs.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.52 presents Mantel-Haenszel OR estimate (2.35) for information-poor females at risk at risk for having an NTD-affected pregnancy. Confounding is based on a 10% differential between the crude odds ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for awareness and behavior among information-poor females was computed at 2.35, and the adjusted odds ratio was 2.25. The differential of .10 (4.25%) was less than 10 percent and confirmed that survey period was not a confounding factor between information richness and NTD-risk among the survey population.

Table 5.52. Mantel-Haenszel Common Odds Ratio Estimate for Information Poor Females

Estimate			2.248
ln(Estimate)			.810
Std. Error of ln(Estimate)			.138
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.715
		Upper Bound	2.947
	ln(Common Odds Ratio)	Lower Bound	.539
		Upper Bound	1.081

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Information Richness and NTD-Risk Stratified by Ethnicity

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by ethnicity and survey period. Table 5.53 presents the results of the Breslow-Day test.

Table 5.53. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	5.170	3	.160

When stratified by survey period, ethnicity was not an effect modifier (p-value=.160) of the relationship between information richness and NTD-risk. No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the survey period stratum. Because the p-value (.160) was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk, stratified by ethnicity. Within the aggregated data set, ethnicity was not an effect modifier (p =.064) was not an effect modifier of the relationship between information richness and NTD-risk among female participants, stratified by ethnicity. Table 5.54 presents the results of the Breslow-Day test for the aggregate data set.

Within the aggregated data set, ethnicity was not an effect modifier (p-value=.064) of the relationship between information richness and NTD-risk. No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the ethnicity stratum. Because the p-value (.064) was not significant, it was

acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Table 5.54. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	3.419	1	.064

Tables 5.55 and 5.56 present the test results of statistical significance for information richness and NTD-risk, stratified by ethnicity. Information richness was significantly correlated with Latino or Hispanic females at risk for having an NTD-affected pregnancy (p-value =.006), and with non-Latino or non-Hispanic females at risk for having an NTD-affected pregnancy (p-value < 0.05).

Table 5.55. Chi-Square Tests for Information Richness and NTD-Risk Stratified by Ethnicity

Gender	Ethnicity		Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	Latino or Hispanic	Pearson Chi-Square	7.463[a]	1	.006		
		Fisher's Exact Test				.018	.011
		N of Valid Cases	21				
	Not Latino or Hispanic	Pearson Chi-Square	34.272[a]	1	.000		
		Fisher's Exact Test				.000	.000
		N of Valid Cases	900				

[a]3 cells (75.0%) have expected count less than 5. The minimum expected count is 3.05. [b]0 cells (.0%) have expected count less than 5. The minimum expected count is 187.60.

Using SPSS and EPI Info statistical software, odds ratios for information-poor females at risk for having an NTD-affected pregnancy were stratified by ethnicity. Table 5.57 presents the crosstabulation for Latino or Hispanic and non-Latino and non-Hispanic females. Of the female respondents, 11 (84.6%) of the females of Latino or Hispanic origin were information poor and at risk for having an NTD-affected pregnancy. In comparison,

231 (60.5%) non-Latino or non-Hispanic females were information poor and at risk for having an NTD-affected pregnancy.

Table 5.56. Symmetric Measures for Information Richness and NTD-Risk Stratified by Ethnicity

Gender	Ethnicity			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Female	Latino or Hispanic	Interval by Interval	Pearson's R	.596	.181	3.237	.004[c]
		N of Valid Cases		21			
	Not Latino or Hispanic	Interval by Interval	Pearson's R	.195	.033	5.962	.000[c]
		N of Valid Cases		900			

[a]Not assuming the null hypothesis. [b]Using the asymptotic standard error assuming the null hypothesis. [c]Based on normal approximation.

Table 5.57. Crosstabulation Information Richness * NTD-Risk * Ethnicity * Gender

Gender				NTD-risk	
	Ethnicity	Information Richness		At risk for having an NTD-affected pregnancy	Not at risk for having an NTD-affected pregnancy
Female	Latino or Hispanic	Information Poor	Count	11	2
			% within	84.6%	25.0%
		Information Rich	Count	2	6
			% within	15.4%	75.0%
	Not Latino or Hispanic	Information Poor	Count	231	211
			% within	60.5%	40.7%
		Information Rich	Count	151	307
			% within	39.5%	59.3%

Table 5.58 presents the risk estimate for information-poor females, stratified by ethnicity. Among the Latino or Hispanic females, the odds of being *information poor* among participants that were at risk for having an NTD-affected pregnancy were 16.50 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=16.50, 95% CI=1.832, 148.606; p=.004). Among the non-Latino or non-Hispanic females, the odds of being *information poor* among

participants that were at risk for having an NTD-affected pregnancy were 2.226 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=2.226, 95% CI=1.699, 2.915; p<.05). These relationships were statically significant as the odds ratio is greater than one, the 95% confidence interval does not include one, and the p-values are much less than 0.05.

Table 5.58. Risk Estimate for Information Richness and NTD-Risk Stratified by Ethnicity

				95% Confidence Interval	
Gender	Ethnicity		Value	Lower	Upper
Female	Latino or Hispanic	Odds Ratio[a]	16.500	1.832	148.606
		N of Valid Cases	21		
	Not Latino or Hispanic	Odds Ratio	2.226	1.699	2.915
		N of Valid Cases	900		
		Crude Odds Ratio[b]	2.343	1.7796	3.0367

[a]Odds ratio calculated in SPSS and EPI Info software programs. [b]Crude odds ratio calculated in EPI Info software program.

The crosstabulation percentages also correspond to the odds ratios. Of the Latino or Hispanic females, 84.6 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 25 percent that were information poor among those not at risk for having an NTD-affected pregnancy. Of the non-Latino or non-Hispanic females, 60.5 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 40.7 percent that were information poor among those not at risk for having an NTD-affected pregnancy.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.59 presents Mantel-Haenszel OR estimate (2.30) for information-poor females at risk of being unaware about folic acid and at risk for having an NTD-affected pregnancy.

Table 5.59. Mantel-Haenszel Common Odds Ratio Estimate for Information Richness and NTD-Risk Stratified by Ethnicity

Estimate			2.302
ln(Estimate)			.834
Std. Error of ln(Estimate)			.136
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.763
		Upper Bound	3.006
	ln(Common Odds Ratio)	Lower Bound	.567
		Upper Bound	1.101

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Confounding is based on a 10% differential between the crude odds ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for information-poor females, stratified by ethnicity, was computed at 2.343, and the adjusted odds ratio was 2.302. The differential of .041 (1.75%) was less than 10 percent, and confirmed that ethnicity was not a confounding factor between information richness and NTD-risk among the survey population.

Information Richness and NTD-Risk Stratified by Race

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by race and survey period. Table 5.60 presents the results of the Breslow-Day test.

Table 5.60. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	.138	3	.987

When stratified by survey period, race was not an effect modifier (p-value=.987). No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the survey period stratum. Because the p-value (.987) was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by race. Table 5.61 presents the results of the Breslow-Day test for the aggregate data set.

Table 5.61. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	.348	1	.555

Within the aggregate data set, race was not an effect modifier (p-value=.555) of the relationship between information richness and NTD-risk. No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the race stratum. Because the p-value (.555) was not significant, it was acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Tables 5.62 and 5.63 present the test results of statistical significance for information richness and NTD-risk among white and nonwhite females. Information richness was significantly correlated with white females at risk for having an NTD-affected pregnancy (p-value < 0.05), and with non-white females at risk for having an NTD-affected pregnancy (p-value < 0.05).

Table 5.62. Chi-Square Tests for Information Richness and NTD-Risk Stratified by Race

Gender	Race		Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	White	Pearson Chi-Square	30.344[a]	1	.000		
		Fisher's Exact Test				.000	.000
		N of Valid Cases	788				
	Non-white	Pearson Chi-Square	8.251[a]	1	.004		
		Fisher's Exact Test				.005	.003
		N of Valid Cases	927				

[a]0 cells (.0%) have expected count less than 5. The minimum expected count is 156.92. [b]0 cells (.0%) have expected count less than 5. The minimum expected count is 27.15.

Table 5.63. Symmetric Measures for Information Richness and NTD-Risk Stratified by Race

Gender	Race			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Female	White	Interval by Interval	Pearson's R	.196	.035	5.611	.000[c]
		N of Valid Cases		788			
	Non-white	Interval by Interval	Pearson's R	.250	.084	2.944	.004[c]
		N of Valid Cases		132			

[a]Not assuming the null hypothesis. [b]Using the asymptotic standard error assuming the null hypothesis. [c]Based on normal approximation.

Using SPSS and EPI Info statistical software, odds ratios for information-poor females at risk for having an NTD-affected pregnancy were stratified by race. Table 5.64 presents the crosstabulation for white and non-white females. Of the white female respondents, 195 (59.5%) were information poor and at risk for having an NTD-affected pregnancy. In comparison, there were 45 (70.3%) non-white females that were information poor and at risk for having an NTD-affected pregnancy.

Table 5.64. Crosstabulation for Information Richness * NTD-Risk* Race * Gender

Gender	Race	Information richness		NTD-risk: At risk for an NTD-affected pregnancy	NTD-risk: Not at risk for an NTD-affected pregnancy
Female	White	Information Poor	Count	195	182
			% within	59.5%	39.6%
		Information Rich	Count	133	278
			% within	40.5%	60.4%
	Non-white	Information Poor	Count	45	31
			% within	70.3%	45.6%
		Information Rich	Count	19	37
			% within	29.7%	54.4%

Table 5.65 presents the risk estimate for information-poor, white and non-white females at risk for having an NTD-affected pregnancy. Among the white female respondents, the odds of being *information poor* among participants that were at risk for having an NTD-affected pregnancy were 2.24 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=2.24, 95% CI=1.68, 2.99; $p<.05$).

Table 5.65. Risk Estimate for Information Richness Stratified by Race

Gender	Race		Value	95% Confidence Interval: Lower	95% Confidence Interval: Upper
Female	White	Odds Ratio[a]	2.240	1.677	2.990
		N of Valid Cases	788		
	Non-white	Odds Ratio[a]	2.827	1.379	5.795
		N of Valid Cases	132		
		Crude Odds Ratio[b]	2.335	1.7872	3.0510

[a]Odds Ratio calculated in SPSS and EPI Info software programs. [b]Crude Odds Ratio calculated in EPI Info software program.

This relationship was statistically significant as the odds ratio was greater than 1, the 95% confidence interval did not include 1, and the p-value was much less than 0.05.

The crosstabulation percentages also correspond to the odds ratios. Of the white female respondents, 59.5% percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 39.6 percent that were information poor among those not at risk for having an NTD-affected pregnancy.

Among the non-white female respondents, the odds of being *information poor* among participants that were at risk for having an NTD-affected pregnancy were 2.83 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=2.83, 95% CI=1.38, 5.80; p=.004). This relationship was statistically significant as the odds ratio was greater than 1, the 95% confidence interval did not include 1, and the p-value was much less than 0.05. The crosstabulation percentages also correspond to the odds ratio. Of the non-white female respondents, 70.3 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 45.6 percent that were information poor among those not at risk.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.66 presents Mantel-Haenszel OR estimate (2.314) of being information poor and at risk for having an NTD-affected pregnancy. Confounding is based on a 10% differential between the crude odds ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for information-poor females at risk for having an NTD-affected pregnancy was computed at 2.335, and the adjusted odds ratio was 2.314. A differential of .021 (0.89%) was less than 10 percent and confirmed that race was not a confounding factor between information richness and NTD-risk in the survey population.

Table 5.66. Mantel-Haenszel Common Odds Ratio Estimate for Information Richness and NTD-Risk Stratified by Race

Estimate			2.314
ln(Estimate)			.839
Std. Error of ln(Estimate)			.137
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.770
		Upper Bound	3.025
	ln(Common Odds Ratio)	Lower Bound	.571
		Upper Bound	1.107

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Information Richness and NTD-Risk, Stratified by Urban-Rural Proximity

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by urban-rural proximity and survey period. Table 5.67 presents the results of the Breslow-Day test.

Table 5.67. Tests of Homogeneity of the Odds Ratio

	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	.173	1	.982

When stratified by survey period, urban-rural proximity was not an effect modifier (p-value=.982). No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the survey period stratum. Because the p-value (.982) was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk

among female participants, stratified by rural-urban proximity. Table 5.68 presents the results of the Breslow-Day test for the aggregate data set.

Table 5.68.Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	.035	1	.852

Within the aggregate data set, rural-urban proximity was not an effect modifier (p-value=.852). No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the regional proximity stratum. Because the p-value (.852) was not significant, it was acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Tables 5.69 and 5.70 present the test results of statistical significance of information richness and NTD-risk, stratified by rural-urban proximity of surveyed females. Information richness was significantly correlated with NTD-risk among females residing in rural (p-value = .001) and urban (p-value < .05) regions.

Table 5.69. Chi-Square Tests of Information Richness and NTD-Risk Stratified by Rural-Urban Proximity

Gender	Proximity		Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	Rural	Pearson Chi-Square	10.181[a]	1	.001		
		Fisher's Exact Test				.002	.001
		N of Valid Cases	210				
	Urban	Pearson Chi-Square	29.704[a]	1	.000		
		Fisher's Exact Test				.000	.000
		N of Valid Cases	717				

[a]0 cells (.0%) have expected count less than 5. The minimum expected count is 48.53. [b]0 cells (.0%) have expected count less than 5. The minimum expected count is 145.05.

Table 5.70. Symmetric Measures of Information Richness and NTD-Risk Stratified by Rural-Urban Proximity

Gender	Proximity			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Female	Rural	Interval by Interval	Pearson's R	.220	.067	3.255	.001[c]
		N of Valid Cases		210			
	Urban	Interval by Interval	Pearson's R	.204	.037	5.559	.000[c]
		N of Valid Cases		717			

[a]Not assuming the null hypothesis. [b]Using the asymptotic standard error assuming the null hypothesis. [c]Based on normal approximation.

Using SPSS and EPI Info statistical software, odds ratios for information-poor females at risk for having an NTD-affected pregnancy were stratified by urban-rural proximity. Table 5.71 presents the crosstabulation for rural and urban females. Of the rural female respondents, 61 (62.2%) were information poor and at risk for having an NTD-affected pregnancy. In comparison, 181 (60.7%) of the information-poor females residing in urban areas, were at risk for having an NTD-affected pregnancy.

Table 5.71. Crosstabulation for Information Richness * NTD-Risk * Rural-Urban Proximity * Gender

				NTD-risk	
Gender	Proximity	Information Richness		At risk for NTD-affected pregnancy	Not at risk for NTD-affected pregnancy
Female	Rural	Information Poor	Count	61	45
			% within	62.2%	40.2%
		Information Rich	Count	37	67
			% within	37.8%	59.8%
	Urban	Information Poor	Count	181	168
			% within	60.7%	40.1%
		Information Rich	Count	117	251
			% within	39.3%	59.9%

Table 5.72 presents the risk estimates for information-poor females, stratified by rural-urban proximity. Among the rural females, the odds of being information poor among participants that were at risk for having an NTD-affected pregnancy were 2.46 greater than the odds of being information poor among rural females that were not at risk for having an NTD-affected pregnancy (OR=2.46 , 95% CI=1.407, 4.282; p=.001). Among the urban females, the odds of being information poor among participants that were at risk for having an NTD-affected pregnancy were 2.31 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=2.31; 95% CI=1.699, 2.915; p<.05). These relationships were statistically significant as the odds ratio were greater than one, the 95% confidence intervals did not include one, and the p-values were much less than 0.05.

Table 5.72. Risk Estimate for Information Richness and NTD-Risk Stratified by Rural-Urban Proximity

				95% Confidence Interval	
Gender	Proximity		Value	Lower	Upper
Female	Rural	Odds Ratio[a]	2.455	1.407	4.282
		N of Valid Cases	210		
	Urban	Odds Ratio for	2.311	1.706	3.131
		N of Valid Cases	717		
		Crude Odds Ratio[b]	2.34	1.7975	3.062

[a]Odds Ratio calculated in SPSS and EPI Info software programs. [b]Crude Odds Ratio calculated in EPI Info software program.

The crosstabulation percentages also correspond to the odds ratios. Of the rural females, 62.2 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 40.2 percent that were information poor among those not at risk for having an NTD-affected pregnancy. Of the urban females, 60.7 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to

40.1 percent that were information poor among those not at risk for having an NTD-affected pregnancy.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.73 presents Mantel-Haenszel OR estimate (2.343) for urban and rural females being information poor and at risk for having an NTD-affected pregnancy.

Table 5.73. Mantel-Haenszel Common Odds Ratio Estimate and Information Richness and NTD-Risk Stratified by Rural-Urban Proximity

Estimate			2.343
ln(Estimate)			.852
Std. Error of ln(Estimate)			.136
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.795
		Upper Bound	3.059
	ln(Common Odds Ratio)	Lower Bound	.585
		Upper Bound	1.118

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Confounding is based on a 10% differential between the crude odds ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for information-poor females at risk for having an NTD-affected pregnancy was computed at 2.34, and the adjusted odds ratio was 2.34. A differential of zero was less than 10 percent and confirmed that rural-urban proximity was not a confounding factor between information richness and NTD-risk in the survey population.

Information Richness and NTD-Risk Stratified by Region

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between

information richness and NTD-risk among female participants, stratified by region and survey period. Table 5.74 presents the results of the Breslow-Day test.

Table 5.74. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	12.101	14	.598

When stratified by survey period, regional proximity was not an effect modifier (p-value=.598). No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the survey period stratum. Because the p-value (.598) was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by regional proximity. Table 5.75 presents the results of the Breslow-Day test for the aggregate data set. Within the aggregate data set, regional proximity was not an effect modifier (p-value=.264). No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the regional proximity stratum. Because the p-value (.264) was not significant, it was acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Table 5.75. Tests of Homogeneity of the Odds Ratio

	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	8.849	7	.264

Table 5.76 and 5.77 present the test results of statistical significance of information richness and NTD-risk, stratified by regional proximity of surveyed females. Information richness was significantly correlated with NTD-risk among Regions 4, 5, and 6.

Table 5.76. Chi-Square Tests for Information Richness and NTD-Risk Stratified by Region

Gender	Region		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	Region 1	Pearson Chi-Square	.009[a]	1	.924		
		N of Valid Cases	43				
	Region 2	Pearson Chi-Square	2.635[b]	1	.105		
		N of Valid Cases	265				
	Region 3	Pearson Chi-Square	2.435[c]	1	.119		
		N of Valid Cases	69				
	Region 4	Pearson Chi-Square	6.684[d]	1	.010		
		N of Valid Cases	48				
	Region 5	Pearson Chi-Square	16.036[e]	1	.000		
		N of Valid Cases	233				
	Region 6	Pearson Chi-Square	8.748[f]	1	.003		
		N of Valid Cases	86				
	Region 7	Pearson Chi-Square	2.635[g]	1	.105		
		N of Valid Cases	171				
	Region 8	Pearson Chi-Square	2.000[h]	1	.157		
		Fisher's Exact Test				.236	.236
		N of Valid Cases	12				

[a]0 cells (.0%) have expected count less than 5. The minimum expected count is 5.86.[b]0 cells (.0%) have expected count less than 5. The minimum expected count is 31.06. [c]0 cells (.0%) have expected count less than 5. The minimum expected count is 15.77. [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.54. [e]0 cells (.0%) have expected count less than 5. The minimum expected count is 45.92. [f]0 cells (.0%) have expected count less than 5. The minimum expected count is 16.28. [g]0 cells (.0%) have expected count less than 5. The minimum expected count is 29.11. [h]3 cells (75.0%) have expected count less than 5. The minimum expected count is 1.00.

Using SPSS and EPI Info statistical software, odds ratios for information females at risk for having an NTD-affected pregnancy were stratified by region. Table 5.78 presents the cross tabulation for females in Regions 4, 5, and 6.

Table 5.77. Symmetric Measures for Information Richness and NTD-Risk Stratified by Region

Gender	Ethnicity			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Female	Region 1	Interval by Interval	Pearson's R	-.014	.153	-.093	.927[d]
		N of Valid Cases		43			
	Region 2	Interval by Interval	Pearson's R	.100	.062	1.625	.105[d]
		N of Valid Cases		265			
	Region 3	Interval by Interval	Pearson's R	.188	.118	1.566	.122[d]
		N of Valid Cases		69			
	Region 4	Interval by Interval	Pearson's R	.373	.134	2.728	.009[d]
		N of Valid Cases		48			
	Region 5	Interval by Interval	Pearson's R	.262	.063	4.132	.000[d]
		N of Valid Cases		233			
	Region 6	Interval by Interval	Pearson's R	.319	.103	3.084	.003[d]
		N of Valid Cases		86			
	Region 7	Interval by Interval	Pearson's R	.124	.075	1.626	.106[d]
		N of Valid Cases		171			
	Region 8	Interval by Interval	Pearson's R	.408	.284	1.414	.188[d]
		N of Valid Cases		12			

[a]No statistics are computed because AT_RISK_NTD is a constant. [b]Not assuming the null hypothesis. [c]Using the asymptotic standard error assuming the null hypothesis. [d]Based on normal approximation.

Of the female respondents in Region 4, 18 (72%) were information poor and at risk for having an NTD-affected pregnancy. In comparison, 87 (69%) of the females in Region 5 were information poor and at risk for having an NTD-affected pregnancy. In review of Region 6, 34 (66.7%) of the females were considered information poor and at risk for having an NTD-affected pregnancy.

Table 5.78. Crosstabulation Information Richness * NTD-Risk * Region * Gender

Gender	Region	Information Richness		NTD-Risk: At risk for an NTD-affected pregnancy	NTD-Risk: Not at risk for an NTD-affected pregnancy
Female	Region 4	Information Poor	Count	18	8
			% within	72.0%	34.8%
		Information Rich	Count	7	15
			% within	28.0%	65.2%
	Region 5	Information Poor	Count	87	46
			% within	69.0%	43.0%
		Information Rich	Count	39	61
			% within	31.0%	57.0%
	Region 6	Information Poor	Count	34	12
			% within	66.7%	34.3%
		Information Rich	Count	17	23
			% within	33.3%	65.7%

Table 5.79 presents the risk estimate for information-poor females at risk for having an NTD-affected pregnancy in Regions 4, 5, and 6. Among the female respondents in Region 4, the odds of being *information poor* among participants at risk for having an NTD-affected pregnancy were 4.821 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR 4.82, 95% CI=1.418, 16.399; $p < .010$). Among the female respondents in Region 5, the odds of being *information poor* among participants at risk for having an NTD-affected pregnancy were 2.958 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR 2.958, 95% CI=1.728, 5.065; $p < .05$). Among the female respondents in Region 6, the odds of being *information poor* among participants at risk for having an NTD-affected pregnancy were 3.833 greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR 3.833, 95% CI=1.545, 9.513; $p < .05$).

Table 5.79. Risk Estimate for Information Richness and NTD-Risk Stratified by Region

Gender		Value	95% Confidence Interval Lower		Upper
Female	ND Region 4	Odds Ratio[a]	4.821	1.418	16.399
		N of Valid Cases	48		
	ND Region 5	Odds Ratio[a]	2.958	1.728	5.065
		N of Valid Cases	233		
	ND Region 6	Odds Ratio[a]	3.833	1.545	9.513
		N of Valid Cases	86		
		Crude Odds Ratio[b]	2.346	1.7975	3.062

[a]Odds ratio calculated in SPSS and EPI Info software programs. [b]Crude odds ratio calculated in EPI Info software program.

These relationships were statistically significant as the odds ratios were greater than one, the 95% confidence intervals do not include one, and the p-values are much less than 0.05. The crosstabulation percentages also correspond to the odds ratios. Of the females in Region 4, 72 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 34.8 percent that were information poor among those not at risk for having an NTD-affected pregnancy. Of the females in Region 5, 69 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 34.8 percent that were information poor among those not at risk for having an NTD-affected pregnancy. Of the females in Region 6, 66.7 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 34.3 percent that were information poor among those not at risk for having an NTD-affected pregnancy.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.80 presents the Mantel-Haenszel OR estimate (2.192) of information-poor females at risk for having an NTD-affected pregnancy, within regions 4, 5, and 6. Confounding is based on a 10% differential between the crude odds

ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for information-poor females at risk for having an NTD-affected pregnancy was computed at 2.346, and the adjusted odds ratio was 2.192. The differential of .154 (6.56%) was less than 10 percent and confirmed that region was not a confounding factor between information richness and NTD-risk among the survey population.

Table 5.80. Mantel-Haenszel Common Odds Ratio Estimate for Information Richness and NTD-Risk Stratified by Region

Estimate			2.192
ln(Estimate)			.785
Std. Error of ln(Estimate)			.139
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.669
		Upper Bound	2.879
	Ln(Common Odds Ratio)	Lower Bound	.512
		Upper Bound	1.057

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Information Richness and NTD-Risk Stratified by Information Service Provider

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among females, stratified by information service provider and survey period. Table 5.81 presents the results of the Breslow-Day test.

Table 5.81. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	4.944	3	.176

When stratified by survey period, information service provider was not an effect modifier (p-value =.176) of the relationship between information richness and NTD-risk. No significance among homogeneity was observed meaning there was no evidence that the

odds ratios differed across the survey period stratum. Because the p-value (.176) was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among females, stratified by information service provider. Table 5.82 presents the results of the Breslow-Day test for the aggregated data set. Within the aggregate data set, information service provider was not an effect modifier (p-value =.076) of the relationship between information richness and NTD-risk. No significance among homogeneity was observed meaning there was no evidence that the odds ratios differed across the information service provider stratum. Because the p-value (.076) was not significant, it was acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Table 5.82. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	3.145	1	.076

Tables 5.83 and 5.84 present the test results of statistical significance for information richness and NTD-risk among female clients of service providers. Information richness was significantly correlated with NTD-risk among clients of non-extension service providers ($p<.05$), and was significantly correlated among clients of extension service providers ($p=.012$).

Table 5.83. Chi-Square Tests for Information Richness and NTD-Risk Stratified by Service Provider

Gender	Service provider		Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	Non-extension	Pearson Chi-Square	32.463[a]	1	.000		
		Fisher's Exact Test				.000	.000
		N of Valid Cases	528				
	Extension	Pearson Chi-Square	6.344[a]	1	.012		
		Fisher's Exact Test				.015	.008
		N of Valid Cases	927				

[a]0 cells (.0%) have expected count less than 5. The minimum expected count is 114.57. [b]0 cells (.0%) have expected count less than 5. The minimum expected count is 61.05.

Table 5.84. Symmetric Measures for Information Richness and NTD-Risk Stratified by Service Provider

Gender	Service provider		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Female	Non-extension	Interval by Interval Pearson's R	.248	.042	5.870	.000[c]
		N of Valid Cases	528			
	Extension	Interval by Interval Pearson's R	.126	.050	2.533	.012[c]
		N of Valid Cases	399			

[a]Not assuming the null hypothesis. [b]Using the asymptotic standard error assuming the null hypothesis. [c]Based on normal approximation.

Using SPSS and EPI Info statistical software, odds ratios for information-poor females at risk for having an NTD-affected pregnancy were stratified by service provider. Table 5.85 presents the crosstabulation for extension and non-extension female clients. Of the female respondents, 169 (67.3%) female clients of non-extension service providers were at risk for having an NTD-affected pregnancy. In comparison, there were 73 (50.3%) female clients of extension service providers at risk for having an NTD-affected pregnancy. Table 5.86 presents the risk estimate for information-poor females at risk for having an NTD-affected pregnancy among service providers. Among the non-extension clients, the odds of being *information poor* among participants at risk for having an NTD-affected

pregnancy were 2.78 greater than the odds of being information poor among non-extension clients that were not at risk (OR=2.78, 95% CI=1.946, 2.99; p<.05). Among the extension clients, the odds of being information poor among participants at risk for having an NTD-affected pregnancy were 1.697 greater than the odds of being information poor among extension clients that were not at risk for having an NTD-affected pregnancy (OR=1.70, 95% CI=1.123, 2.565; p=.012).

Table 5.85. Crosstabulation for Information Richness * NTD-Risk * Service Provider * Gender

				NTD-risk	
Gender	Service provider	Information richness		At risk for an NTD-affected pregnancy	Not at risk for an NTD-affected pregnancy
Female	Non-extension	Information Poor	Count	169	118
			% within	67.3%	42.6%
		Information Rich	Count	82	159
			% within	32.7%	57.4%
	Extension	Information Poor	Count	73	95
			% within	50.3%	37.4%
		Information Rich	Count	72	159
			% within	49.7%	62.6%

Table 5.86. Risk Estimate for Information Poor Females at Risk for Having an NTD-Affected Pregnancy Stratified by Service Provider Affiliation

Gender	Service provider		Value	95% Confidence Interval Lower	Upper
Female	No extension	Odds Ratio[a]	2.777	1.946	3.962
		N of Valid Cases	528		
	Extension	Odds Ratio[a]	1.697	1.123	2.565
		N of Valid Cases	399		
		Crude Odds Ratio[b]	2.346	1.798	3.062

[a]Odds Ratio calculated in SPSS and EPI Info software programs. [b]Crude Odds Ratio calculated in EPI Info software program.

These relationships were statistically significant as the odds ratios were greater than 1, the 95% confidence interval did not include 1, and the p-values were much less than 0.05. The cross tabulation percentages also correspond to the odds ratios. Of the non-extension clients, 67.3 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 42.6 percent that were information poor and not at risk for having an NTD-affected pregnancy. Of the extension clients, 50.3 percent were information poor among those at risk for having an NTD-affected pregnancy, compared to 37.4 percent that were information poor and not at risk for having an NTD-affected pregnancy.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.87 presents the Mantel-Haenszel OR estimate (2.255) of service providers being information poor and at risk for having an NTD-affected pregnancy.

Table 5.87. Mantel-Haenszel Common Odds Ratio Estimate for Information Richness and NTD-Risk Stratified by Service Provider

Estimate			2.255
ln(Estimate)			.813
Std. Error of ln(Estimate)			.137
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.725
		Upper Bound	2.948
	ln(Common Odds Ratio)	Lower Bound	.545
		Upper Bound	1.081

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

Confounding is based on a 10% differential between the crude odds ratio and an adjusted odds ratio. Using SPSS and EPI Info statistical software, the crude odds ratio for

information-poor females at risk for having an NTD-affected pregnancy was computed at 2.346, and the adjusted odds ratio was 2.255. The differential of .091 (3.87%) was less than 10 percent, and confirmed that extension agency was not a confounding factor between information richness and NTD-risk among the survey population.

Information Richness and NTD-Risk Stratified by Age Group

Using SPSS statistical software, the Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by age groups and survey period. Table 5.88 presents the results of the Breslow-Day test.

Table 5.88. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	5.371	7	.615

When stratified by survey period, age group was not an effect modifier (p-value =.615). No significance among homogeneity was observed, meaning there was no evidence that the odds ratios differed across the survey period stratum. Because the p-value .615 was larger than .05, it was appropriate to aggregate data sets Survey One and Survey Two for further analysis.

The Breslow-Day test for homogeneity of odds ratios was used to compare the degrees of difference seen in the relationship between information richness and NTD-risk among female participants, stratified by age groups. Table 5.89 presents the results of the Breslow-Day test for the aggregate data set. Within the aggregate data set, age group was an effect modifier (p-value=.049). Significance among homogeneity was observed, meaning there was evidence that the odds ratios differed across the age group stratum.

Because the p-value (.049) was significant, it was not acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding.

Table 5.89. Tests of Homogeneity of the Odds Ratio

Test	Chi-Squared	Df	Asymp. Sig. (2-sided)
Breslow-Day	7.880	3	.049

Tables 5.90 and 5.91 present the test results of statistical significance for information richness and NTD-risk among females of various age groups. Information richness was significantly correlated with NTD-risk for the age groups 18-25 years ($p<.05$) and 26-33 years ($p<.05$). Information richness was not significantly correlated with NTD-risk for the age groups 34-41 years ($p=.205$) and 42-49 years ($p=.608$).

Table 5.90. Chi-Square Tests for Information Richness and NTD-Risk Stratified by Age

Gender	Age		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Female	18-25 years	Pearson Chi-Square	35.496[b]	1	.000		
		Fisher's Exact Test				.000	.000
		N of Valid Cases	427				
	26-33 years	Pearson Chi-Square	9.516[c]	1	.002		
		Fisher's Exact Test				.003	.002
		N of Valid Cases	198				
	34-41 years	Pearson Chi-Square	1.608[d]	1	.205		
		Fisher's Exact Test				.216	.145
		N of Valid Cases	106				
	42-49 years	Pearson Chi-Square	.263[e]	1	.608		
		Fisher's Exact Test				.785	.405
		N of Valid Cases	65				
	50+ years	Pearson Chi-Square	.[a]				
		N of Valid Cases	127				

[a]No statistics are computed because NTD-risk is a constant. [b]0 cells (.0%) have expected count less than 5. The minimum expected count is 75.03. [c]0 cells (.0%) have expected count less than 5. The minimum expected count is 31.64. [d]0 cells (.0%) have expected count less than 5. The minimum expected count is 13.98. [e]0 cells (.0%) have expected count less than 5. The minimum expected count is 9.06.

Table 5.91. Symmetric Measures for Information Richness and NTD-Risk Stratified by Age

Gender	Age groups			Value	Asymp. Std. Error[a]	Approx. T[c]	Approx. Sig.
Female	18-25 years	Interval by Interval	Pearson's R	.288	.047	6.208	.000[d]
		N of Valid Cases		427			
	26-33 years	Interval by Interval	Pearson's R	.219	.070	3.146	.002[d]
		N of Valid Cases		198			
	34-41 years	Interval by Interval	Pearson's R	.123	.098	1.266	.209[d]
		N of Valid Cases		106			
	42-49 years	Interval by Interval	Pearson's R	-.064	.124	-.505	.615[d]
		N of Valid Cases		65			
	50+ years	Interval by Interval	Pearson's R	.[a]			
		N of Valid Cases		127			

[a]No statistics are computed because NTD-Risk is a constant. [b]Not assuming the null hypothesis. [c]Using the asymptotic standard error assuming the null hypothesis. [d]Based on normal approximation.

Using SPSS and EPI Info statistical software, odds ratios for information-poor females at risk for having an NTD-affected pregnancy were stratified by age. Table 5.92 presents the crosstabulations for females between 18 and 33 years. Of the females between the ages of 18 and 25 years, 174 (69.6%) were information poor and at risk for having an NTD-affected pregnancy. In comparison, there were 42 (48.3%) information-poor females between the ages of 26 and 33 years at risk for having an NTD-affected pregnancy. Table 5.93 presents the risk estimates for information-poor females aged 18 through 33 years, at risk for having an NTD-affected pregnancy.

Among the females between aged 18 through 25 years, the odds of being information poor among participants that were at risk for having an NTD-affected pregnancy were 3.34 times greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=3.34, 95% CI=2.231, 4.997; $p<.05$). Among the females aged 26 through 33 years, the odds of being

information poor among participants that were at risk for having an NTD-affected pregnancy were 2.52 times greater than the odds of being information poor among participants that were not at risk for having an NTD-affected pregnancy (OR=2.52, 95% CI=1.392, 4.562; p<.05).

Table 5.92. Crosstabulation for Information Richness * NTD-Risk * Age * Gender

				NTD-risk	
Gender	Age	Information richness		At risk for an NTD-affected pregnancy	Not at risk for an NTD-affected pregnancy
Female	18-25 years	Information Poor	Count	174	72
			% within	69.6%	40.7%
		Information Rich	Count	76	105
			% within	30.4%	59.3%
	26-33 years	Information Poor	Count	42	30
			% within	48.3%	27.0%
		Information Rich	Count	45	81
			% within	51.7%	73.0%

Table 5.93. Risk Estimate for Information Richness and NTD-Risk Stratified by Age

				95% Confidence Interval	
Gender	Age		Value	Lower	Upper
Female	18-25 years	Odds Ratio[a]	3.339	2.231	4.997
		N of Valid Cases	427		
	26-33 years	Odds Ratio[a]	2.520	1.392	4.562
		N of Valid Cases	198		
		Crude Odds Ratio[b]	2.7039	2.0301	3.6011

[a]Odds ratio calculated in SPSS and EPI Info software programs. [b]Crude odds ratio calculated in EPI Info software program.

These relationships were statistically significant as the odds ratios (3.34, 2.52) were greater than one, the 95% confidence intervals did not include one, and the p-value were much less than 0.05. The crosstabulation percentages also correspond to the odds ratios. Of the females aged 18 through 25 years, 69.6 percent were information poor among those at

risk for having an NTD-affected pregnancy, compared to 40.7 percent that were information poor among those not at risk for having an NTD-affected pregnancy.

The Mantel-Haenszel method was used to calculate the stratified adjusted odds ratio with test-based confidence limits. Table 5.94 presents the Mantel-Haenszel OR estimate (2.524) of information-poor females at risk for having an NTD-affected pregnancy, ranging in age from 18 through 33 years.

Table 5.94. Mantel-Haenszel Common Odds Ratio Estimate for Information Richness and NTD-Risk Stratified by Age

Estimate			2.524
ln(Estimate)			.926
Std. Error of ln(Estimate)			.150
Asymp. Sig. (2-sided)			.000
Asymp. 95% Confidence Interval	Common Odds Ratio	Lower Bound	1.881
		Upper Bound	3.385
	ln(Common Odds Ratio)	Lower Bound	.632
		Upper Bound	1.219

Note. The Mantel-Haenszel common odds ratio estimate is asymptotically normally distributed under the common odds ratio of 1.000 assumption. So is the natural log of the estimate.

When it is inappropriate to use a summary odds ratio, confounding is based on a 10 % differential between the cross product odds ratio and the adjusted odds ratio. Using SPSS and EPI Info statistical software, the cross product odds ratio for information-poor females between 18 and 25 years, and at risk for having an NTD-affected pregnancy was computed at 3.34, and the adjusted odds ratio was 2.524. The differential of .816 (32.33%) was greater than 10 percent, and confirmed that age was a confounding factor between information richness and NTD-risk among females between 18 and 25 years of age.

Using SPSS and EPI Info statistical software, the cross product odds ratio for information-poor females between 26 and 33 years, and at risk for having an NTD-affected

pregnancy was computed at 2.52, and the adjusted odds ratio was 2.524. The differential of .004 (.15%) was less than 10 percent, and confirmed that age was not a confounding between information richness and NTD-risk among females between 26 and 33 years of age.

North Dakota NTD Prevalence Rates

Live birth data and NTD-prevalence rates for North Dakota were provided by Carmell Barth, an analyst at the North Dakota Department of Health Division and Vital Records. Table 5.95 presents the number of live births using pooled data for the years 2006 through 2008.

Table 5.95. Number of Live Births for Years 2006 Through 2008

Year	Number of live births in North Dakota
2006	8616
2007	8818
2008	8931
Total Pooled Live Births (2006-2008)	26365

Data Source: North Dakota Department of Health Division of Vital Records (Barth, personal communication, December 2, 2009).

Table 5.96 presents the number of anencephaly and spina bifida cases and prevalence rates using pooled data for the years 2006 through 2008.

Table 5.96. NTD Prevalence Rates for Years 2006 Through 2008

Defects	North Dakota[b] cases	North Dakota[b] birth prevalence[a]
Anencephalus	9	.341
Spina bifida without Anencephalus	8	.303

[a]per 1,000 live births. [b]ND pooled data from birth years 2006-2008. Data Source: North Dakota Department of Health Division of Vital Records (Barth, personal communication, December 2, 2009)

Attributable Fractions

Based on pooled data for years 2006 through 2008, the North Dakota prevalence rates for anencephaly and spina bifida per 1,000 live births were respectively .341and .303.

The number of respondents for the combined data set (Survey One plus Survey Two) was approximately 1,000. From results extracted from the combined data set (Survey One plus Survey Two), an odds ratio of 2.35 was calculated for information-poor females who were at risk for having an NTD-affected pregnancy. The computed odds ratio of 2.35 was used to approximate the risk ratio, a figure that was necessary for calculating an Attributable Fraction (AF). In turn, the AF was statistically combined with the available North Dakota NTD prevalence rates in order to compute the population Attributable Fraction (AFp). The survey data sets have been successfully linked to the North Dakota NTD prevalence rates, through odds ratios computations related to information richness.

Table 5.97 presents the computed ratios and fractions for the survey population. Based on the calculated AFp for anencephaly (.228), we can infer that 22.8% of the anencephaly birth defects occurring in the North Dakota population can be attributed to information poorness. Based on the calculated AFp for spina bifida (.285), we can infer that 28.5% of the spina bifida birth defects occurring in the North Dakota population can be attributed to information poorness.

Table 5.97. Computed Ratios and Fractions for the Survey Population

NTD	Odds Ratio (OR)[a]	Attributable Fraction (AF)[b]	Prevalence[c]	Population Attributable Fraction (AFp)[d]
Anencephaly	2.35	0.574	.22	.228[e]
Spina Bifida	2.35	0.574	.538	.285[e]

Note. AF = (OR-1) / OR . AFp = p(OR-1) / p(OR-1)+1. [e]Figure is calculated per 1000 live births.

Summary

This chapter presented the results of the data analysis for Surveys One and Two. In order to reveal variations in results, data were analyzed using descriptive, aggregate and differential analyses. Without conducting proper tests of homogeneity, data might have

been inappropriately portioned. This chapter demonstrated that data runs the risk of being inappropriately partitioned, if thorough testing is not conducted. Inappropriately partitioned data sets can present findings that lead to less accurate conclusions.

DISCUSSION

In Chapter One, two questions pertaining to study design and data analysis were raised. How can these diffusion research limitations be properly addressed and overcome in a study design? How can improvements be made to the way in which data are gathered and analyzed in diffusion studies? In order to address these questions, a statewide folic acid campaign strategy was designed and used to test a new diffusion model's potential to overcome past diffusion research shortcomings. As demonstrated in chapters four and five, specific procedures and methods were incorporated into the present study in order to improve the way that data are handled and analyzed. The seven hypotheses proposed in Chapter Three will be discussed in the current chapter.

Overview of Study

The purpose of this study was to advance Rogers' conceptual paradigm of diffusion. In order to advance the conceptual paradigm of diffusion, the existing model and potential shortcomings of previous research were investigated. In the literature review, shortcomings to diffusion research were presented as: (1) lack of consequence research, (2) change agent tendencies, (3) pro-innovation bias, and (4) research methods. In order to address diffusion shortcomings, Rogers (2003) presented the following recommendations: (1) investigate the effects of innovation adoption (p. 440), (2) encourage contact initiation from change agents to disadvantaged individuals (p. 383), (3) recognize and clarify any pro-innovation bias (pp. 106-107), and (4) incorporate alternative methods in the study design that will shed the pro-innovation bias in order to avoid misrepresentation of findings (p. 107).

Rogers' (2003) diffusion model and his recommendations were incorporated into the development of a new and complex diffusion model. Additionally, the new model incorporated gap analysis paradigm of Tichenor and colleagues (1970). Taken together, diffusion and gap analysis offered a useful theoretical framework through which to ascertain an understanding of change among individuals, following the diffusion of an innovation among publics.

In the present study, the integration of these two conceptual frameworks into the new diffusion model provided a richer foundation through which to evaluate how individuals understand the USPHS recommendation, and differences in levels of awareness and understanding of the communicated message contributed to knowledge-based gaps. Thus, the extended model was tested through the application of a statewide folic acid campaign that aimed to improve levels of awareness, knowledge and behavior related to folic acid and NTD-prevention among multiple publics.

Consequence Research

Rogers (2003) pointed out that very little consequences research exists in the diffusion field (pp. 96-97) because consequences are difficult to measure (p. 441), and most past diffusion research has stopped with the analysis of a decision to adopt a new idea, ignoring the consequences related to choice (p. 440). Instead of limiting investigations to variables related to innovativeness, an extension to diffusion research includes investigations that target the effects of adopting an innovation. Thus, future studies need to uncover effects of adopting an innovation (Rogers, 2003, p. 440).

In order to address lack of consequence research, the current study incorporated a statewide preventative campaign aimed at reducing the prevalence of NTDs. The campaign

established three objectives through which to measure campaign effectiveness. The statewide campaign was modeled after the NCFA *Ready or Not* campaign and targeted women of childbearing age. The investigation sought to ascertain the number of women of childbearing age who reported taking a folic acid containing supplement every day. For women of childbearing age, the effects (consequences) of the decision to reject daily consumption (behavior) of a folic acid containing supplement (innovation) were measured by the NTD-risk related to folic acid consumption. Women of childbearing age who did not take a daily folic acid containing supplement were at risk for having an NTD-affected pregnancy. In contrast, women who did take a folic acid containing supplement every day, reduced their risk for having an NTD-affected pregnancy by up to 70 percent (CDC, 1992, CDC, 1998a). Thus, a direct consequence of vitamin consumption among women of childbearing age is their risk level for having an NTD-affected pregnancy.

Although the adoption of the daily consumption of folic acid containing supplements are scientifically shown to be beneficial in preventing NTDs, or promoting cardiovascular health, "closer analysis might identify certain disadvantages that accompany the advantages for some adopters" (Rogers, 2003, p. 111). For example, individuals over the age of 50 years who consume folic acid containing supplements on a daily basis may be at greater risk for developing colorectal adenomas that can become cancerous over time. As such, the direct and indirect, desirable and undesirable, anticipated and unanticipated consequences related to daily folic acid intake behavior will vary among publics. In the present study, data analysis could be stratified by gender, age, and daily folic acid intake behavior in order to reveal publics at risk, resulting from the decision to adopt or reject the behavior of consuming a daily supplement containing folic acid.

Change Agent Tendencies

Rogers (2003) pointed out that change agents tend to direct innovation promotion efforts toward socioeconomic elites, rather than individuals of lower status (p. 456). In order to address this change agent tendency that typically widens the socioeconomic gap and decreases equality in the social system, a variety of information service providers were recruited on the basis that they would focus their education intervention efforts to include individuals considered disadvantaged or hard-to-reach. The three types of different information service providers included agents from Extension food and nutrition, WIC agencies, and public health.

> Seldom is it implied in diffusion research publications that a source or the channel of innovations might be at fault for not providing more adequate information, for promoting inappropriate innovations, or for failing to contact less educated members of an audience who may especially need a change agent's help (Rogers, 2003, p. 121).

Thus, in the present study, in order to overcome shortcomings of past diffusion research, change agent tendencies were addressed in the design setup. Channel of impact was evaluated through a process of data stratification. For example, the levels of information richness among clients were aggregately and differentially measured, after controlling for the information service provider variable.

Pro-innovation Bias

Considered one of the most serious of diffusion research shortcomings, new diffusion studies that differ from the past are needed in order to shed the pro-innovation bias (Rogers, 2003, p. 112). If unsuccessful innovation studies exist, they are difficult to

find and read about. We know far more about innovation success than we do about innovation failures (Rogers, 2003, p. 111), and diffusion publications of successful innovations can influence the rate of adoption that are retroactively studied by diffusion scholars (p. 110). One way to shed this pro-innovation bias is to investigate the impact of the channel or the source of an innovation and seek to publish studies of unsuccessful innovations.

Much diffusion research that is funded by change agencies will include a pro-innovation bias. In order to address the change agency pro-innovation bias that is inherent with change agencies, additional funding was requested from sources beyond the NCFA. In order to address the potential bias of funding and support typically associated with Extension, this study additionally incorporated unfunded information service providers from WIC and public health. Although funding was provided to one United States Extension specialist for the purpose of covering material acquisition and message dissemination, in the current study the NCFA and medical foundation (change agencies) did not dictate the campaign's implementation strategies or message distribution channels. The NCFA identifies the population of interest as women of reproductive age. The current study's education intervention was not limited to the NCFA recommended target population. Study results indicate the inclusion of both males and females, ranging in age from 18 to 80 years.

Another way to shed the innovation bias is to investigate the innovation-decision process through the eyes of the potential adopters (Rogers, 2003, p. 116). One way to view the perspectives of potential adopters is to ask them to report why they decide to adopt or reject an innovation. In order to shed the pro-innovation bias, Rogers (2003) posited that

investigators need to question the assumption that an innovation is advantageous for all adopters, and instead gather data about how individuals perceive the innovation (p. 116). In this study, the folic acid campaign's emphasis was on educating the public about the need to consume a daily supplement containing folic acid. Thus, in the present study, respondents who rejected daily supplement consumption were asked to provide reasons behind their decision. Rogers (2003) pointed out that investigations including "why" questions about adoption are seldom probed and therefore, little is known about the reasons behind an individual's innovation-decision process (p. 115).

Research Methods

Cross-sectional survey designs are limited in scope. They are unable to reveal data that answer the "why" questions related to the adoption or rejection process, and do not tell us much about the broader issue of causality. One way to shed the pro-innovation bias typical of past diffusion research designs is to incorporate alternative methods into a study. Alternative methods for the data gathering process are: (1) field experiments, (2) longitudinal studies, (3) use of archival records, and (4) case studies of the innovation process (Rogers, 2003, p. 127). Alternative methods may better reveal data related to an individual's innovation-decision process, that often remain undiscovered in one-shot survey designs. Rogers (2003) suggested that greater use of field experiments should be made in diffusion research (p. 129).

Thus, in order to incorporate an alternative method for this study for the purpose of addressing pro-innovation bias, a field experiment was conducted, with the control established as type of *information service provider*. In order to address the weakness of a one-shot survey design, the current study incorporated data collection at two different

points. During the current study, data were gathered before and after an intervention, among multiple publics. Rogers (2003) posited that field experiments are ideally suited for assessing the effect of various independent variables on a dependent variable (p. 128).

Rogers (2003) clarified that variance research is appropriate for investigating variables, such as those related to innovativeness, but cannot probe the time-related element of the innovation-decision process (p. 196). A highly structured quantitative gathering of data and variance analysis was incorporated into the new model, in order to investigate both communication and scientific effects related to diffusing a preventative innovation. Thus, the focus of this study excluded the element of time associated with the innovation-decision process. Rather the focus of this study was to explore the individual's level of level of knowledge, level of information richness, whether an innovation was rejected or adopted, reasons for rejecting an innovation, and the health risk associated with the adoption or rejection behavior.

Linear relationships were clearly defined in the model and prompted the need to incorporate a variety of statistical analyses. The extended model incorporated tests of causal approach. "The pro-innovation bias in diffusion research, and the overwhelming reliance on correlational analysis of survey data, often led in the past to avoiding or ignoring the issue of causality among the variables in the study" (Rogers, 2003, p. 128). Mediation among single and multiple variables were tested through processes of causal approach and bootstrapping.

Measures were added to the model in order to determine the most appropriate way to partition data sets for analysis. More specifically, tests of homogeneity were utilized to determine how best to partition data for aggregate and differential analyses. Tests of

confounding and modification effects were incorporated into the model through stratification in order to determine interaction. Procedures were added to the model in order to quantify communication based risk estimates among publics. Communication-based risk estimates were attributed to the prevalence of neural tube birth defects. Thus, the extended model was used aggregately and differentially to measure communication and scientific effects, while quantifying a communication-based risk estimate of NTDs.

The ability to overcome past diffusion research limitations, presented an opportunity to create a new and improved diffusion model. The developing model is presented in six stages. The six stages conclude that an extension to diffusion results when previous shortcomings are addressed and data are appropriately partitioned and analyzed using a combination of statistical and epidemiologic procedures. Hypotheses One through Seven are addressed in greater detail through the following six stages of model development.

Stage One Model Development

Rogers (2003) identified five stages within the innovation-decision process as: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, (5) confirmation (p. 170) and defines three types of knowledge within the knowledge stage as: (1) awareness-knowledge, (2) how-to knowledge, and (3) principles-knowledge (p. 173). Within the knowledge stage, awareness and understanding are a positioned as merged process, with little differentiation between the two. Rogers (2003) posited that "knowledge occurs when an individual (or other decision-making unit) is exposed to an innovation's existence and gains an *understanding* of how it functions" (p. 169). Thus, individuals must pass through each type of knowledge in order to complete the knowledge stage. For example, in the

awareness-knowledge stage individuals might seek answers to questions such as "What is folic acid?" and "Where is folic acid found?" or "What are some sources of folic acid?" In the how-to knowledge stage, individuals might seek answers to the questions "How much folic acid is needed for women of childbearing age?" and "When should folic be consumed by women of reproductive age?" In the principles-knowledge stage, individuals might seek answers to the question "Why is folic acid needed for childbearing-aged females?" However, knowledge is different from awareness.

Awareness

In the present study, a variance approach positions *awareness* and *level of understanding* as distinct and measureable variables. An individual's awareness to an innovation, such as a folic acid message, results from exposure. An individual needs to develop a level of understanding of the message, in order to act upon the message recommendation. Sellnow et al. (2009) reminded us that simple exposure to information does not translate into understanding (p. 9). A measurement of exposure stops short of understanding how an individual interprets, understands, and responds to a message. For example, an individual may be aware of folic acid's existence, yet not know what it is, where it's found, how much is needed, who needs it, or how it functions. Thus, in the developed model, awareness was considered a precedent to an individual's ability to understand an innovation. A survey question such as "Have you ever heard, read or seen anything about folic acid or folate?" was asked to assess an individual's basic level of awareness of folic acid.

Overall in the present study, folic acid awareness increased to 76.1 percent from Survey One to Survey Two among females following the statewide education intervention

(up 0.2%). Campaign objective number one stated: following the intervention, folic acid awareness among female participants will increase to at least 50 percent. Therefore, following the intervention, the campaign's first objective was measureable and achieved (76.1% > 50%).

In order to demonstrate the richness of partitioned data, the variable *awareness* was categorized according to self-reported recall of message sources. Of the females reporting folic acid awareness (76.1%), approximately 46 percent were able to recall between one and three folic acid message sources, 19.8 percent were able to recall between four and six folic acid message sources, 8.1 percent were able to recall at least seven folic acid message sources. These measures would not be revealed if data were not partitioned into differential categories of source recall levels.

Level of Understanding

Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use (Rogers, 2003, p. 257). For some ideas, complexity presents a barrier to adoption. If the public health folic acid recommendation is too complicated to understand, many females of childbearing age will not understand the relationship between folic acid intake and neural tube defects. Complexity may discourage the adoption of the public health recommendation by individuals who feel confused. The public health folic acid recommendation includes five areas related to folic acid knowledge. In order to fully understand the public health recommendation, women need to know: 1) what folic acid is; 2) where it is found; 3) why it is recommended to women of childbearing age; 4) how much is recommended daily; and 5) when folic acid should be taken during childbearing age.

Rogers (2003) pointed out that only a small number of diffusion investigations have included field experiments where variables of knowledge, attitudes and rate of adoption (K-A-P) are analyzed between benchmark and follow-up surveys (p. 72). Making a distinction between variables of awareness and knowledge presents an opportunity to evaluate in greater depth, an individual's level of understanding regarding an innovation. The level of understanding of the USPHS folic acid recommendation may vary from individual to individual. For example, some may know what folic acid is, but do not know where to find it. Others may know what it is, and where to find it, but do not know how much is needed on a daily basis. In the present study, in order to measure *level of understanding* among individuals, the first step was to evaluate, for correctness, their responses to five questions pertaining to folic acid facts.

Following the intervention, of the female respondents, 67.3 percent were able to correctly identify folic acid as a vitamin (up 16%), 12 percent were able to correctly identify five food sources of folic acid (up 10.3%), 79.2 percent were able to identify the relationship between folic acid and NTD-prevention (up 9.5%), 45.2 percent were able to identify the daily recommendation of 400 mcg (up 16.9%), and 44 percent knew that folic acid should be taken every day (13.9%). It was helpful to evaluate responses to each folic acid related question so that specific gaps in knowledge could be more precisely determined. Doing so, allows an opportunity to modify a campaign strategy for the purpose of addressing knowledge gaps while the diffusion process is ongoing. Figure 6.1 presents Stage One of the developing model, where *awareness* and *understanding* are positioned as distinct variables, and level of understanding is further partitioned by survey questions.

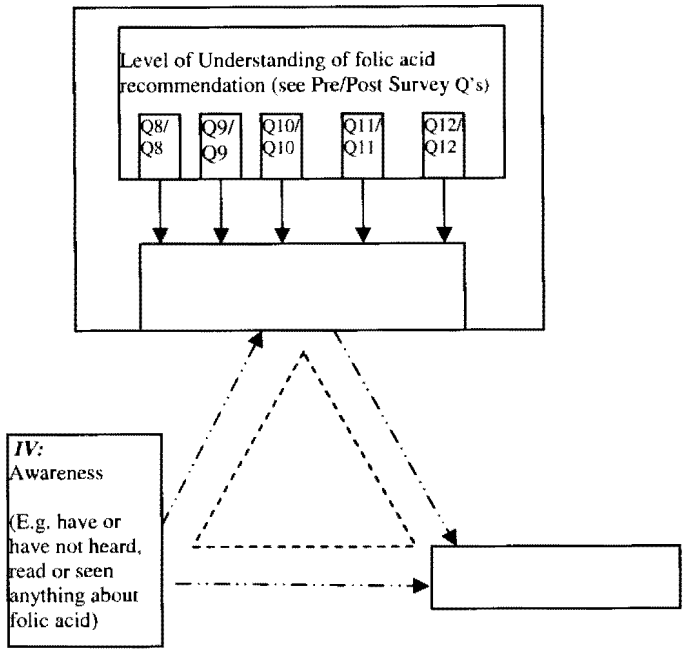

Figure 6.1. Stage One awareness and level of understanding.

Stage Two Model Development

Behavior and Barriers

Preventative innovations have a slower rate of adoption because individuals have difficulty perceiving a nonevent that may or may not occur if the innovation is adopted (Rogers, 2003, p. 176). For example, the delayed consequence of having an NTD-affected pregnancy that results from taking folic acid now, is difficult for some women to perceive and comprehend, because it represents a nonevent. In family planning programs, KAP surveys often find a "K-A-P-gap," with a relatively high percentage of knowledge (K) increase and favorable attitudes (A) toward family planning methods, but a relatively low rate of adoption (P) (Rogers, 2003, p. 70).

In the present study, following the intervention, 58.6 percent of the surveyed females reported taking a folic acid supplement every day (up 15.2%). The campaign's third objective stated: Following the intervention, self-reported folic acid intake through

supplementation among female participants will be greater than 25 percent. Therefore, folic acid intake behavior among women of childbearing age increased beyond 25 percent and the campaign's third objective was measureable and achieved. One explanation for this increase in vitamin consumption may be the reported reduction in the number of females perceiving barriers to vitamin intake. Self-reported perceived barriers to daily vitamin intake dropped to 50.9 percent (down 14.7%), following the education intervention. Figure 6.2 presents Stage Two of the model development with the addition of vitamin behavior and barriers to vitamin intake.

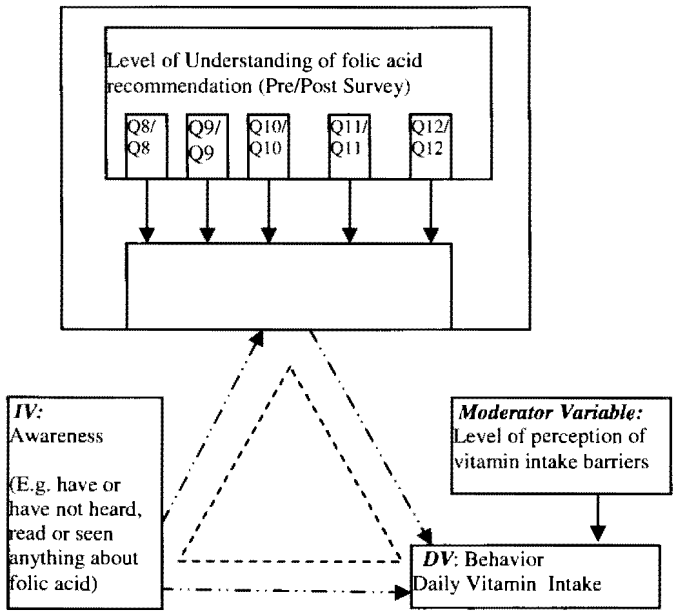

Figure 6.2. Stage Two with the addition of daily vitamin consumption and barriers to daily vitamin consumption.

Stage Three Model Development

Level of Information Richness

As Rogers (2003) pointed out, "diffusion of innovation generally causes wider socioeconomic gaps among publics" (p. 457). In the present study, communication effects can be classified as a consequence of the innovation, education intervention. Although

diffusion of an innovation usually decreases the degree of equality in a social system, this tendency need not occur if steps are taken to narrow a gap (Rogers, 2003, p. 457). However, before steps can be taken to narrow a (knowledge) gap, the gap must first be recognized and appropriately measured. In the new model, there are four steps necessary in order to assess communication effects that occur among publics.

The first two steps pertain to evaluating individual scores of survey responses by participants. In the present study, the first step was to ascertain an individual's level of understanding of the five survey questions related to folic acid facts. This was calculated by scoring the individual's five answers for correctness. Step two required the formation of a composite score of the correctness of five survey questions related to folic acid facts, for each individual. Using a formula scoring method proposed by Thurston (1919) and Holzinger (1924), a composite score was created to ascertain an individual's level of information richness pertaining to the USPHS folic acid recommendation. The information-richness score served to quantify communication effects on an individual level. The evaluation of information richness set the stage to test the seven hypotheses of the present study.

Steps three and four pertained to quantifying communication effects from a survey population perspective. Information- richness scores of all survey respondents were analyzed and partitioned into quartiles. At the midpoint, the information rich were separated from the information poor and the communication effect of the survey population was revealed. Figure 6.3 presents Stage Three of the developing model, where level of information richness is incorporated.

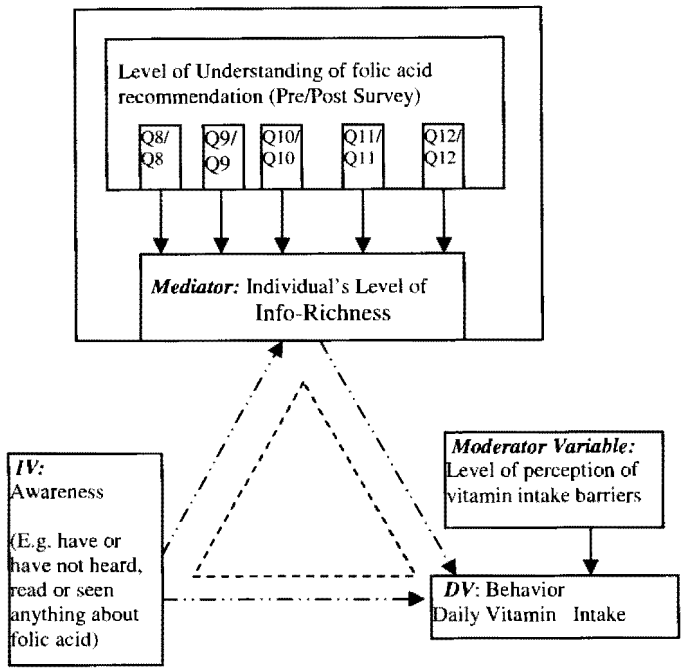

Figure 6.3. Stage Three with the addition of information richness.

Stage Four Model Development

Simpson's Paradox

When data has limited sample size, meaningful adverse impact analyses can be conducted by aggregating the data across variables such as time periods, locations, or groups. One needs to be cognizant of Simpson's Paradox when partitioning and aggregating data (Simpson, 1951, p. 238). Simpson's Paradox (1951) is concerned with the improper aggregation of data just for the sake of increasing sample. A Breslow-Day statistical test result can be calculated in order to determine when it is appropriate to combine data for analysis purposes.

Gap Paradigm

Diffusion research defines two areas of communication effects. In the first dimension, changes in knowledge, attitudes, and overt behavior are often explored, as investigators assess the average change among an audience or population (Rogers, 2003, p. 457). In the second dimension, differential changes are measured within an audience or population and investigators ascertain the equality of communication effects. Using the gap paradigm proposed by Tichenor and collegues (1970), data are collected at multiple points in time, before and after an intervention (Rogers, 2003, p. 460) in order to reveal who are impacted most, and who are impacted least. Gap analysis was used to test Hypotheses One.

H1: The percentage of information-poor females will not decrease following an educational intervention that promotes the USPHS folic acid recommendation.

H1a: The percentage of information-poor females will decrease following an educational intervention that promotes the USPHS folic acid recommendation.

In order to demonstrate dimension one analysis, information richness was investigated for aggregate effects. In the present study, information-rich females increased to 62.5 percent following the intervention (up 19.8%), and the null hypothesis (H1) was rejected. Additionally, campaign objective two stated: following the intervention, folic acid knowledge among female participants will increase to at least 50 percent. Therefore, objective number two of the campaign was measurable and achieved (62.5%>50%).

In order to demonstrate dimension two, information richness was investigated for differential effects. Following the education intervention, of the females surveyed, the number of information-poor white females dropped by 15.6 percent, information-poor black females dropped by 0.3 percent, information-poor Asians dropped by .8 percent,

information-poor Native Americans dropped by 3.3 percent, and the number of information-poor Native Hawaiians increased by 0.2 percent. Using differential analysis, the number of information-poor females changed the most among white females.

In contrast, differential analysis was conducted by collapsing the data set of female participants into race categories of white and non-white. Following the education intervention, the percentage of information-poor white females dropped by 15.6 percent, and the percentage of information-poor non-white females dropped by 5.9 percent. Using this particular form of differential analysis among information-poor females, the increase in information-poor Native Hawaiians becomes undetectable.

The following differential analysis was used to test Hypothesis Two.

H2: Extension service providers will not have a smaller percentage of information-poor female clients than will non extension service providers, following an education intervention.

H2a: Extension service providers will have a smaller percentage of information-poor female clients than will non extension service providers, following an intervention.

Information richness was stratified by information service provider and evaluated for differential effects. Following the education intervention, of the females surveyed, the percentage of information-poor females among extension clients decreased by 8.3 percent from Survey One (21.5%) to Survey Two (13.2%). In comparison, the percentage of information-poor females among non-extension clients decreased by 11.4 percent from Survey One (35.7%) to Survey Two (24.3%). Although extension information service providers had the smallest percentage of information-poor female clients, it was the non-

extension service providers who experienced the greatest decrease in the percentage of information-poor female clients. However, because the extension service providers had fewer information-poor female clients (13.2%) than did non-extension service providers (24.3%) following the folic acid intervention, the null hypothesis (H2) was rejected. This analysis demonstrates how variations in conclusions that are drawn are dependent on how data are partitioned and interpreted.

In an additional example, information richness was stratified by age and evaluated for differential effects. Following the education intervention, Survey Two revealed that the age group of information-poor females most affected were between 18 and 25 years of age, and the group least affected were between ages of 26 and 33 years. Had the age groups been aggregated into an information-rich and information-poor dichotomy, the differential results would not have been as revealing. In sum, data will yield different results when partitioned aggregately or differentially and it is critical to understand when it is appropriate to collapse a data set because variations in conclusions will be drawn. Figure 6.4 presents Stage Four of the developing model with the addition of communication effects.

Stage Five Model Development

Simple Mediation

The aim of the current research project was to investigate folic acid awareness, attitudes and overt behaviors among North Dakotans using a mediator approach. Mediator variables account for the relation between the predictor and criterion. Baron and Kenny (1986) argued the necessary execution of three analytic steps to fully test a mediation hypothesis.

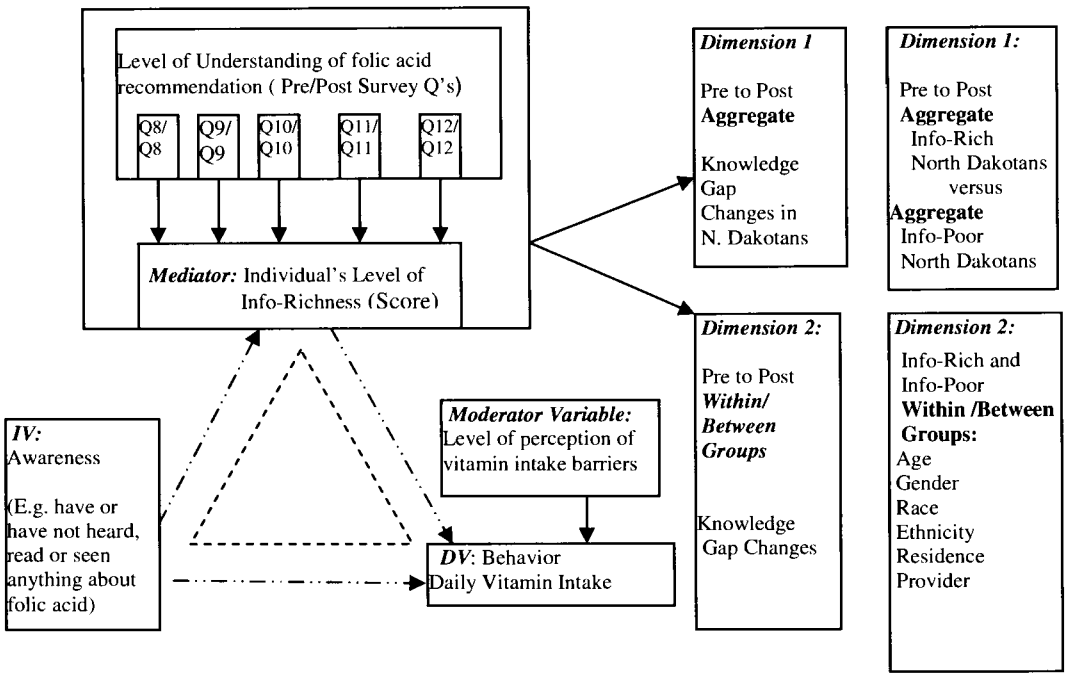

Figure 6.4. Stage Four communication effects.

To establish mediation, the following steps must be executed: (1) regress the dependent variable on the independent variable, finding a significant relation; (2) regress the mediator on the independent variable, finding a significant relation; (3) regress the dependent variable on the independent variable and the mediator, finding a weakened effect of the independent variable (Baron & Kenny, 1986, p. 1177). Because the statistical tests themselves do not indicate causal direction, investigators must have theoretical assumptions of the causal relations between variables (Malhotra & Kronsick, 2007, p. 253).

Recent meditation analysis advancements have focused on relaxing parametric assumptions to better estimate the confidence interval associated with the mediating effect (MacKinnon, Lockwood, & Williams, 2004; Shrout & Bolger, 2002). However, the key to thoroughly assessing mediation is to assess explicitly assess whether the mediator variance shared with the independent variable is also shared with the dependent variable through structure modeling and path analysis, Thus, meditational analysis employs specific analytic

steps to explicitly test for conditions that must be obtained to test the validity of hypotheses positing indirect causal effects (Malhotra & Kronsick, 2007, p. 254).

In the present study, information richness was significantly correlated with the relationship between awareness and behavior ($p < .01$). Additionally, an individual's level of information richness was believed to be a mediating factor between the folic acid awareness-behavior relationship. Tests of mediation were performed to test Hypothesis Three.

H3: Information richness will not mediate the relationship between awareness and behavior.

H3a: Information richness will mediate the relationship between awareness and behavior.

Using Baron & Kenny's (1986) approach, mediation effects of information richness were computed individually for data set one (Survey One), and data set two (Survey Two). Additionally, mediation was assessed for differential change between the two periods. The mediating effect of information richness (0.07) was significant at the .05 level for Survey Two, which reflected a decrease from Survey One (down 0.01). When data sets were merged and tested on an aggregate level, the indirect effect of mediation (0.05) remained significant at the .05 level. Mediation of information richness on the awareness-behavior relationship was additionally confirmed differentially and aggregately using the bootstrapping method.

Multiple Mediation

In order to test the multiplicity of intervening variables, a more modern approach is warranted to investigate multiple mediation of the relationship between the independent

and dependent variables. In order to determine whether there is more than one variable that might mediate a relationship, a complex process of multiple mediation, called *bootstrapping* is required. Due to the complexity of multiple mediation analysis, a statistical software macro developed by Preacher and Hayes (2008) can be used to test variables for intervening effects.

The bootstrapping method was used to analyze the specific and total indirect effects of the present study's sampling distribution. In order to determine which of the five variables of folic acid knowledge were responsible for mediating effects, tests of multiple mediation were performed. This method factored all of the variables of interest into the resampling process at the same time, and provided confidence intervals for each potential mediator. As with differential analysis, the separation of mediating variables provided far richer data as one can pinpoint more specifically where the mediation is taking place among variables of interest. For example, in a test of two mediating variables, one variable may reflect mediation while another does not, thus cancelling each other out, which leads to a conclusion of no mediation. However, in the present study, a closer look at each potential mediator indicated that mediation was present among several variables. Therefore through the bootstrapping method of multiple mediation, the indirect effects were assessed for each variable and more accurate conclusions were drawn.

Survey One. A mediating effect, of the five folic acid knowledge variables, was tested for Survey One data using the bootstrapping method. Of the five variables, three were found to be mediating factors of the awareness-behavior relationship. Individually, mediation was confirmed for variables: food sources of folic, how much folic, and when to take folic. Although mediation was confirmed for the five variables when assessed in

combination, differential analysis revealed the two of the five variables did not reflect a mediating effect when assessed individually.

Survey Two. In comparison, a mediating effect, of the five folic acid knowledge variables, was tested for Survey Two data using the bootstrapping method. Of the five variables, three were found to be mediating factors on the awareness-behavior relationship. In Survey Two, mediation was confirmed among variables: what is folic, why take folic, and how much folic to take. Although mediation was confirmed for the five variables when assessed in combination, differential analysis revealed that two of the five variables did not reflect a mediating effect when assessed individually.

Survey One and Survey Two. A mediating effect, of the five knowledge variables, was tested for an aggregated data set (Survey One plus Survey Two) using the bootstrapping method. Of the five variables, four were found to be mediating factors on the awareness-behavior relationship. Mediation was not confirmed on the variable *what is folic* when the five variables were assessed individually. However, total mediation was confirmed when the five variables were assessed in combination.

In conclusion, tests of simple and multiple mediation confirmed that information richness was a mediating factor in the folic acid awareness-behavior relationship. Thus, the null hypothesis (H3) was rejected. Figure 6.5 presents Stage Five of the developing model with the addition of the mediation process.

Stage Six Model Development

Neural Tube Birth Defect Risk Assessment

In the present study, individuals were assessed for two different risks, based on age and vitamin consumption patterns. Females were categorized as being at risk for having an

NTD-affected pregnancy when two conditions were met. First, the female had to be within childbearing age, which for the present study was determined to be between the ages of 18 and 49 years.

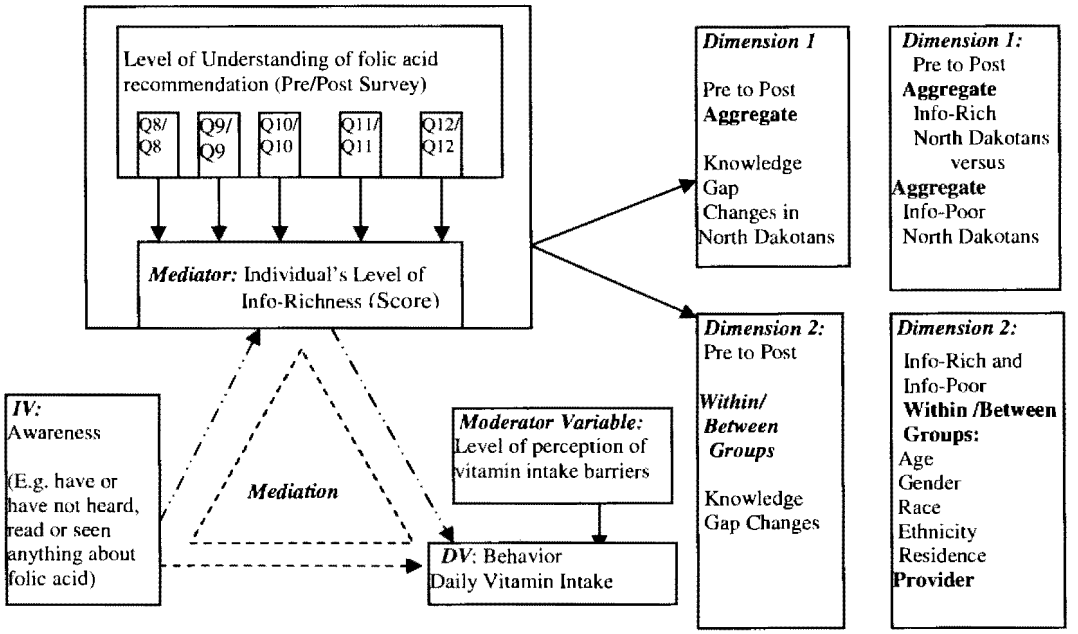

Figure 6.5. Stage Five mediation process.

As an example of partitioned data, female survey participants could have been considered at risk for having an NTD-affected pregnancy based only on the criteria "within childbearing age." However, the data would not have been as revealing, without the added correlation of vitamin intake behavior. Rather, the data results would have been exaggerated due to an inclusion of all females between the age of 18 and 49 years, regardless of vitamin behavior. In this example, females between the ages of 18 and 49 years who were taking a daily vitamin should not have been considered at risk.

In another example of partitioned data, females simply could have been considered at risk for having an NTD-affected pregnancy based only on the criteria vitamin intake behavior. Female survey participants who were not taking a daily vitamin would have been

categorized as being at risk for having an NTD-pregnancy. However, the data would not have been as revealing, without the added correlation of childbearing age. Rather, the data results for females at risk would have been exaggerated due to an inclusion of all surveyed females who did not take a daily vitamin containing folic acid, regardless of age. In this example, females 50 years and older were not considered of childbearing age, and should not have been considered at risk.

Colorectal Adenoma Risk Assessment

Males and females were categorized as being at risk for developing a colorectal adenoma when two conditions were met. First, the individual had to be at least 50 years of age and second, had to be consuming a daily folic acid-containing supplement. Research indicates that both males and females are at risk for developing a colorectal adenoma, when they reach the age of 50 years, and the consumption of daily folic acid may be an additional risk factor.

As an example of partitioned data, survey participants could have been considered at risk for developing a colorectal adenoma based only on the criteria "50 years and older." However, the data would not have been as revealing, without the added correlation of vitamin intake behavior. Rather, the data results would have been exaggerated due to an inclusion of all participants at least 50 years old, regardless of vitamin behavior. In this example, males and females at least 50 years of age who were not taking a daily vitamin containing folic acid should not have been considered at risk.

In another example of partitioned data, males and females simply could have been considered at risk for developing a colorectal adenoma based only on the criterion vitamin intake behavior. Survey participants who were taking a daily vitamin would have been

categorized as being at risk for developing a colorectal adenoma. However, the data would not have been as revealing, without the added correlation of age. Rather, the data results for males and females at risk would have been exaggerated due to an inclusion of all surveyed individuals who were taking a daily vitamin containing folic acid, regardless of age. In this example, males and females younger than 50 years of age who were taking a daily vitamin containing folic acid were yet at risk for developing a colorectal adenoma and should not have been considered at risk. Figure 6.6 presents Stage Six of the developing model with the addition of the risk assessment.

Epidemiologic Evaluation

Causal Inference

Epidemiology is concerned with the study of disease and the exposing factors that influence the outcome of disease. For example, epidemiologic research has confirmed the influence of folic acid intake on neural tube birth defects. Research findings indicate a strength of association between timely and adequate folic acid intake levels and the prevalence of NTDs (CDC, 1992). Because epidemiologic research focuses on the influence of exposure on disease (or outcome), epidemiologic approaches were incorporated into the present study in order to investigate the influence of communication effects (exposure) on NTD-risk (outcome) among women of childbearing age. More specifically, in the present study, information richness was positioned as the exposure and NTD-risk was positioned as the outcome.

Strength of Association. Determining how relative a specific factor is in the development of an outcome or disease may be difficult. Therefore, measuring the *strength of association* between a specific factor and an outcome allows its importance to be

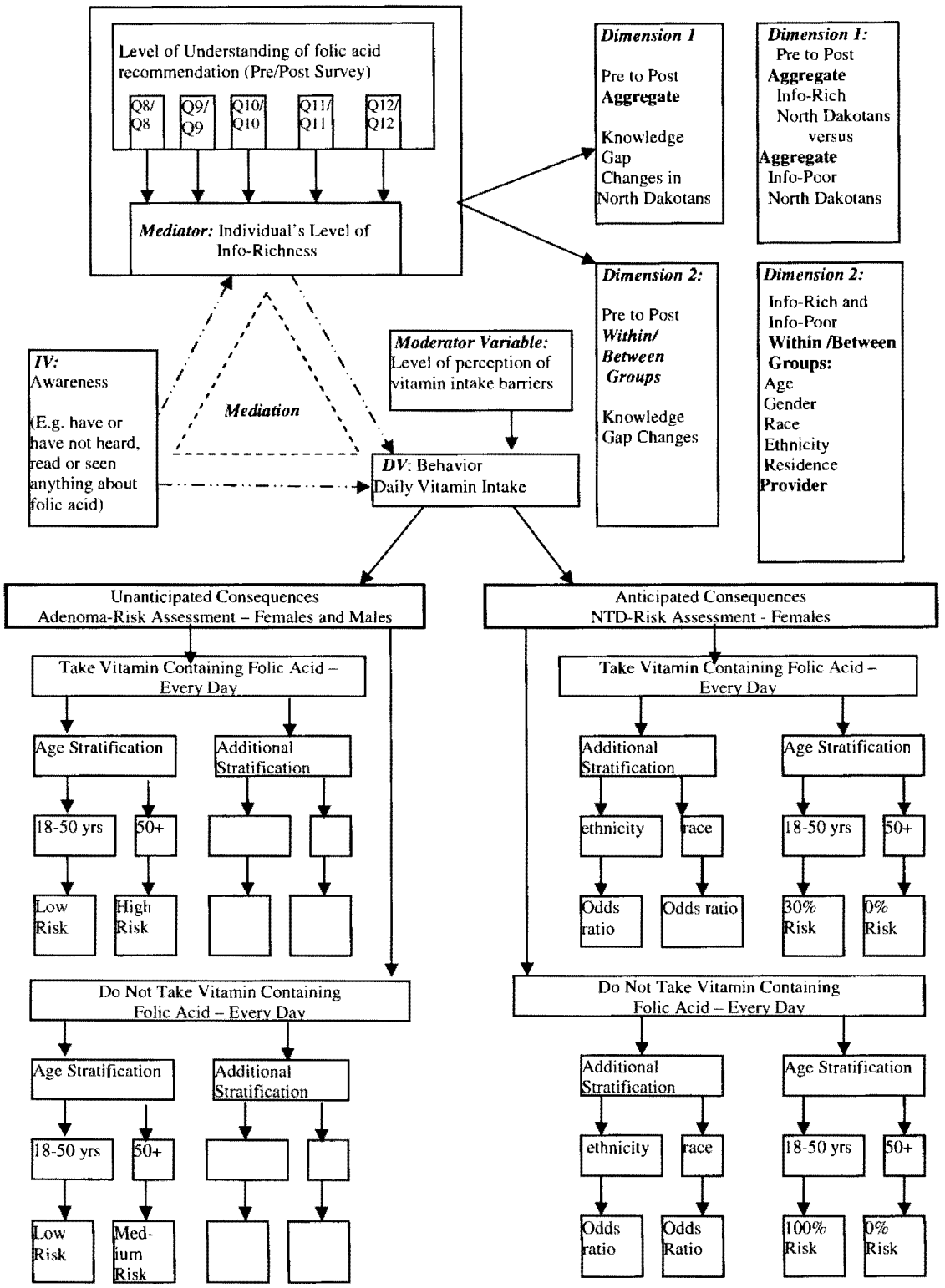

Figure 6.6. Stage Six with the addition of neural tube birth defect and adenoma risk assessment.

quantified. Thus, the stronger the association, the more likely the factor is to be a cause of the outcome, and less likely to be the result of errors (Friis & Sellers, 2009, p.77). For example, research findings have repeatedly demonstrated that timely and adequate folic acid intake is greatly associated with reducing the risk of having an NTD-affected pregnancy. In this example, the criterion for strength of association has been met.

Consistency of Effect. In observational studies, it is essential to validate the results with other studies. Through *consistency of effect*, associations between factor and outcome have been observed by different persons in different places, circumstances, and times (Friis & Sellers, 2009, p. 77). Since controlled experiments are not possible in an observational study, replications of the study in other populations and by different study designs can validate original conclusions. Multiple studies have consistently found that a relationship exists between folic acid levels and the prevalence of neural tube birth defects. In this example, the criterion for establishing consistency of effect has been met.

Biologic Plausibility. The mechanism by which the associated risk factor causes the outcome or disease must make biologic or etiologic sense in order for the statistically significant association to be useful in proving causation. Although the molecular mechanism is not understood, research findings indicate that it is biologically possible to prevent folic-acid-preventable anencephaly and spina bifida through timely and adequate folic acid consumption. In this example, the criterion for establishing biologic plausibility has been met.

Dose-response Relationship. Dose-response is related to strength of association. As dose or exposure increases, the likelihood of the related outcome increases, and thus the stronger the association. Duration of exposure can additionally be considered a dose such

that the longer an individual is exposed to a factor, the more likelihood there is to develop an outcome. For example, research indicates that if a female takes a daily vitamin containing 400 mcg of folic acid every day, starting at least a month prior to conception, her odds of having an NTD-affected pregnancy are reduced by up to 70 percent (CDC, 1992; CDC, 1999a). In this example, the criterion for establishing a dose-response relationship has been met.

Temporal Sequence. Causation is not possible without the cause of the outcome occurring before the effect and temporal sequence can only be determined with prospective studies where the development of outcome is observed during the period of study. Through observation, the development of an outcome is related to the suspected risk or protective factor(s). Research findings indicate that there were higher rates of NTD-affected pregnancies among females who did not consume adequate folic acid, starting at least a month prior to conception. In this example, the criterion for temporal sequence was met.

Specificity of Effect. Specificity of effect cannot be independent of the strength of association. Because specificity of effect means that a cause leads to one effect rather than multiple effects, it is rare to find a one-to-one relationship between an exposure factor and the outcome in question. This is because most variables cause several diseases just as most diseases are caused by multiple factors. Although there are several factors that may contribute to having an NTD-affected pregnancy, such as folic acid intake levels and genetic pre-disposition, the strength of association between timely and adequate folic acid intake and NTD-affected pregnancies is significant. Thus, the ability to meet the criteria for specificity of effect is highly probable.

Tests of Correlation

In order to begin exploring the potential relationships between "awareness and behavior," and "information richness and NTD-risk," two groups of variables needed to be defined and tested for correlation in order to rule out insignificant relationships between variables. Group one correlations consisted of the variables gender, awareness, information richness, behavior, barriers, NTD-risk, and adenoma risk. Group two correlations consisted of the variables extension affiliation, urban or rural proximity, ethnicity, race, age groups, information richness, NTD-risk, and adenoma.

With the exception of the variable adenoma risk, variables of gender, awareness, information richness, behavior, barriers, and NTD-risk were all significantly correlated at the 0.01 level in group one. More specifically, adenoma risk was significantly correlated with variables of awareness, behavior, barriers to behavior, and NTD-risk at the 0.01 level. However, adenoma risk was not significantly correlated with gender or information richness at the 0.01 level. In group two, it was revealed that the variable *information richness* was significantly correlated with variables of information service provider, race, age groups, and NTD-risk at the 0.05 level. Because correlations were significant between "awareness and behavior", and "information richness and NTD-risk," these relationships were stratified, and tested for significance using Chi-Square tests and tests of symmetric measures.

Tests of Significance

Tests of significance were conducted for each stratified relationship. At a p-value level greater than .05, the relationship was considered insignificant and was removed from additional calculations of odds ratios, confounding, and effects modification. For example,

when information richness and NTD-risk was stratified by eight regions, regions one, two, three, seven, and eight were insignificant, and therefore were removed from additional calculations of odds ratio, confounding, and effects modification. When the association between information richness and NTD-risk was stratified by five age groups, only the age groups 18 to 25 years, and 26 to 33 years were significant at the .05 level, and remained to be additionally tested for confounding and effects modification.

Risk Estimates

Crosstabulations were conducted for the purpose of computing odds ratios. Torrence (1997) points out," the odds ratio can be used as a measure of association between a factor (exposure) and an outcome in more types of study designs and in circumstances in which there is less known about the population " (p. 60). The odds ratio is calculated by comparing the odds of exposure among two populations. When the incidence of disease remains unknown, an absolute risk can only be estimated, not definitively calculated, and an odds ratio serves as a good approximation of the relative risk (Torrence, 1997, p. 59). In the present study, odds ratios served as approximations of the relative risk for measuring associations.

Stratified by information richness, an odds ratio was computed for the folic acid awareness-behavior relationship. A computed odds ratio was necessary in order to test Hypothesis Four.

H4: Of the information-poor females, the odds of being unaware of folic acid among females who do not take a folic acid containing supplement every day will not be greater than the odds of being unaware of folic acid among females who do take a folic acid containing supplement every day.

H4a: Of the information-poor females, the odds of being unaware of folic acid among females who do not take a folic acid containing supplement every day will be greater than the odds of being unaware of folic acid among females who do take a folic acid containing supplement every day.

Findings concluded that the odds of being unaware of folic acid among participants who were at risk for not taking folic acid every day were 3.755 greater than the odds of being unaware of folic acid and taking folic acid every day. In conclusion, the null hypothesis (H4) was rejected.

In order to test Hypothesis Five, the relationship between information richness and NTD- risk was stratified by variables of gender, survey periods (One / Two), ethnicity (Hispanic / non Hispanic), race (white / nonwhite), urban-rural proximity, regional proximity, information service provider (extension / non extension), and five age groups.

H5: Among stratified groups of females, the odds of being information poor among females at risk for having an NTD-affected pregnancy will not be greater than the odds of being information poor among females not at risk for having an NTD-affected pregnancy.

H5a: Among stratified groups of females, the odds of being information poor among females at risk for having an NTD-affected pregnancy will be greater than the odds of being information poor among females not at risk for having an NTD-affected pregnancy.

For each stratified relationship, findings concluded that the odds of being information poor among females at risk for having an NTD-affected pregnancy was greater than the odds of

being information poor among females not at risk for having an NTD-affected pregnancy. In conclusion, the null hypothesis (H5) was rejected.

Test for Homogeneity

The computations of odds ratios of stratified relationships were necessary in order to conduct tests of confounding and effects modification. Before testing for confounding could be conducted, a Breslow-Day test needed to be run to determine whether any of the odds ratios differed across stratum. The Breslow-Day procedure tests for homogeneity of the odds ratio, and requires a large sample size within each stratum. The Breslow-Day tests the null hypothesis under the assumption that the odds ratios are equal in each strata. Typically, the null hypothesis for this test is that *the association (or lack of association) between exposure and outcome is the same in each stratum (homogeneity).* The Breslow-Day test would come out significant if service providers aggravated the risk of information richness on NTD-risk but did not increase NTD-risk among information-poor individuals. Homogeneity does not require independence. A non-significant Breslow-Day test result would mean that there is no evidence that the odds ratios differ across stratum, therefore it would be acceptable to combine the odds ratios into a summary odds ratio.

In the present study, tests of homogeneity were run on stratified awareness-behavior relationship, and the stratified relationship between information richness and NTD-risk. The awareness-behavior relationship was stratified by information richness. The relationship between information richness and NTD-risk was individually stratified by variables of: gender, survey period (one / two), ethnicity (Hispanic / non Hispanic), race

(white / nonwhite), urban-rural proximity, regional proximity, information service provider (extension / non extension), and five age groups.

With the exception of the age group stratum, all of the strata resulted in non-significant results, and therefore it was acceptable to combine their odds ratios into a summary odds ratio. For the non significant relationships, it was also acceptable to evaluate the data on an aggregate basis. However, within the age group stratum, the test of homogeneity resulted in a significance level less that .05, and therefore it was not acceptable to combine computed odds ratios into a summary odds ratio when testing for confounding. Further collapsing the age groups into a dichotomy, such as 18 to 25 years versus over 25 years, would not have been as revealing of the levels of significance among categories.

Test for Conditional Independence

The Mantel-Haenszel procedure is a non-regression analysis that is used to identify confounders and control for confounding during the statistical phase of the study. The (Cochran)-Mantel-Haenszel statistic tests the null hypothesis that exposure and outcome are independent when conditioned on the confounder. Typically, the null hypothesis states that *when conditioned on the confounder, exposure and outcome are independent.* Once you condition on a variable, such as information service provider, information richness and being at risk for having an NTD-affected pregnancy are independent if the MH test comes out non-significant. On the other hand, a significant CMH test result would mean that there does appear to be an association between information richness and being at risk for NTD-affected pregnancy, after controlling for information service provider. The Mantel-Haenszel procedure was used to test Hypothesis Six.

H6: Variables of ethnicity, race, proximity, information service provider affiliation, and age will confound the relationship between information richness and being at risk for having an NTD-affected pregnancy.

H6a: Variables of ethnicity, race, proximity, information service provider affiliation, and age will not confound the relationship between information richness and being at risk for having an NTD-affected pregnancy.

A significant Mantel-Haenszel test would indicate that there does appear to be an association between information richness and being at risk for having an NTD-affected pregnancy, after controlling for a variable of interest. Effect modification results when the effect of an exposure differs among different subgroups. When it is inappropriate to use a summary odds ratio, confounding is based on a 10% differential between the cross product odds ratio and the adjusted odds ratio.

In the present study, effects modification was tested for the relationship awareness and behavior, stratified by information richness. The relationship between information richness and NTD-risk were individually stratified by gender, survey period (one / two), ethnicity (Hispanic / non Hispanic), race (white / nonwhite), urban-rural proximity, regional proximity, information service provider (extension / non extension), and five age groups. A differential of 28.65 percent was revealed when tests for confounding were conducted on the relationship between awareness and behavior, stratified by information richness. The Mantel-Haenszel test confirmed that information richness was a confounding factor between awareness and behavior among the survey population. The Mantel-Haenszel test confirmed that confounding was not present in the relationship between information richness and NTD- risk when controlling for gender, survey period, ethnicity,

race, urban-rural proximity, regional proximity, and information service provider. However, confounding was noted among females within the age group 18 to 25 years. Therefore, age was a confounding factor in the relationship between information richness and NTD-risk. In conclusion, the null hypothesis (H6) was not rejected because age was determined to be a confounding factor.

Prevalence

It is necessary to understand the difference between incidence and prevalence when conducting analysis of an exposure-outcome relationship. As Torrence (1997) points out, it is vital to differentiate between the incidence and prevalence of an outcome so that correct conclusions about the outcome may be drawn (p. 51). In the field of epidemiology, incidence represents the rate of occurrence of new cases of disease or an event in a population during a specific time period, and can only be used to express the risk of becoming ill (Torrence, 1997, p. 51). On the other hand, prevalence is a ratio that is used to estimate the probability of a population being ill at specific time period. "If incident cases continue to remain diseased over time, they become prevalent cases; therefore prevalence equals incidence times duration" (Torrence, 1997, p. 51). In sum, incidence rate is used to measure the frequency with which new cases of a disease (or outcome) are occurring in a population, and prevalence represents the number of existing cases of disease (or outcome) during a specific time period. Thus, time is the variable that differentiates incidence from prevalence. Presenting a snapshot in time, prevalence ratios are used to measure risk factors of a disease (or outcome), and can also used to measure the influence of survival of an individual with a disease (or outcome) (Torrence, 1997, p. 52).

Diffusion of innovation is situated within a time-order sequence. Past diffusion research studies have consisted mainly of correlational analysis and cross-sectional data gathered in one-shot surveys of respondents; thus presenting a snapshot of an innovation's diffusion process at a given point (Rogers, 2003, p. 127). Although a data collection point may indicate a snapshot of the continuous diffusion process, using an epidemiologic approaches of odds ratios and prevalence ratios provide an opportunity to measure communication effects during the freeze-action process. In order to address the snapshot survey limitations noted in past diffusion research studies, the present study incorporated epidemiologic methods to calculate odds ratios and attributable fractions as representative measures of the influence of information richness on NTD-risk.

Attributable Fractions

An Attributable Fraction can be calculated to measure the reduction in an outcome, such as NTD-risk, when a risk factor is removed, such as being information poor (Torrence, 1997, p. 62). Such estimates are useful for determining whether it is worthwhile to pursue a prevention program such as NTD-prevention. Attributable fractions were calculated in order to test Hypothesis Seven.

H7: A portion of the NTDs occurring in North Dakota cannot be attributed to information poorness.

H7a: A portion of the NTDs occurring in North Dakota can be attributed to information poorness.

In the present study, odds ratios served as approximations of the relative risk between the information-richness and NTD-risk relationship. Computed odds ratios were necessary in order to calculate attributable fractions, and attributable fractions were

necessary in order to determine AFp. The population attributable fractions were necessary in order to draw inferences between the survey population and NTD prevalence in North Dakota. Based on the calculated AFp for anencephaly (.228), we were able to infer that 22.8 percent of the anencephaly birth defects occurring in the North Dakota population can be attributed to information poorness. Based on the calculated AFp for spina bifida (.285), we were able to infer that 28.5 percent of the spina bifida birth defects occurring in the North Dakota population can be attributed to information poorness. Thus, the null hypothesis (H7) was rejected.

These inferences suggest that reducing the levels of information poorness among females presents an opportunity to reduce NTDs occurring in North Dakota. Measurements of information richness and attributable fractions provide a far richer analysis of a campaign's total impact. Public health campaigns need to go further than simply evaluating the percentages of change in awareness and behavior among target audiences. Methods leading up to and including the calculation of attributable fractions were useful in quantifying risk related to communication effects, namely information richness. Subsequently, the methods leading up to and including the calculation of population attributable fractions were useful in associating the survey population with North Dakota NTD-prevalence. In order to better reveal how the changes in communication effects will directly impact scientific effects, measurements of levels of information richness should be incorporated into the evaluation of the effectiveness of a public health campaign.

Limitations and Future Research

There are several limitations to the type of study application used test the new model. First, the model was tested using a quantitative study that did not investigate

measures related to time as a continuous factor. In the future, a similar study could be conducted with the inclusion of open-ended questions in a survey. For example, rather than asking individuals to select multiple-choice options when responding to vitamin intake barriers, an open-ended question may have provided far richer data. Another alternative would be to conduct a similar study using a qualitative approach, where data are revealed through focus groups and interviews. Future studies using a qualitative approach may be able extend the model in a direction that explores the time pattern of the innovation-diffusion process.

Second, the analysis was limited to the use of odds ratios for the purpose of approximating risk. Future studies could gather additional data from participants that may reduce the need to use approximations of odds ratios and prevalence. For example, future studies might also investigate the actual incidence of NTDs among surveyed participants, and utilize calculations of relative risk. The model can be extended in a direction that measures the absolute relative risk between an outcome and exposure.

There were limitations to the actual design of the folic acid campaign that was used to test the model. The survey questions were directed at ascertaining perceptions of survey participants regarding the USPHS recommendation. Surveys were not administered to information service providers. However, during face-to-face communication with clients, information service providers may have an opportunity to explain in greater detail the USPHS recommendation during client appointments. A study could explore how information service providers communicate with their clients about folic acid and NTD-prevention. Survey responses from clients and information service providers could be correlated to reveal folic acid-education gaps that exist from an interpersonal

communication perspective. For example, a study could investigate how service providers communicate with clients about folic acid, and how clients respond to the messages they receive. A level of feedback-richness could be developed in a similar fashion as was information-richness. Level of feedback-richness between information service providers and clients could be explored as a mediating factor on an individual's behavior.

Another limitation to the present study is that very few males completed the surveys in comparison to females. Although the primary target audience of folic acid campaign was females of childbearing age, 66 (6.6%) of the surveys were completed by males, and 938 (93.4%) were completed by females. A future study could target both females and males, and ascertain the understanding of the USPHS recommendation from a gender-based perspective. For example, males may offer a unique perspective on the possibility of fathering a child born with an NTD. A survey that targets both males and females may reveal unique information-richness gaps related to folic acid intake and NTD-prevention.

The primary focus of the present study was to ascertain knowledge of the USPHS recommendation among female participants. The primary data analysis revealed anticipated consequences related to folic acid intake behaviors among females of childbearing age. Secondary data analysis revealed unanticipated consequences related to age and folic acid intake behaviors among males and females. The increased risk for colorectal adenoma development was considered an unanticipated consequence for any individual over the age of 50 years consuming a daily folic acid-containing supplement. The study did not directly probe whether one gender was at greater risk than the other for developing a colorectal adenoma. Additionally, the current study was limited in that it did not directly ask participants any questions related to the risks of colorectal adenoma development. A future

study could include survey questions that directly investigate the unanticipated consequence of colorectal adenoma among participants. For example, a study could investigate an individual's level of understanding of colorectal adenomas. A survey could ask individuals to identify the folic acid-containing supplements that they are taking on a daily basis, and this data could be used to quantify a folic acid mcg intake from supplementation. Because males and females are at risk for colorectal adenoma development, a future study could target a balanced representation of both genders when administering surveys.

The implementation of the folic acid study experienced a limitation related to data gathering during survey period two. During the spring of 2009, the state of North Dakota experienced tremendous flooding. Survey administrators and survey respondents were impacted by the record flooding. Several survey administers were unable to administer additional surveys during survey period two. For example, universities were closed, and survey administrators and respondents were displaced. As a result, the total number of completed surveys for data set two was lower than originally anticipated.

Survey design was limited in length, which presented another limitation to the folic acid study. Fewer questions, including those related to demographics, were omitted from the surveys, in order to maintain a one-page limit. For example, the collection of additional attributes related to survey participants may have been relevant to the folic acid study analysis. The present survey did not gather responses related to socioeconomic factors of education or income. These attributes may have influenced an individual's responsiveness to the folic acid campaign.

Future research could gather additional attributes of participants for the purpose of assessing confounding and effects modification. For example, the CDC states that other factors may play a role in NTD development. Future studies could further stratify the relationship between information richness and NTD-risk using attributes that are measured to a greater degree. For example, awareness could be measured in greater degree as an individual's level of awareness. Vitamin behavior could be measured in greater degree as the level of vitamin intake behavior. Additional questions could be asked to probe in greater detail an individual's level of understanding of the USPHS recommendation. Although limitations are noted within the present study, the model shows potential for continued work.

The extended new model can be tested in a variety of contexts. As Rogers (2003) pointed out, the diffusion model has relevance for many disciplines and cuts across various fields (p. 103). Using the model as a guide, research may be able to better quantify risks associated with communication effects. Because the model has the potential to quantify risk, it may be useful for investigating the publics' level of understanding and information richness in a variety of situations. For example, studies related to food safety, food recalls, food protection and defense, emergency preparedness, and terrorism could be applied to this model.

Additionally, because level of understanding and information richness are shown to mediate an individual's behavior, a study investigating effectiveness of university efforts to recruit students into a program could be applied to this model. Other applications for the model may be drawn from the public health field. For example, additional public health campaigns may be tested, that differ from the folic acid campaign. These are just a few

examples. This model has relevance for many disciplines because of its ability to assess level of understanding and information richness among individuals, publics, and the general population using differential and aggregate analysis.

CONCLUSION

The purpose of this study was to develop a model that would serve to probe direct and indirect consequences of communication and scientific effects, while exploring awareness, attitudes and behavior among multiple publics. Specifically, this study used a model to guide the examination of knowledge gap changes and potential health risks among vulnerable publics, including hard-to-reach individuals living in North Dakota. The application of an education intervention campaign served to test the model's potential to guide research and overcome shortcomings of past diffusion research that included: lack of consequence research, change agent tendencies, pro-innovation bias, and limited research methods.

The present study incorporated a folic acid related communication intervention in order to conduct consequence research. Although change agents typically do not concentrate their efforts on their most disadvantaged clients (Rogers, 2003, p.383), multiple change agents specifically connected to disadvantaged and hard-to-reach publics were selected as information service providers for this study. The potential for pro-innovation bias was addressed through the random selection of survey participants that included hard-to-reach publics, university students, and the general public. Pro-innovation bias was potentially addressed through the involvement of multiple information service providers statewide, including extension agents, public health clinicians, WIC agents, university instructors and students. Epidemiologic tests were incorporated in data analysis in order to investigate the potential bias of confounding variables. Because so few diffusion investigations have analyzed differences between benchmark and follow up surveys

(Rogers, 2003, p. 72), the present study gathered data at two different points in time, before and following a health-related communication intervention.

Thus, in order to address shortcomings of past diffusion research studies, this study included a field experiment where communication components were uniquely implemented, variables of knowledge, attitudes and overt behavior among multiple publics were aggregately and differentially analyzed between two different data collection periods, and assessment of risk was quantified through epidemiologic means. Folic acid awareness, knowledge, behavior, and information-richness levels were measured aggregately and differentially among multiple publics in North Dakota. Strength of association was examined between an individual's level of information richness and health-related risks.

Information richness was used to quantify health risk related to neural tube defects. Through calculations of attributable fractions, we were able to infer that a portion of anencephaly and spina bifida defects occurring in the North Dakota population can be attributed to information poorness. More specifically, a level of risk can be quantified for information richness and we can infer that a portion of anencephaly and spina bifida defects occurring in the North Dakota population can be attributed to information-poor individuals. Through a model development process, Rogers' (2003) diffusion research recommendations were applied and his existing diffusion research model was extended while investigating communication and scientific effects.

The model defined methods and a process that are transferrable to a variety of research context. This model has value in that it may support the collaborative efforts of multi-disciplinary projects, while promoting and strengthening the position of each

discipline through joint research. More specifically, the model will serve to help researchers seek, find, and work within a respected and common ground platform.

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APPENDIX A

Survey Instrument One

NDSU Extension Service
North Dakota State University

NORTH DAKOTA FOLIC ACID TASK FORCE

Date _____

Circle the letter that corresponds to your answer(s) or fill in the blank.

1) How old are you? (please fill in the blank): _____ years old

2) Are you male or female? (circle one answer) a) Male b) Female

3) Are you of Latino or Hispanic origin? (circle one answer) a) Yes b) No

4) What is your race? (circle one answer) a) White b) Black c) Asian
d) American Indian or Alaska Native e) Native Hawaiian or Other Pacific Islander

5) Where do you live? (Please fill in your county and/or city):_____

6) Have you ever heard, read or seen anything about folic acid or folate?
(circle one answer)
a) Yes b) No c) I don't know

7) What is folic acid or folate? (circle one answer)
a) a poisonous chemical b) a vitamin c) a mineral d) I don't know

8) What are some sources of folic acid or folate? (circle the letters of all that apply)
a) chocolate b) bread c) chicken d) beef e) pork f) seafood
g) beans h) orange juice i) leafy green vegetables j) multi-vitamin
k) I don't know

9) Folic acid reduces homocysteine levels in the body. High homocysteine levels are associated with: (circle one answer)
a) cancer b) heart disease c) Tuberculosis
d) anthrax e) Hepatitis B f) I don't know

10) Some health experts recommend that women get the recommended amount of folic acid/folate to: (circle one answer)
a) prevent high blood pressure b) reduce the effects of PMS
c) prevent birth defects d) lose weight e) I don't know

APPENDIX A (Continued)

11) How much folic acid/folate is recommended daily for women during childbearing age? (circle one answer)

a) 0 micrograms b) 10,000 micrograms c) 4 grams
d) 400 micrograms e) depends on how much you weigh f) I don't know

12) During childbearing age, when should women take folic acid?
(circle the letters of all that apply)

a) never b) before a pregnancy c) during a pregnancy d) after a pregnancy
e) I don't know

13) Do you take a prenatal or a multi-vitamin pill or a pill containing folic acid?
(circle one answer) a) Yes b) No c) I don't know

14) Do you take a pill containing folic acid on a "daily basis"?
(circle one answer) a) Yes b) No c) I don't know

15) If you don't, why don't you take a vitamin or mineral supplement on a daily basis? (circle the letters of all that apply)

a) I forget to take it b) I don't need to take it c) It is too expensive
d) I already get balanced nutrition from my food e) I don't know

16) What percent of pregnancies are unplanned? (circle one answer)

a) 90 percent b) 15 percent c) 1 percent d) 50 percent e) I don't know

APPENDIX B

Survey Instrument Two

NDSU Extension Service North Dakota State University — NORTH DAKOTA FOLIC ACID TASK FORCE

Date _____

Circle the letter that corresponds to your answer(s) or fill in the blank.

1) How old are you? (please fill in the blank): _____ years old

2) Are you male or female? (circle one answer) a) Male b) Female

3) Are you of Latino or Hispanic origin? (circle one answer) a) Yes b) No

4) What is your race? (circle one answer) a) White b) Black c) Asian
d) American Indian or Alaska Native e) Native Hawaiian or Other Pacific Islander

5) Where do you live? (Please fill in your county and/or city):
_____

6) Which best describes your current condition?
(circle and/or fill in all answers that apply to you)
a) capable of becoming pregnant b) definitely not pregnant
c) not sure, but may be pregnant d) incapable of becoming pregnant
e) accidentally pregnant f) intentionally pregnant
g) trying to not get pregnant h) trying to get pregnant
i) I am _____ weeks pregnant

7) In the past two months, where have you seen or heard information about folic acid or folate? (circle the letters of all answers that apply to you and/or fill in the blank)
a) I haven't b) I'm not sure c) clinic d) billboard e) newspaper
f) radio g) brochure h) food label i) display j) poster display
k) restaurant l) WIC m) classroom n) from a friend o) email
p) Internet q) pharmacy r) coupon s) salon/spa t) recipe card
u) survey v) television w) magazine x) college
y) supplement bottle label z) health-care provider Other:_____

8) What is folic acid or folate? (circle one answer)
a) a poisonous chemical b) a vitamin c) a mineral d) I don't know

9) What are some sources of folic acid or folate? (circle the letters of all that apply)
a) chocolate b) bread c) chicken d) beef e) pork f) seafood
g) beans h) orange juice i) leafy green vegetables
j) multivitamin k) I don't know

APPENDIX B (Continued)

10) Some health experts recommend that women get the recommended amount of folic acid/folate to: (circle only one answer)
a) prevent high blood pressure b) lose weight c) reduce the effects of PMS
d) prevent birth defects e) I don't know

11) How much folic acid/folate is recommended daily for women during childbearing age? (circle only one answer)
a) 0 micrograms b) 10,000 micrograms c) 4 grams
d) 400 micrograms e) depends on how much you weigh f) I don't know

12) During childbearing age, when should women take folic acid?
(circle all answers that apply)
a) never b) before a pregnancy c) during a pregnancy d) after a pregnancy
e) I don't know

13) How long have you been taking a daily multivitamin or supplement containing folic acid? (circle only one answer)
a) less than a month b) more than a month c) I do not take one

14) If you don't, why don't you take a vitamin/mineral supplement each day?
(circle all that apply)
a) I forget to take it b) I don't know c) It is too expensive
d) It is not safe to take one e) I get balanced nutrition from my food
f) not necessary each day g) Other: _____

15) In the next month, how often are you likely to meet the daily folic acid/folate recommendation? (circle all answers that apply to you)
a) every day b) sometimes c) most of the time d) never
e) I don't know f) I am unable to meet the daily recommendation
g) I do not know how much I require daily

16) If you previously redeemed coupons that stated a folic acid message, which coupons did you redeem?
(circle the letters of all answers that apply to you and/or fill in the blank)
a) none b) bread coupon c) restaurant coupon d) vitamin coupon
e) Other:_____